Proceedings

of the

Radio Club of America

Incorporated

June-1930

Volume 7, No. 6

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PROCEEDINGS
of the
RADIO CLUB OF AMERICA

Vol. 7 JUNE, 1930 No. 6

AUTOMOBILE RADIO RECEIVERS†

*By Arthur V. Nichol**

IT is the purpose of this paper to discuss the special considerations involved in the design of automobile radio broadcast receivers. A brief history of the development of radio reception in motor-cars will also be reviewed.

Possibly all radio men are a little queer, or just miss being normal, but ever since a crystal detector made its appearance and I daresay, a bit before, some of us have attempted reception and transmission from vehicles. We couldn't get enough of radio, pardon me—"wireless," at home and much effort was expended toward the portable receiver so we could carry it with us. Most of these early attempts were purely portable sets. By the time tubes came into general use, and the waves between two hundred and six hundred meters became something more than the amateurs' playground, some very good portable receivers had been constructed. About 1922 several of these receivers had been installed and operated in automobiles, but they were essentially portable receivers, which the automobile receiver of today distinctly is not.

It remained for Wm. M. Heina to definitely design an installation which was so constructed as to make it a part of the automobile rather than an accessory, a mobile, rather than a portable receiver. This was in 1925. Since then much development has been done, until today it is possible to enjoy approximately the same reception in your motor car as you do in your home.

Auto-radio therefore is not an overnight development as would appear from some of the current newspaper and trade journal articles. It has had its laboratory stages, and emerges much as other radio developments, a dependable product properly engineered and designed to perform under those conditions encountered in the automobile.

To more fully bring out the highly specialized receiver necessary for motor car operation we may follow its developments:

The first sets were usually operated on separate batteries, rather than from the car battery. Their batteries were carried wherever convenient; in all probability in the rear where the acid from the storage "A" could conveniently spill and ruin the floor mat. The antenna consisted either of a loop; an erection similar to a small fence around the car roof, or a series of wires strung about the car which gave it much the appearance of a full rigged ship. A speaker was seldom present but if one was used it usually occupied as much room as the set. Owing to motor interference, operation was not possible while driving except on signals of high level.

One by one these crudities of early design were overcome. Today the plate supply batteries are housed in a water-tight compartment under the floor. The antenna is concealed in the roof, between the deck material and the head lining. The speaker has assumed much smaller dimensions and is now mounted under the cowl. "A" power is supplied by the car battery and all that remains to be seen of the radio receiver is a dial and switch on the instrument board, as much a part of the car as the speedometer.

For clarity let us divide a typical installation into its various components. We have:

1. The antenna system.
2. The radio-frequency system.
3. The audio-frequency system and reproducer.
4. Means for overcoming the interference from the electrical systems of the car.

The Antenna System

The importance of antenna system design cannot be too highly stressed. Extensive tests on various types, sizes and constructions have definitely pointed to the superiority of the large area screen antenna over all others, with the horizontally coiled loop as a second choice. The effective height is woefully low which means that a receiver of high gain is necessary. The capacity of the antenna should therefore be made as high as possible. In cars using poultry wire as a support for the deck material this netting may be insulated and makes an excellent antenna.

Many automobile manufacturers are insulating this poultry wire from the car by a spacer built into the roof construction. A lead wire is brought down the right front post to facilitate installation. Measurements of these antennas show, for sedan models, a capacity of about 200 $\mu\mu$f. and a resistance of about 1.5 ohms at 1,000 kc. The inductance is negligible. This capacity compares favorably with that of a good broadcast antenna, but the effective height averages but .4 meter. In cars having a slat roof, the antenna may consist of copper window screen tacked against the under side of the bows and concealed by the head lining. In factory installations this copper screen is placed between the slats and the deck material. The characteristics of this type are much the same as those of the poultry wire antenna, but as they are necessarily smaller in area they show no improvement in reception.

