The Radiobuilder No. 21

SM

October 15, 1930

This Is Superheterodyne Year!

It had been hoped and anticipated that this issue of the RADIOBUILDER, describing as it does the new 1931 line-up of S-M custom-built receivers, would have been mailed about the first of September, but the unfortunate delay necessary to perfect the designs in the short time available—the months of July, August and September—has held up this RADIOBUILDER until October. But delayed as it is, it contains data upon the new models which have gone into production recently, and it is hoped that this data will in some measure excuse the delay.

Every experimenter, service man and custom-builder today knows only too well the effects upon the radio industry of R.C.A.'s last minute release of super-heterodyne patents to licensees upon July 9th of this year. Consternation has reigned ever since in practically every factory in the country, for every licensee had its new line of t.r.f. receivers introduced at the June R.M.A. Trade Show practically in production, yet each one realized that as soon as one or two independent super-heterodynes were put on the market, t.r.f. sets would be practically unsaleable. At first glance, it would seem that every manufacturer would have pushed engineering work on supers to the limit, yet on the other hand, every licensee was pretty thoroughly "scared to death" of supers, and didn't want to be forced into building them if there was any way to avoid it, for the engineering and production of a super that would be satisfactory today is a long throw from t.r.f. engineering and production, and not a single licensee except Silver-Marshall had ever had a bit of practical super experience.

Amid all this gnashing of teeth and tearing of hair, apparently only one licensee remained calm and serene, for as stated, Silver-Marshall alone among all licensees, had had actual super-heterodyne engineering and manufacturing experience. The S-M business had been built up on custom-built super-heterodynes and super kits, and although S-M had retired from the super field a year ago, upon taking out an R.C.A. license, super-heterodyne development work had gone on unchecked in the S-M laboratories, for it was felt that before long S-M would again be able to make supers. Just how sound this policy was can be realized from the fact that, through it, S-M was enabled to announce the first licensed super-heterodyne, and will probably be, by a wide margin, the first to announce R.C.A. licensed custom-built supers for experimenters, service stations and service men.

It is a bit difficult to state definitely the tangible value of previous super-heterodyne experience off-hand, but the attitude of other manufacturers' engineers to S-M's representatives at the R.C.A. engineering meetings at which the super patents were released, spoke volumes for the value other manufacturers placed upon it, and the further fact that since July, only two other manufacturers have gotten even so far as to be able to announce a forthcoming super, while Silver-Marshall is in production and delivery, points in some measure to the tremendous value of this experience, neglecting entirely what it will mean in terms of efficient production and final trouble-free performance of receivers in the hands of users.

Front View of 724

It will be remembered that S-M built and sold supers all during the five years between 1924 and 1929, and that even before that, McMurdo Silver had done practically all of the design, development and production work upon the Haynes-Griffin super-heterodyne introduced in the fall of 1923—the first popular super-heterodyne in the whole world. McMurdo Silver's personal portable super-heterodyne, built during the early summer of 1923, and illustrated in RADIO BROADCAST for October of that year, was probably the first really portable super-heterodyne ever built, and likewise probably stands today as the smallest portable super ever made. It is with a background of super experience second to none, that S-M offers the three new R.C.A. licensed, custom-built super-heterodyne designs described herewith.

One of these new models is designed for short-wave reception, and is actually a converter which, when used with any standard broadcast receiver, turns it into a highly efficient short wave super-heterodyne. Another model is a super-heterodyne broadcast tuner, for use with any standard type of audio amplifier, and designed especially for use in or very near powerful broadcasting stations, for it offers the highest degree of adjacent channel and image frequency selectivity ever attained. The third is a broadcast super-heterodyne complete in a single unit, and showing sensitivity and selectivity never before attained in any commercially practical radio receiver. The type numbers are 738 for the Converter, 714 for the Tuner, and 724 for the complete set. All are fully A.C. operated, but the 714 may be battery operated, while a battery model of the 724 is available.

724 AC Superheterodyne Receiver

The 724 A.C. is a nine tube, all A.C., super-heterodyne, designed to provide a higher order of sensitivity than can be used in ninety-five out of every one hundred home locations, in order that need for additional sensitivity may never be felt, and to provide a degree of selectivity adequate to give positive 10 kc. selectivity except in the case of extra-powerful and nearby locals—tho so far, no condition has been found where any local at all, even in New York or Chicago, would cover more than 10 kc., or just its own channel, on the tuning dial. It has so often been said of radio sets in the past that "You've got to tune it to appreciate its selectivity," that some hesitation is felt in saying just that of the 724, but the uncontravertable fact stands out that the 724 is far, far more selectivity than *any* t.r.f. receiver ever built, and that it provides a degree of selectivity which no one, including S-M, has ever believed to be commercially possible before.

The 724 consists essentially of a one stage -24 tuned r.f. amplifier, followed by a -24 tuned first detector, to which is coupled a -27 oscillator, the -24 detector feeding into two 175 kc. intermediate frequency stages using -24 tubes, then into a -24 second or power detector, which, in turn, feeds two -45 tubes in a push-pull output stage. All power is supplied by a self-contained power unit using oversize power transformer, dry electrolytic (semi-self-healing) filter condensers and an -80 rectifier tube.

The top view of the formed steel chassis shows the layout of the parts quite clearly. At the right front is the 410 mmf. three-gang condenser which tunes the r.f. stage, first detector and oscillator, with its aligning trimmers easily accessible on top. These trimmers in themselves are quite an important feature—while not extremely critical in setting, it is quite important that, once set, they remain constant, and all ordinary spring trimmers have been found to be unsatisfactory. The trimmers used in the 724 employ extra heavy spring plates, together with special ratchet-type adjusting screws which positively insure permanence of settings, since they cannot turn, no matter how severe the jars and jolts are to which the chassis may be subjected. The gang condenser itself is three-point mounted, with one point so circled about by slots in the chassis that no ordinary cabinet warpage affecting the chassis can affect the condenser tracking.