In roadsters and touring cars a flexible wire is woven into a horizontal loop supported by cloth which is stitched to the pads which support the top material at each side. A lining of the same material as the top is stretched beneath to conceal it from view. In such an installation, the top may be folded back as the lead wire is brought down the rear of the top and along the body sill to the cowl. The set may be operated with the top up or down, although better reception is of course had with the top up. This antenna is about 75 per cent. as efficient as the screen, but because of the smaller masses of metal about it, its effective height is greater than that of the screen. These two factors tend to offset one another, and a very successful installation can therefore be made even in a roadster. A touring car antenna often is superior to that possible in a sedan.

Many unusual types have been tried, such as using a capacity to earth, the use of insulated bumpers, trunk racks and so forth. Probably one of the most interesting was an insulated plate fastened beneath each running board. Shielded leads were run from these plates to the receiver. The antenna transformer primary was grounded at the exact center. The idea was that spark radiation from the ignition sys-

† *Presented before the Club, April 9th, 1930.*
**Asst. Chief Engineer, Automobile Radio Corp.*

tem would be picked up equally by these two plates and being in phase across the antenna coil would cancel out. The signal, however, being slightly out of phase would induce a potential in the secondary. It was far from successful from an elimination standpoint, but was a rather good antenna. However, it was directional and therefore discarded.

Wire, tinsel tapes or small loops mounted inside the car do not prove satisfactory because of the shielding effect from the metal parts of the body. These antennas necessitate receivers of too high a gain to be practical and their advantage from an installation angle is slight.

We find, therefore, that the best antenna is one which combines the highest possible capacity with the greatest effective height, or in other words maximum spacing from metal parts of the body.

The Radio-Frequency Amplifier

Cars today show the effects of standardization to a marked degree. The space available and its location however is subject to wide variation. The receiver must be mounted in an accessible position. It must be easily installed and must not in any way interfere with service or replacement of any parts or accessories already installed in the automobile. Careful consideration shows the space most readily available to be under the cowl between the instrument board and the engine partition. This position has the added advantage of allowing direct control of the tuning elements without the necessity of flexible shafts, gears or rods, and therefore materially reduces the installation expense.

The receiver may conveniently be broken into two units, one containing the radio-frequency amplifier, detector and tuning control and the other containing the audio amplifier, voltage regulator and output system. These units can be interconnected by a flexible shielded cable enabling the audio unit to be mounted in the most practical position. This further simplifies installation.

As the antenna is necessarily rather inefficient it is necessary that the receiver have high sensitivity. Owing to the fact that the receiver will be used in congested areas where many large and powerful broadcast stations are in operation, the selectivity must be about equal to that of a home receiver. The smaller and less efficient antenna somewhat simplifies this but the increased gain still makes selectivity a factor.

Our choice of circuits is limited. High amplification with selectivity calls for a multiplicity of tuned circuits. In properly designed circuits using the 201-A tube, it has been found possible to obtain voltage amplifications as high as 15 per stage. These tubes have the advantage of low filament consumption, comparative freedom from microphonic noise and a high degree of uniformity even when different makes of tubes are compared. This is of considerable advantage from a service angle. Three of these tubes working into a 112-A detector give ample sensitivity for all ordinary conditions of reception.

We have not found it possible to utilize the screen-grid tube to advantage in such radio-frequency amplifiers. This is due to several causes. At least three tuned stages are necessary for good selectivity. With screen-grid tubes the gain per stage is several times that obtained with the 201-A type, hence we reach the practical limit of amplification without having a sufficient number of tuned stages to give a proper degree of selectivity. By practical limit of amplification, we mean that limit imposed by raising the background noise level to a point where it becomes objectionable and interferes with reception. There is no permanent advantage in increasing sensitivity beyond this point. If we do, it merely means we shall have to operate the receiver with the gain control at a point considerably below maximum. There are times, of course, under exceptional conditions such as exist in the country during the fall and winter, when the background noise level is low enough to allow full gain, but under normal conditions it is rarely possible to increase the sensitivity beyond 20 microvolts per meter and obtain satisfactory reception.

We can, with three 201-A type tubes obtain a sensitivity better than 5 microvolts per meter. This sensitivity could be obtained with 2 type 224 tubes, but with 201-A's we have the added advantage of another tuned stage which increases selectivity to such a marked degree that it warrants the additional space required. The production cost is about equal, as the screen-grid amplifier requires careful shielding and more expensive construction in order to withstand the mechanical abuse to which the receiver is subjected.

Low filament consumption is necessary as the additional load of the receiver on the car battery must be kept at a minimum. The 222 and 199 type tubes, while possessing desirable filament characteristics, are mechanically weak and are microphonic. The 224 type requires a high filament current and even when operated in series parallel this current is sufficient to endanger the proper operation of the car battery system.

We may therefore consider it good practice to utilize 201-A tubes as radio-frequency amplifiers. The best method of using these tubes is in a tuned neutralized amplifier.

As the receiver is to be operated when the engine is running it is necessary to compensate for voltage variations of the battery when under charge. To offset this difficulty it is advisable to adjust the minimum possible filament potential to such a value as will keep the tubes in saturation at all times. A negative grid bias of high value should be used to prevent deactivation of the tube filaments when operating at such excessive potential as may be developed by a gassing battery.

Some ripple from the generator commutator may enter through the detector filament but as the 112-A type tube has an oxide filament of high thermal lag this is of no consequence. A tube having an X L filament may cause considerable trouble at this point.

The Audio-Frequency System and Reproducer

The audio system may be one of two general classes—transformer or resistance coupled.

The selection of the type most adaptable to automobile radio will be governed by the available space, total output, type of tubes and battery requirements.

Space being at a premium the plate supply must be limited to 180 volts with provision for operation on 135 volts if necessary. Resistance coupling would be satisfactory if 180 volts could be used in all installations but space for batteries is not available in some instances. It would of course be necessary to use a tube of the 240 type in the first audio. These tubes are a possible source of trouble as they are not as uniform as the 201-A and are mechanically weaker. There are, however, some very good arguments which could be advanced in favor of resistance couplings were it not for the battery limitations.

The transformer coupled amplifier has the advantage of higher gain, adaptability to various plate potentials and the use of more rugged tubes.

Working back from the output tube we find that a 171-A will operate at 180 volts plate with a grid swing of 28 volts r.m.s. A 2-1 coupling transformer reduces this to 14 volts from the first audio tube. Therefore a 201-A operated at 90 volts plate and 4.5 volts bias will perform excellently in this position. Accepting 5 as the available amplification from this tube the input becomes 2.8 volts and a transformer of the same ratio; 2—1, means a detector output of 1.5 volts.

The amplifier thus has a gain of approximately 80. It is not advisable to increase the gain beyond this point, for, while the response is increased on weak signals, shadow effects are increased owing to the square law response of the detector. These shadows are caused by reflection and shielding from buildings, railroad bridges, etc., and may become very troublesome if the audio gain is of high value. A volume control tube might be used, but if operated by the carrier, or a function of the carrier, would necessitate visual tuning. This is of course a disadvantage as it further complicates the receiver, makes installation more difficult and is distracting to the car operator.

In the foregoing amplifier the power tube is allowed to overload first. While this condition is not generally desirable it becomes almost a necessity in automobile receivers. The wide variation of conditions under which the receiver must operate necessitates high gain and sufficient audio amplification must be incorporated to maintain output levels between plus 10 and plus 20 dbs. Due to road, traffic and engine conditions the average noise level in the car apparently lies between plus 6 and plus 10 decibels and the signal must be sufficient to blanket this. However, owing to the confined space of the car body audio intensity should be low enough to prevent uncomfortable overload.

The reproducer used must naturally be as efficient as possible as the power available is limited.

Speakers may be divided into two classes: magnetic and dynamic. The magnetic speaker is much better suited for car installation because of its light weight, smaller size and the fact that it can be made dust tight.

The importance of complete protection from dust cannot be over-emphasized. The amount of iron and steel particles contained in ordinary road dust is very high, sometimes as high as 12 per cent., and as a large amount of this dust is tracked into the car, it floats about, is gathered by the magnetic field of the speaker and consequently ruins its operation.

The small space available is a considerable handicap, but because of the acoustics of the car body surprisingly good results may be obtained. The absorption of the higher audio frequencies by the upholstery of the car tends to offset the lack of adequate baffle and the results are very pleasing. The speaker is usually mounted against the engine partition high enough to allow foot room and as a result the cavity resonance of the location further reinforces the middle and low register. It is not possible to cut a hole in the engine partition and utilize this as a baffle for in modern car construction this partition is heavily padded to absorb engine noise, and the aperture filled by the speaker would admit this noise to the decided discomfort of the operator.