Directly behind the gang condenser are, at the right, the -24 r.f. tube, the -24 first detector and the -27 oscillator tube, with their coils and

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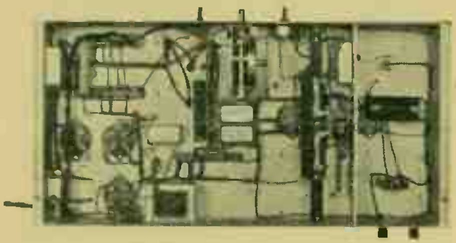
associated apparatus below the chassis. At the rear of the chassis is the 441 (or 442 in the D.C. model) 175 kc. i.f. amplifier and second detector. This amplifier consists of a formed steel chassis carrying the three i.f. transformers, the three shielded tube sockets, and the necessary associated isolating and biasing parts, as well as the phonograph pick-up jack. This entire amplifier is factory assembled, measured, and aligned to exactly 175 kc. for, if the gang condenser alignment is to be simple, it is essential that the i.f. stages be set at exactly 175 kc.



Bottom View of 724

The i.f. transformers consist of small universal wound coils spaced upon wood dowel pins, and each tuned by a compression type mica condenser of from 100 to 220 mmf. capacity. This dual tuned, or selector, feature results in the greatest possible selectivity, and a somewhat flat-topped resonance curve, making for excellent high frequency response despite extreme selectivity. The second and third transformers are identical, but the first is somewhat more sharply tuned by means of looser primary to secondary coupling—accomplished by the use of a small copper spacing ring between the primary and secondary coils. The gain per stage is about 80 times at 175 kc. Each transformer is aligned by two screw adjustments, accessible thru slots in the top of its aluminum can, and these must be tuned by an insul ed screw driver. This, however, is of little im tance, for these adjustments are made at the factory and should not be tampered with—unless an accurate 175 kc. test oscillator is available.

There being a total of six tuned circuits in the i.f. amplifier, as against two for the r.f. stage and first detector, it is apparent that the selectivity of the set is determined almost entirely by the i.f. amplifier, the purpose of the r.f. and detector circuits being to provide image frequency selectivity (see another article in this issue), rather than adjacent channel selectivity. The result is that the selectivity of the whole set is practically constant over the entire broadcast band, since it is determined by the i.f. selectivity, and that is constant. The overall gain is likewise constant, except for a slight drop at 550 kc., due to the sloping curve of the r.f. stage, which does affect the gain slightly.

The r.f. stage employs an antenna transformer having an oversize primary, to prevent resonating the antenna anywhere in the broadcast band, and thereby putting a hump in the gain curve. This also minimizes radiation. A more important point is the ganging problem, as the oversize primary allows almost any antenna length at all, from one to one hundred or more feet to be used without deganging. It is shielded from the detector and oscillator coils by a partition in the chassis. The transformer coupling the r.f. tube to the first detector is conventional in design, and gives with the first tube, a voltage gain of about 30. The coils are not individually shielded as the chassis itself is an effective shield.

The oscillator must, of course, track exactly 175 kc. from the broadcast signal, or r.f. and detector circuits at all times, and a special circuit is employed to effect this. It consists of a Meissner oscillator, having grid and plate coils coupled to a tuned tank circuit, which determines the frequency. This tank circuit is shunted by four condensers, one fixed, one gang section, and two trimmers. The reason for the Meissner circuit is to isolate the tube and associated capacities from the tuned circuit which determines the oscillator frequency, in order that it may be maintained constant, irrespective of tubes used and such variations as might develop over a period of time. The four condensers are so proportioned with the oscillator coil, that the oscillator operates exactly 175 kc. away from the other two tuned circuits. In practice, the trimmer on the gang section aligns the oscillator for high frequencies, and the trimmer across the fixed capacity aligns it for low frequencies, the unaligned oscillator falling out of step only at the two ends of the broadcast band.

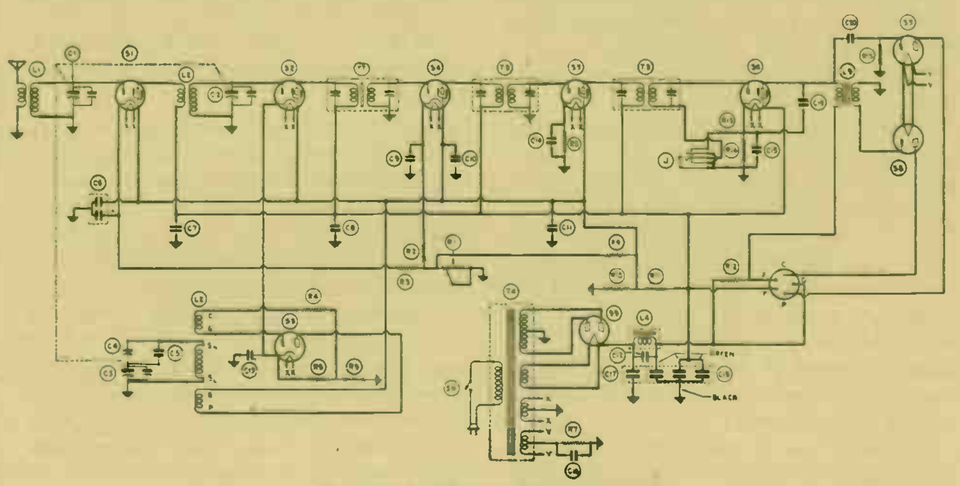
The oscillator is coupled to the first detector by having the two coils (oscillator and detector) placed in the same axis, and close to each other. The 400 ohm resistor in the oscillator grid return serves two purposes—to prevent spurious oscillations in the grid and plate coils, and as a suppressor to hold the oscillator output substantially constant throughout its range. It will be noted that the oscillator and first detector are biased thru common resistances, tho the oscillator bias is tapped off quite low. This is done to maintain a desirably constant bias on the first detector, for the oscillator plate current, being quite constant, and bled thru the detector bias resistor, tends to hold the detector bias more nearly constant than would be the case were the detector only self-biased. The oscillator employs 90 volts on its plate. All other tubes employ 90 volts on their screens and 180 plate, except the second detector which has 180 screen and 250 plate volts and the 245's which have 250 plate and 40 volts grid bias.

The second detector is self-biased, and has two bias resistors, selected by the phonograph jack. When the plug is out, the tube is biased as a power detector—when the pickup is plugged in, the tube is biased, and acts as, an audio amplifier, so that ample phonograph volume will be had. The second detector plate is by-passed by a 150 mfd. condenser, but no r.f. choke is used. The condenser is soldered directly to the tube socket lugs for, as stated in another article in this issue, it is extremely important to avoid any possible coupling of i.f. harmonics generated by the second detector to the input portion of the circuit. The usual r.f. choke has been found to defeat, rather than aid, this purpose, and so is omitted.

The second detector is choke-coupled to the push-pull a.f. stage, as it would be practically impossible to build a good transformer for such use, for the high plate impedance of the -24 tube would result in a poor frequency characteristic. The choke has two windings, the detector feeding thru one to one of the push-pull tubes, and the second winding feeding the second -45 tube. A .25 mfd. coupling condenser and 300,000 ohm resistor serve both to isolate the detector plate voltage from the -45 grids, and to equalize the frequency response over the audio range.

The question may arise as to why only one audio stage is used. The first reason is that the gain of the set is so high that a second audio stage would be of no advantage, and the second reason is economy. One audio stage requires less power supply filtration, but more r.f. gain, which, however, is easier to obtain in a super than is additional audio gain.

The power tube plates are brought out to a socket on the rear of the chassis, as are the leads



Schematic Wiring Diagram of 724

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from the speaker field, into which a five-prong speaker plug is inserted.

The power supply employs the large transformer at the left front of the chassis, one choke and the speaker field. The -80 rectifier feeds into a 1 mfd. paper input condenser, then into a tuned choke and then thru the speaker field. Three 4 mfd. dry electrolytic condensers follow the choke and field, and from this point the plate, screen and bias voltages are bled off thru resistors, except the second detector and 245 plate voltage, which is taken from between the choke and speaker field.

Volume is controlled by varying the bias of the r.f. and first i.f. tubes, this method controlling the volume smoothly and effectively. A minimum biasis maintained on both tubes by 375 ohm resistors, and a 3000 ohm rheostat controls the variable bias.

The sensitivity of the set ranges between .2 and 1.0 microvolts per meter in production, and averages about .5 microvolt. Even the lowest sensitivity is higher than that of the 1929-30 Silver Radio, which was acknowledged to be the "hotest" set on the market. In any event, it can be definitely stated that sensitivity in excess of 1.0 microvolts per meter, is higher than can be used in the best of locations. The proof of any pudding is in the eating, and the 724 in any typical location will ordinarily bring in a station for every dial degree.

The selectivity is really so great that unless the vernier dial is turned very slowly, most local stations, not to mention distant stations, can be passed over and never heard! There will seldom be a case in which it will be impossible to get distant stations on the channels on either side of powerful locals. In Chicago, for instance, to get WLW on 700 kc., thru WGN on 720 kc. and WMAQ on 670 kc. is considered good for a very good t.r.f. set, yet the S-M 724 will not only do this, but will get a station on the one channel between WGN and WLW, and two stations on the two channels between WLW and WMAQ. At 1500 kc. the selectivity is almost equally as good and an absolute revelation after the poor low wave selectivity of even the best t.r.f. sets, such, even, as the 710 Sargent-Rayment and the 712.

With such selectivity, the question of tone fidelity arises. While some side-band cutting exists, despite the flat-topped i.f. stages, the audio stage compensates very nicely for this, and when a speaker of good high frequency response, such as the S-M 851, is used, the tone, both for lows and highs, is all that could be desired, the overall frequency characteristic being flat to within a few decibels from 40 to 4000 cycles. Hum is so low as actually to be hard to hear even with the ear close to the speaker.

Despite the high gain, isolation is very simple, due to amplification occurring at three different frequencies, with the major gain at 175 kc. where feedback problems are very slight.

The 724 is 19½" long, 10½" deep and 8½" high. When mounted in a cabinet it must be cushioned from the speaker, as excessive vibration of any of the gang condenser plates would result in poor tone due to the tremendous selectivity. This is taken care of by two metal clamps, one for each end, and sponge rubber pads, the control shafts either going thru oversized holes in the cabinet panel, or the metal control panel, if used, being set about 1/16" to 3/32" behind the cabinet cut-out.

The 724DC is practically the same set as the 724AC except for the omission of the power supply and rectifier tube, to be replaced by batteries, and the substitution of -30, -31 and -32 tubes for -27, -45 and -24 tubes respectively. The selectivity is the same, and the sensitivity about 1.0 microvolt per meter.