The dynamic speaker, while being slightly more sensitive, and possessing better fidelity has the disadvantage of additional current consumption for energizing the field. Automotive engineers desire that the total current consumption be kept as low as possible and the addition of this speaker field current, which is often greater than that drawn by the receiver, offers a decided objection. Low field consumption could be had but the manufacturing difficulties attending such construction would not warrant the design.

A brief description of a receiver designed with these considerations in view is of interest.

Description of a Representative Receiver

The radio-frequency unit consists of a steel chassis measuring about 8 inches x 10 inches on which the components of the r-f. amplifier and detector circuits are mounted. This chassis is secured in a drawn steel box immediately behind the instrument board. The box consists of two similar sections separating on the center line of the condenser shaft thus allowing access to the unit by the removal of a single knurled screw which releases the cover section. The entire chassis may be removed by loosening four retaining screws. As the chassis are completely interchangeable the replacement of a defective unit is but a matter of a few minutes, in fact the change can be made in much less time than it takes to change the car battery, and is as simple. The circuits of the r-f. amplifier and detector are conventional. Particular attention had to be paid to the elimination of possible modulation due to vibration. For this reason the variable condenser is designed to permit maximum rigidity of both rotor and stator plates.

The tuned circuits are brought to resonance by means of inductor discs which move coaxially with the r-f. transformers, rather than with the conventional trimming condensers, as condensers may vibrate and introduce modulation. The condensers used to neutralize the capacity coupling of the tubes take the form of plungers which are rigidly supported on the chassis, the opposite plate being a sleeve moulded into the body of the condenser. The wiring is extremely short and direct and therefore further reduces the chance of modulation from small changes in capacity or coupling.

As previously stated a "C" bias on all tubes is necessary to prevent deactivation of the tube filaments and to render the performance of the receiver independent of the polarity of the filament supply. To accomplish this the filament end of the r-f. transformer secondary must be at "C" potential. It must, however, be at chassis potential to the r-f. currents in the circuit. To accomplish this a 1/4 mf. condenser is placed between these points, effectively in the tuned circuit. To prevent possible coupling and eliminate the possibility of damage from defective tubes, short circuits, etc., protective resistors are inserted in both plate and "C" leads. These resistors are, of course, heavily by-passed. By thus isolating each circuit much higher gain may be incorporated without serious trouble from stray coupling such as usually exists when common feeders are used for these circuits.

A conventional grid detector is used. Additional capacity must be introduced to compensate for the absence of reflected capacity in the detector stage. A small piece of braid over the detector grid lead supplies this.

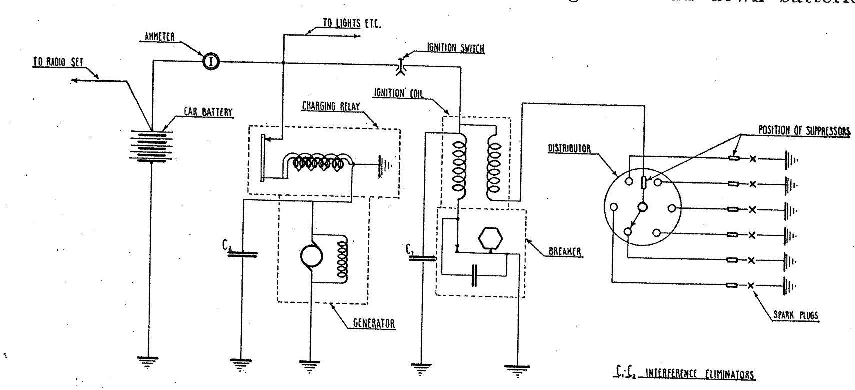
Tuning is accomplished by a single control extending through the instrument board. To facilitate installation the control shaft is a hollow tube, and the gain control is mounted on the rear of the condenser and articulated by means of a small knob in the center of the tuning dial. Switch leads for controlling the filaments enter through a grommet secured when the cover is placed in position.