714 Superheterodyne Tuner

The 714 Super-heterodyne Tuner has been designed especially for use in broadcasting stations, directly under powerful transmitters, or in locations where the most exacting degree of both image frequency and adjacent channel selectivity is required. It employs one -24 r.f. amplifier, preceded by a dual selector circuit and is coupled to a -24 first detector by a second dual selector, to which an oscillator similar to that of the 724 is coupled. The first detector feeds into a 175 kc. i.f. amplifier, essentially similar to the 441 amplifier of the 724, except that it employs a -27 second detector in order that the output impedance of the tuner may be such as to match the input of typical standard audio amplifiers now on the market. The tuner contains no power supply, it being contemplated that the required source of 90 and 180 volts d.c. for "B" and "C" and 2.5 volts a.c. at 10½ amperes will be available from the audio amplifier with which the tuner is used.

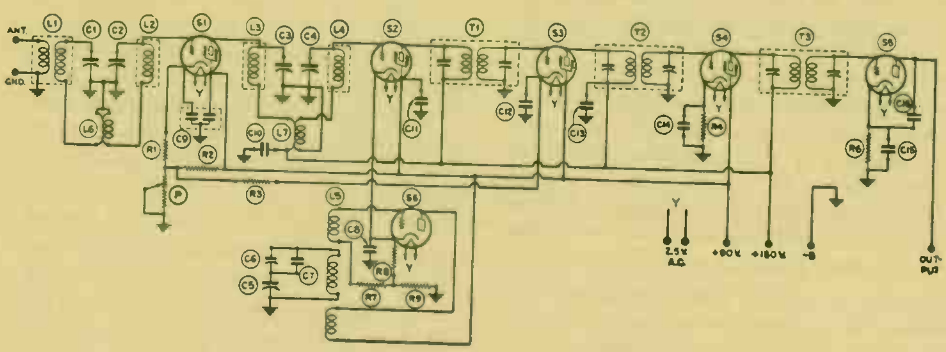
The general type of assembly is essentially similar to that of the previous 712 Tuner, the tuner being housed in a complete metal shielding cabinet which, in itself, may serve as the only cabinet for the tuner, or which may be enclosed in a regular wood cabinet, if desired.

A five-gang condenser is used, the first two sections tuning the antenna selector, the second two sections tuning the circuit between the r.f. and detector tubes, and the fifth section tuning the -27 oscillator. The selectivity of the r.f. amplifier

Front View of 714

and first detector, with their four tuned circuits, is, in itself, as good as, or better than, that of the best four-gang broadcast receivers. This selectivity, coupled to that of the intermediate frequency amplifier, absolutely assures positive 10 kc. selectivity, even when the receiver is located directly in the operating room of a powerful broadcasting station. Likewise, the image frequency selectivity is so high that, even under these same operating conditions, no interference would be experienced if an attempt were made to receive a weak distant station the image frequency, or 350 kc., away from the broadcast station. As the intermediate frequency amplifier and oscillator have been described in conjunction with the 724 receiver, there is little point in adding anything at this place, except to mention that the phonograph jack arrangement is omitted, since it will be simpler to arrange an external switch to cut either the tuner or the pickup directly into the audio amplifier itself.

It has been contemplated that the 714 Tuner would be used with a two-stage audio amplifier, such as the 677B or other standard types on the market. As a matter of fact, it may be used to precede such an amplifier as the 692; or other high quality three-stage amplifiers, such as public address amplifiers. With the 692 and with any other amplifier not furnishing the necessary ABC supply for the 714 Tuner, the 674S supply is needed.



Schematic Wiring Diagram of 714

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the selectivity problem for the intermediate amplifier is 20 times simpler than for a t.r.f. amplifier operating at 1000 kc., or 300 meters. Obviously, the lower the intermediate amplification frequency used, the greater will be the arithmetical selectivity advantage, or the percentage frequency separation of wanted and unwanted signals on adjacent channels. The factor, however, of image frequency interference which will be considered below, enters into the problem and limits the low level at which the intermediate frequency amplification may take place. For practical purposes, it has been determined that 175 kc. represents the optimum value of intermediate frequency. In this case, where a wanted and an unwanted signal on adjacent channels have both been heterodyned by the oscillator, the wanted signal will appear at 175 kc. and the unwanted signal will appear at 165 kc., still 10 kc. apart. In terms of percentage frequency separation, however, the difference is approximately 5.6%, so that in comparison with the original 300 meter or 1000 kc. signal and an unwanted signal having 1% frequency separation, it will be seen that an improvement of 5.6 times has been obtained from a selectivity standpoint by heterodyning the 1000 kc. signal to 175 kc., with respect to adjacent channel selectivity.