The audio chassis is approximately 5 inches x 10 inches. In addition to the tubes, sockets and transformers it carries an output filter and an iron core reactor. The filaments are fed through this reactor. It thus serves a double purpose; that of filtering any ripple which may be present in the filament circuit; and in addition, offers a convenient method of adjusting the filament potential to the correct value.

Knockout slots are provided in the box for the interconnecting cables. As there are four knockouts, any two of which may be used, this box may be mounted in any convenient position. The cover is held in position in the same manner as that of the r-f. box. The interconnecting cables terminate at each end in connecting blocks, carrying plug and jack connectors which provide a rapid and foolproof means of connecting the units.

These connecting blocks slip into the rectangular knockouts provided in both boxes and are held firmly in position when the covers are in place. This method has proven very satisfactory and trouble from faulty hook-up is almost unknown. The battery cable, which connects the audio chassis with the box containing the B and C batteries is usually run under the floor boards and is connected to the battery box by means of a water-tight coupling. Either lead cable or a special waterproof housing is used.

Particular attention must be given to making the battery box water-tight. A small amount of moisture may cause bad leakage and run down batteries.



ELECTRICAL SYSTEM OF A CAR

Figure 1.

Special moulded case waterproof batteries have been developed for this type of service, and their use is recommended wherever possible. The battery box is usually mounted so that the cover fits flush with the car floor thereby making the batteries readily accessible for test and replacement.

Tests conducted over the past four years show the standard V30D type most economical and suitable for automobile installation, where the total plate current drain is twenty milliamperes or less. Under these conditions and with normal use a good make of battery will give approximately four months service, and it is not exceptional to exceed this.

Elimination of Interference Caused by the Electrical Systems of the Car

Motor and ignition noise was by far the most important obstacle to overcome. This type of interference is present to a varying extent in all cars, and some means of successfully eliminating its effect upon reception had to be found. In 1927, A. A. Leonard, working on the problem, made several important discoveries which led to a practical system of eliminating this trouble. Briefly, his findings were these: The high tension ignition wires of an engine may be considered as miniature antennas, grounded at the spark-plug end and oscillating at a frequency dependent upon their distributed inductance and capacity, practically determined by their length. The passage of the spark at the plug excites these miniature antennas and as their radiation efficiency is extremely high a considerable amount of power is radiated. Owing to the high radiation resistance damping in these circuits is also high and the energy thus radiated in highly damped trains impacts the antenna. The resultant interference is similar to that experienced by broadcast receivers from 600-meter spark transmitters of high decrement. In the car, however, the interfering damped train from the ignition system has a frequency lying between 10 and 60 megacycles, in some cases higher. Also, coupling is much closer. Shielding was tried but it had the serious disadvantage of materially curtailing the efficiency of the ignition system, besides being costly and inconvenient to install. Mr. Leonard then conceived the idea of destroying the oscillatory character of the currents in the ignition wires. This proved very successful. It can readily be seen that a resistance of sufficiently high value introduced into the oscillatory circuit will render it aperiodic. In other words, the value of $\frac{R}{2L}$ is increased to be equal to or greater than $\frac{1}{\sqrt{LC}}$. This is a condition in which oscillation is impossible, and the current becomes a single pulse. This in no way affects the efficiency of the ignition system, and may even improve it by materially reducing the time constant of the ignition coil.

Gasoline vapor under compression behaves somewhat like dynamite, and must be exploded by impact from the rupture of the gap at the plug, rather than by the heat of the arc after the rupture has taken place.

It therefore follows that the introduction of resistance, even in the order of several hundred thousand ohms, in series with the theoretically infinite resistance of the gap before rupture, will have no effect. It will however rapidly dissipate the energy fed to the circuit by the coil after the rupture has occurred, thus dissipating this energy as heat rather than radiating it at radio frequencies.

In practice it is customary to introduce a resistance of approximately 25,000 ohms directly at the plug. This value is higher than is necessary to satisfy the equation of $\frac{R}{2L}$ being equal to or greater than $\frac{1}{\sqrt{LC}}$, but as there is some aging effect in the resistors, it is considered good practice to use a higher value than actually necessary. Incidentally, two well-known manufacturers of carbon resistances have developed a special type of resistor which is suitable for use in ignition circuits. The ordinary carbon resistor is unsatisfactory for this use, as its value may decrease very rapidly under high potential discharges. A thorough life test under actual operating conditions should be given a resistor intended for this use.

We now have a circuit in which the damping factor is raised to a point preventing oscillation. However, in a car the wires directly associated with the plugs are not the only source of trouble. These wires terminate at the distributor, which is in reality a rotary switch. The center arm of the distributor is fed from the high tension terminal of the coil. This arm is separated from the various contacts by a definite gap, and this gap is important, being placed there for a particular purpose. If a plug is fouled, owing to carbon deposits, the resistance of the gap at the plug can no longer be considered infinite, but assumes a high value, generally several megohms. The high potential current induced in the coil secondary would leak off across this resistance rather than rupture the gap at the plug. The purpose of this distributor gap, then, is to permit the secondary current to exist at fairly high potential before passage to the spark-plug, thus insuring a spark even though the plug be partially shorted by the resistance due to fouling. We therefore must insert a resistance in series with the lead to the distributor brush in order to destroy such oscillation as may occur in this lead.

Some question may arise as to the actual efficiency of operation of these resistors as oscillation suppressors. Some rather simple but interesting tests may be described which show definitely their action.

Suppose we introduce a neon tube of low internal capacity into a high tension lead. We know that the glow will occur only on the positive plate of the tube. Without the resistor in the circuit the glow will definitely show on both plates, although one will be considerably brighter than the other, owing to the damping. Upon introducing the resistor, however, the glow will be confined to one plate only and there will be no indication of reversal of potential which must accompany oscillation. This method is extremely sensitive, as neon lamps are available which will glow brilliantly at potentials as low as 120 volts. This is about 1 per cent. of the possible potential developed by the coil. It may also be noted that the resistance of the neon tube is very high until ionization occurs, consequently the development of oscillation is unhindered by introduction of resistance by the tube.

The cathode ray tube also presents an admirable method of determination although its associated circuits render it more cumbersome. For determination of oscillation the tube may be capacitively coupled to the high tension wire by means of a small piece of foil, or even by the lead wire itself. Owing to the high potentials which may be induced between the control plates by possible resonance of the lead wires with the high-frequency oscillation in the circuit under observation, the tube should be protected by shunt resistances to prevent arcing. It is almost impossible to introduce a time axis owing to the ultra high frequencies at which oscillations occur, and the usefulness is limited to determination of oscillation, and measurement of peak potentials.

A tube voltmeter may be used in much the same manner. It will be necessary to operate the coil at such polarity that the reversal of secondary current will supply positive potential to the grid. The spark frequency must also be increased to at least 50 per second, otherwise this method will produce negative results. The cathode ray tube is by far the most sensitive and has the advantage of calibration, which is not possible with either of the other methods as the neon tube is insensitive to less than its ionization voltage, and in calibrating the tube voltmeter, the frequency of the spark and form factor of the wave must be taken into consideration.

With the elimination of the high tension circuit interference the major source of trouble is overcome. However, electrical interference may still be present, caused by various elements of the low tension circuit. The primary of the ignition coil; the automobile fraternities' name for the induction coil, still causes trouble owing to the oscillatory nature of the break at the timing points. When the points are open this circuit contains the primary of the induction coil in series with a condenser of about .2 to .4 mf. The purpose of this condenser is to absorb the potential developed across the primary of the induction coil by the rapid collapse of the field in the coil when the points are opened thus preventing an arc which would fuse the contacts rendering them inoperative. This potential however is rapidly changing in value as the flux becomes less, and in a very short time the potential across the coil terminals falls below that impressed upon the condenser. The condenser then discharges through the coil, not only reducing the flux to zero, but actually causing a reversal of potential, hence a reversal of flux in the primary of the coil. This is of course an oscillatory condition which may go through several complete cycles. Its frequency, disregarding for the sake of clarity the secondary coil, is determined by the inductance of the coil primary, the capacity of the condenser, and the resistance of the circuit. The resistance is high, owing to the copper losses of both secondary and primary. Iron losses must also be considered. The frequency is rather low, seldom higher than 2500 cycles, but can readily couple to the audio system of the receiver. To a great extent this is overcome by providing a short path for these oscillations to flow through. A condenser of 1 to 2 mf. capacity is connected between the battery side of the coil and ground. This is termed a drainage condenser. It also prevents any radio frequency which may be developed at the breaker points from travelling back through the primary wiring of the car to the radio set. A small choke coil might be interposed in this lead but care must be taken to see that it does not affect the ignition operation at high speeds. It is not practical to do this on 8-cylinder or high-speed engines as resonant conditions may be obtained which might do considerable damage to the coil, points, and condenser.