Image frequency interference, as it is termed today, is comparable to the old familiar repeat spot problem. Obviously, there are two oscillator frequencies which will serve to heretodyne an unwanted signal to the desired intermediate frequency, one being the intermediate frequency below the frequency of the wanted signal, and the other being the intermediate frequency above the wanted signal or, in the case of a 1000 kc. signal and a 175 kc. intermediate amplifier, 825 kc. and 1175 kc. Conversely, one oscillator setting will serve to heterodyne two signals to the intermediate frequency, these signals being separated by double the intermediate frequency, or 350 kc., in the case of a 175 kc. intermediate amplifier, assuming, of course, that both signals reach the first detector. This means that in a practical receiver, tuned to a 1000 kc. signal, with the oscillator set at 1175 kc. to properly heterodyne this signal, if a 1350 kc. signal also reaches the first detector, it will, likewise, be heterodyned to 175 kc., with the result that the two signals, originally of 1000 kc. and 1350 kc., will both reach the intermediate amplifier as 175 kc. signals. To obviate this type of interference, it is essential that the selectivity preceding the first detector be such as to definitely eliminate the unwanted signal double the intermediate frequency away from the wanted signal. In the past, only one method has been employed to effect this end—that of raising the intermediate frequency to a point where the second signal that a given oscillator setting would heterodyne would be so far away from the wanted signal to which the first detector was tuned that the selectivity of the first detector would be sufficient to suppress it; or, in the extreme case of the Infradyne where intermediate amplification was actually below the broadcast band, so that the image frequency would be entirely outside the broadcast band and, therefore, no two broadcast stations could come through to the intermediate amplifier for a given oscillator setting. The second, and preferable, method of accomplishing this end is really a combination of raising the intermediate frequency to the highest practical value below the broadcast band which is, in some measure, determined by another factor which will be considered below, and at the same time by placing a sufficient number of tuned circuits ahead of the first detector to definitely insure that the image frequency for a given oscillator setting will never be allowed to reach the first detector with sufficient magnitude to cause interference, even in the case of the most powerful local stations. This involves the use of a minimum of two tuned circuits preceding the first detector, and the simplest means of employing these circuits is in the form of a single stage tuned radio frequency amplifier to precede the tuned first detector circuit. The combined selectivity of these two circuits suppresses the image frequency for a 175 kc. intermediate frequency amplifier and does not allow it to reach the first detector in sufficient magnitude to cause serious image frequency interference. This use of the tuned r.f. amplifier preceding the first detector also is beneficial in the matter of crosstalk interference for, where the signal is fed directly from the antenna to the first detector thru the single tuned circuit, the possibility of crosstalk appears—that form of interference so familiar to all who have used t.r.f. receivers having an untuned input stage, and taking the form of the modulation of one or more powerful local stations riding in upon the carriers of other stations, reception of which may be attempted.

This third type of interference, termed intermediate frequency harmonic interference, is due to the feeding back of harmonics of the intermediate frequency generated in the second detector by virtue of its rectifying action, to the first detector or preceding r.f. amplifier. It has been found that the second and third harmonics of the intermediate frequency will generally appear with sufficient intensity to cause serious interference if these harmonics fall within the broadcast band. It is this factor which has determined the high limit below the broadcast band at which intermediate amplification may take place, and has largely determined the figure of 175 kc. The third harmonic of 175 kc. is 525 kc., which falls just far enough below the broadcast band to cause no trouble due to feed-back between second detector and first detector or r.f. amplifier. The fourth harmonic of 175 kc., of course, falls at 700 kc. but, ordinarily, this point is so weak as to cause no trouble in a well designed receiver even if some slight feedback does exist. At first glance, it may appear that it would be a simple enough matter to filter out harmonics of the intermediate frequency appearing in the second detector plate circuit to an extent which would prevent their feeding back to the input end of the receiver but, actually, it is an extremely difficult problem to accomplish with the high orders of amplification obtained in a good super-heterodyne and one which many designers have found practically insurmountable. As an example, it was found in the S-M laboratories that the r.f. by-pass condenser in the second detector plate circuit must be mounted directly upon the tube socket terminals—that is, between cathode and plate, for if even very short lengths of leads are employed to connect this condenser to the second detector socket terminals, sufficient circulating currents will be set up to cause serious feed-back with a high gain amplifier. It has likewise been found that the use of the customary r.f. choke in the second detector plate circuit is usually impractical, for the feed-back from this choke, even when reasonably well shielded, is sufficient to cause serious trouble. For this reason, only r.f. by-pass condensers are employed in the second detector plate circuit of S-M super-heterodynes.

In brief, the high limit of the intermediate amplification frequency is today determined by, not the amplifieation that may be obtained, for high orders of amplification can be obtained at any frequency from 1500 kc. on down, but by the fact that the third harmonic of the intermediate frequency must fall outside the broadcast band. The low limit of intermediate frequency amplification is determined by the problem of image frequency selectivity—that is, of keeping the second signal which a given oscillator setting will heterodyne to the intermediate frequency far enough away from the wanted signal, so that excessive selectivity is not required before the first detector to prevent the image frequency reaching the first detector in sufficient magnitude to cause interference. Still another factor determines that the intermediate frequency should be a multiple of 5 kc. rather than a multiple of 10 kc. which results, for example, in the selection of a 175 kc. intermediate frequency rather than 170 kc.—an apparently unimportant variation. This choice is due to the fact that broadcast stations are separated in the American broadcast band by 10 kc. If the intermediate frequency were set at a multiple of 10, as say, 170 kc., then two stations also separated by 170 kc. would, in themselves, serve to heterodyne each other to the intermediate frequency and cause interference, if allowed to reach the first detector. Although, at first glance, the selection of 175 kc. does not in itself, appear sufficient to prevent this type of interference, yet, in actual fact it is, for good intermediate frequency amplifiers can today be built with an order of selectivity easily sufficient to discriminate between two stations separated by only 10 kc.

If this brief resume is carefully read, digested and borne in mind in considering super-heterodyne designs which may appear on the market from time to time, it will be reasonably possible for the average service man to determine in advance what may be expected in the way of selectivity and interference from such designs.

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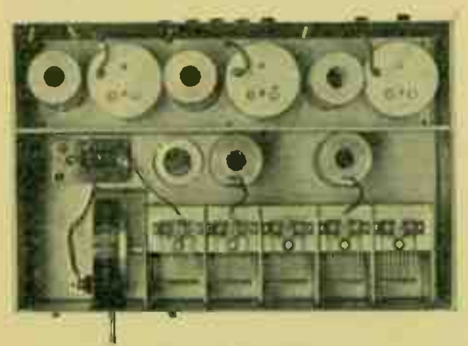
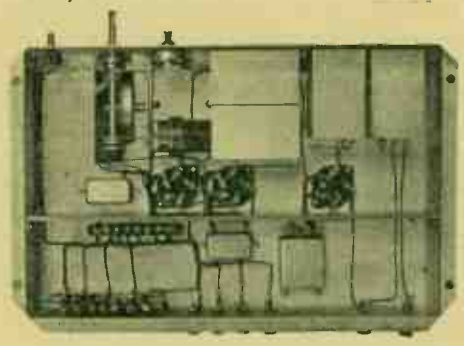
The sensitivity of the 714 Tuner in conjunction with the 677B amplifier is on the order of a fraction of a microvolt and will be found in every case to be more than can be used in the best location, which simply means that the user of the 714 Tuner will never find himself in a position where more sensitivity would be of benefit for, without question, the 714 in any known American location, will bring in any signal audible above the prevailing noise level. The volume control arrangement corresponds to that of the 724, being effected by varying the control grid bias of the r.f. and first i.f. tubes.



Top View of 714

At this point, it might be well to mention that in both the 714 and 724 diagrams, a number of circuit and by-pass condenser returns are shown to ground, whereas, as a matter of fact, they are all brought to one common ground upon the chassis, no r.f. currents being allowed to circulate in the chassis. This is extremely important, for with such sensitivity as is obtained by the 714 and 724, the minute coupling caused by circulating currents in the chassis would be sufficient to upset the stability of the circuits.



Bottom View of 714

The 714 Tuner is 16½" long, 10½" deep, and 8½" high and is provided with on-off switch for connection to the power supply or amplifier with which it is used, volume control, and tuning knobs, as well, of course, as dial escutcheon. It has an illuminated drum dial, calibrated directly in kilocycles, as has the 724 receiver.

738 Short Wave Superheterodyne Converter

While a complete short wave super-heterodyne might have been designed, it was believed to be preferable to construct only the apparatus necessary to convert any broadcast receiver into a short wave super-heterodyne, inasmuch as if a short wave super-heterodyne were built, it would preferably employ an i.f. amplifier having a frequency falling in or just below the broadcast band. Every user of a short wave super-heterodyne would unquestionably have a broadcast band receiver in his possession, so it seemed best to work the short wave super-heterodyne out as a converter rather than as a complete receiver, in order not to penalize the buyer by forcing him to buy i.f. and a.f. amplifiers and power supply when he would already have this material in any t.r.f. broadcast receiver.

Without doubt, the super-heterodyne system is the best known system for short wave reception, inasmuch as it is the only one which permits a high order of amplification to be obtained, due to the insurmountable difficulties encountered in building high gain short wave r.f. amplifiers. Altho it might seem unnecessarily complicated for short wave reception, this objection cannot carry much weight when it is realized what truly remarkable results can be obtained from a good short wave super-heterodyne, and it is felt that in the matter of simplicity, the use of the 738 Adapter with a typical broadcast receiver can hardly be considered anything but ridiculously simple.

The 738 Short Wave Converter consists of a first detector and oscillator, together with a self-contained power supply. Three tubes used are one -24 as first detector; one -27 as oscillator, and one -26 as rectifier, as the power required from the power supply is very little and the 226 is a cheap tube, amply large and sufficiently rugged to perform the required rectifying function.

When the 738 converter is placed beside any standard broadcast receiver, by simply connecting the antenna to the converter, one lead from the converter to the antenna post of the receiver and one lead to ground post of the receiver (already grounded), and the power plug is inserted in the socket, the full conversion of the broadcast receiver to a short wave super-heterodyne has been accomplished. To eliminate the converter, it is only necessary to shift the antenna lead back to the broadcast receiver again, leaving the ground connection between broadcast receiver and converter permanently made, if desired. In many cases, the antenna lead from converter to set need not be disconnected, altho it is desirable to do so. When this connection is made, the r.f. amplifier of the broadcast receiver, tuned to some clear channel in the neighborhood of 1000 kc., serves as i.f. amplifier for the super-heterodyne, the broadcast receiver detector functioning as second detector and the audio channel in the conventional manner. In this manner, the full amplification of the broadcast receiver is utilized at short waves—a far higher order of amplification than has ever been within reach of users of conventional short wave receivers or previous converters, while still further, tho slight, gain results from the frequency conversion in the converter.

The 738 Converter consists of a -24 first detector with plug-in coils which, due to its relatively non-critical tuning, is tuned by means of a 140 mmfd. vernier, or midget, type condenser, the control of which is brought out to a knob—tuning not being so critical as to require a dial. The tuning of the oscillator is extremely sharp, as is the case with all good super-heterodynes, and it is tuned by the 140 mmfd. condenser, which is controlled by a vernier dial. Obviously, the calibration of the oscillator dial is dependent entirely upon the intermediate frequency (broadcast dial setting),

Front View of 738

and if the intermediate frequency is varied, the oscillator dial reading will vary. It is assumed, however, that where the converter is used with a broadcast receiver, every time the converter is used the main tuning dial of the broadcast receiver will be set at the same point and, this being done, the oscillator dial of the converter may be logged definitely. For each frequency band to be covered, two coils are required, one for the oscillator and one for the first detector, and for the whole short wave band of 17 to 200 meters, a total of eight coils, or four sets, are required. As the coils are marked with distinguishing numbers, it would be difficult to insert them improperly in the sockets.