Noise from the generator is seldom very noticeable. A condenser connected directly across the brushes will clear up any but the most perverse ripples. If this is insufficient the generator must need attention. Dirty commutation or open bars are definitely noticeable in the radio receiver, and the set serves as an excellent check on generator operation.

In conclusion the writer wishes to thank the Chrysler Motors Engineering Department and the engineering department of Dodge Bros., Inc., for the suggestions and assistance they have rendered in the development of automobile radio; the Allen Bradley Company, Inc., and the Erie Resistor Corporation for development of resistors suitable for use in ignition circuits; the Sterling Mfg. Co., Inc., and Mr. Geo. Eltz, Jr. for reproducer development; also members of the engineering and service departments of the Automobile Radio Corporation and the Willard Storage Battery Co., for data used in compiling this paper.

MUSEUM OF SCIENCE AND INDUSTRY

The Rosenwald Industrial Museum has requested the Radio Club of America to donate any radio apparatus which is of historical interest. The museum is now under construction in Jackson Park, Chicago. The building is to be a reproduction, in more permanent form, of the Fine Arts Building of the World's Columbian Exposition of 1893. In addition to having a large collection of historical models, the Museum will have a great number of working models and films illustrating the operation of the exhibits.

Mr. Waldemar Kaempffert, Director of the Museum, writes that much space will be given to communication, and naturally, radio will be strongly emphasized.

The apparatus used by the members in the early days of the Radio Club of America is now of considerable historical interest and might properly be placed in an industrial museum. Since the apparatus is the property of the members, full credit for the donation or loan will be given to the individual member.

Will those who still have some of this historical apparatus please communicate with our President, Mr. L. G. Pacent, so that a list of available apparatus may be sent to the Museum?

CLUB NOTES

The June meeting of the Club was held on June 3, 1930, at Atlantic City, N. J., in connection with the RMA Convention.

Mr. Julius G. Aceves, chief engineer of Amy, Aceves & King, Inc., presented a paper entitled "Design and Application of Adjustable Tone Compensating Circuits for the Improvement of Audio Amplifiers."

Following this paper, Mr. Allen B. DuMont, vice-president of the DeForest Radio Company, described a new type of vacuum tube employing a rotating control element.

New Members

(elected at meeting of the Board, April 29, 1930)

Ray D. Rettenmeyer,
George R. Campbell,
Charles B. Aiken,
Walter R. Kiefer,
Joseph H. Schmidt,
John Weare,
Tore Lundahl,
Edmund A. Veazie,
Dixon B. Penick,
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W. Edward Miles,
George L. Graveson,
Horace Roberts, Jr.,
Donald O. Peterson,
Lester F. Burlein,
Norman E. Wunderlich*

*Transferred to the grade of Fellow at this meeting.

SUGGESTIONS TO CONTRIBUTORS

Contributors to the Proceedings, by bearing in mind the points below, will avoid delay and needless expense to the Club.

1. Manuscripts should be submitted typewritten, double-spaced, to the Chairman of the Papers Committee.* In case of acceptance, the final draft of the article should be in the hands of the Chairman on or before the date of delivery of the paper before the Club.

2. Illustrations should invariably be in black ink on white paper or tracing cloth. Blueprints are unacceptable.

3. Corrected galley proofs should be returned within 12 hours to the office of publication. Additions or major corrections cannot be made in an article at this time.

4. A brief summary of the paper, embodying the major conclusions, is desirable.

5. The Club reserves the right of decision on the publication of any paper which may be read before the Club.

*For 1930 the Chairman of the Papers Committee is F. X. Rettenmeyer, 463 West Street, New York City.