Two trimmer type condensers are used, one an antenna coupling condenser for the first detector and the other an oscillator coupling condenser—both of these require a screw driver for adjustment. They are located at the rear of the converter chassis, where it is contemplated that they will be permanently adjusted when the converter is first installed or used, one initial adjustment of

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------**No. 21. 737 Short-Wave Bearcat.**
------**No. 22. 770 Auto-Set.**
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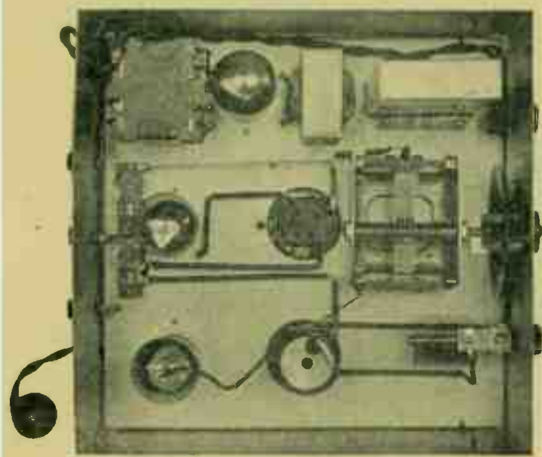
------**No. 24. 724AC Screen-Grid Superhet Receiver.**
------**No. 25. 714 Superhet Tuner.**
------**No. 26. 724DC Screen-Grid Superhet. Receiver.**
------**No. 27. 737DC Short-Wave Bearcat.**

World Radio History

each being sufficient. All apparatus for the converter is mounted upon a formed steel chassis which is housed in a black crystalline lacquered steel shielding cabinet, 11" wide, 11" deep and 7¼" high, and the whole may be placed either upon or beside any broadcast receiver, where it may be left permanently or may be removed and stored away when not in use.



Top View of 738

The power supply consists of a small power transformer furnishing filament current for all tubes, and high voltage A.C. for B supply, which is rectified by the -26 tube and filtered by a single choke and two 4 mfd. dry electrolytic condensers. Plate voltage for the -24 detector is taken off thru the 300,000 ohm coupling resistor. This resistor and a .0001 condenser serve to couple the first detector tube to the first r.f. tube (or, when the converter is used, to the "first i.f." tube) of the broadcast receiver. The plate current for the oscillator is bled thru the -10,000 ohm resistor and screen-grid voltage for the first detector thru the second 300,000 ohm resistor.

There is little more to be said about the 738 Converter, for it is extremly simple, tho the results obtained with it in conjunction with a good t.r.f. broadcast receiver will, indeed, be a revelation as to sensitivity, selectivity and tone quality.

Altho designed primarily for broadcast reception, the converter may also be used for CW telegraph signal reception, without the use of an external oscillator to heterodyne the signal to audibility. This is accomplished by tuning the broadcast receiver close to some station, the carrier of which then serves to heterodyne the CW telegraph signal to audibility.

When the converter is used with a broadcast band super-heterodyne receiver, some few squeals may be heard at different settings of the converter dial, due to the beating of harmonics of the broadcast receiver's oscillator and the short wave oscillator. In every case, however, these squeals, if they appear upon the wave length of some station which it is desired to receive, may easily be shifted beyond audibility by shifting the main tuning dial of the broadcast superheterodyne slightly, thereby changing the dial setting and, therefore, the oscillator setting both for the receiver and the converter.

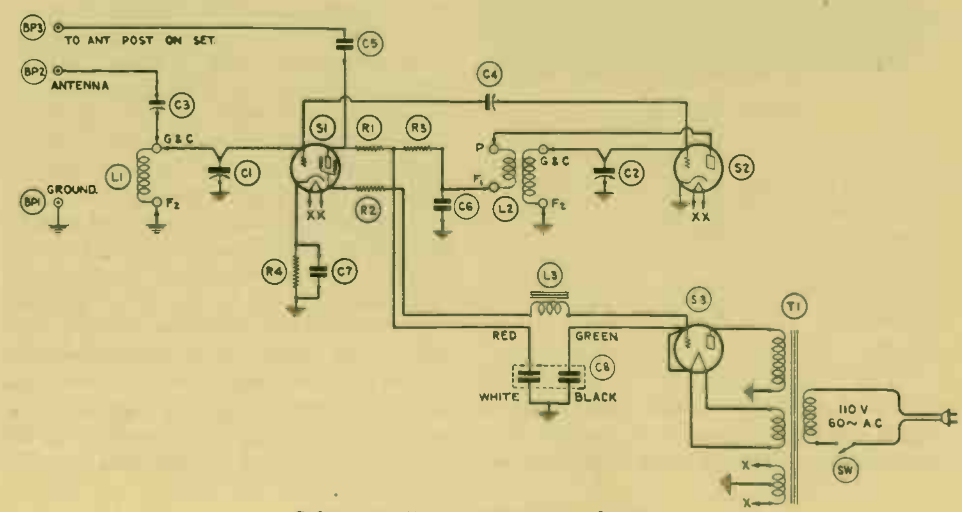
Superheterodyne Features

As the fall of 1930 almost certainly marks the turning point in broadcast radio receiver sales from tuned radio frequency circuits to the super-heterodyne system, it seems well to point out briefly some of the factors which must be considered in super-heterodyne design if receivers satisfactory for present day conditions are to result.

In a simple super-heterodyne, amplification takes place at a fixed frequency, the desired signals in the broadcast band being, in effect, tuned to the frequency of the fixed band amplifier in contradistinction to tuned radio frequency receivers, in which the amplifier is manually tuned to the desired signal. The essential and original reason for the use of a fixed frequency for all amplification was the extreme difficulty in the early days of radio of building short wave radio frequency amplifiers which would give high orders of amplification as compared with the relatively simple problem of building long wave radio frequency amplifiers giving a high order of gain. While the advent of screen-grid tubes has greatly simplified the problem of obtaining high amplification at broadcast frequencies, it has likewise simplified the problem of obtaining high amplification at what are termed intermediate or low radio frequencies, so that today the super-heterodyne possesses, not simply its original advantage of being the only means of obtaining high amplifications at broadcast frequencies, but of providing the simple stand most suitable means of obtaining such high amplifications.

Today, however, the real advantage of the super-heterodyne lies in the unusually high order of selectivity which may be obtained from a well designed super-heterodyne—an order of selectivity far in excess of what may be obtained from the best commercially practical design of t.r.f. receivers.

In a super-heterodyne where i.f. amplification takes place at some fixed frequency of, say, 175 kc., broadcast signals in the range of 550 to 1500 kc. are all converted to 175 kc. signals by means of an oscillator operating 175 kc. away from the broadcast signal and heterodyning the original broadcast signal frequency to the intermediate, or amplification, frequency of 175 kc. One great selectivity advantage lies in this very action and may be termed the arithmetical selectivity factor but, at the same time, two very serious problems arise in the form of image frequency or repeat spot interference and intermediate frequency harmonic interference, both of which may assume very serious proportions unless the super-heterodyne receiver has been designed with very great care exercised to suppress both of these sources of interference. A simple understanding of the arithmetical selectivity factor may be had by considering the problem of separating two stations on adjacent channels, that is, 10 kc. apart, at say, 300 meters or 1000 kc., which is the average for the broadcast band and, on the other hand, separating two stations in turn separated 10 kc. from each other at, say, 50 kc. In the first case, with one signal operating at 1000 kc. and another signal operating at 1010 kc., the percentage frequency separation is seen to be 1%; whereas, in the case of a 50 kc. intermediate amplifier both signals having been heterodyned by the oscillator, one to 50 kc., and the other to, say, 40 kc., they are still 10 kc. apart, but the percentage separation is seen to be 20% in the second case which, in simple terms, mean that



Schematic Wiring Diagram of 738

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The Radiobuilder

No. 20

SM

July 15, 1930

This Summer It's the Singing Automobile

Although the automobile receiver has only been out a short time, we already have first hand information regarding its performance in a large number of installations. It has been our pleasure to bring out a number of high performance receivers in the past few years, but we have never had one which brought in such uniformly enthusiastic reports within such a short time.

The SM-770 Auto-Set in its present form is the final result of over a year's highly specialized experimentation in the automobile field, and of course, three year's experience in the design of screen-grid tube receivers.

A study into the requirements which are peculiar to automobile receivers led to the decision that sensitivity was of prime importance. With the small antennae that are available in cars and their low "effective" height, a receiver of unusual sensitivity is required to give performance which is even comparable to that of the better console receivers. So the S-M Auto-Set was made to be the most sensitive production automobile receiver on the market. As an inspection of Fig. 1 will show, the sensitivity ranges from $2\frac{1}{2}$ to $14\frac{1}{2}$ microvolts per meter with an average of about 8 for the entire band. This is much higher than that of the average console receiver, and very much more sensitive than the average automobile receiver.

This sensitivity has been provided not with the idea of permitting Pekin, China, to be tuned in, but because there are many comparatively "dead" spots in and near the larger cities where satisfactory reception is impossible with the usual automobile receiver, and because in cross-country trips the motorist frequently finds himself two or possibly three hundred miles from the nearest broadcasting station.

The selectivity, with three highly efficient tuned circuits, is adequate to provide separation of the locals, even in the most congested areas, and will

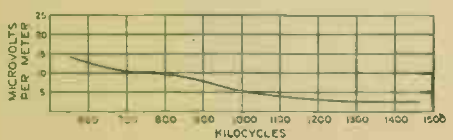


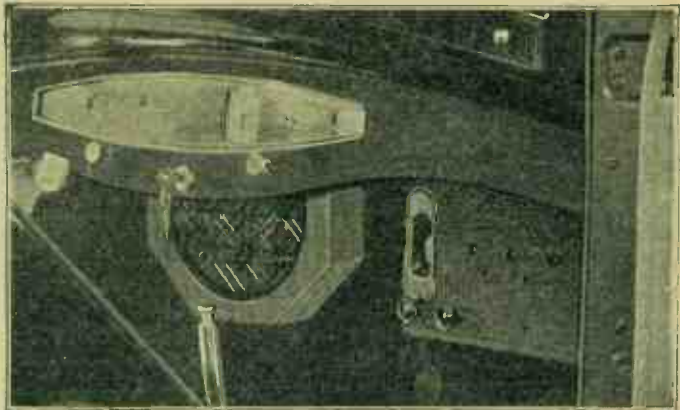
Figure 1

permit the reception of distant stations with reasonable frequency separation.

Next in the order of importance from the motorist's viewpoint is uninterrupted reception. We find that there is nothing quite as discouraging to a man who has just had a receiver put in his car, as having to run around to the service station every three days to have some loose connection repaired or the batteries replaced because of a short circuit.

The chassis is very small and rigid, and all parts and wiring are rigidly anchored to prevent trouble from mechanical vibration.

Those who have listened to what automobile receivers are on the market, have a pleasant surprise in store for them when they listen to the Auto-Set with the S-M 870 speaker. Since the



pedance of a magnetic speaker varies over wide limits with frequency, it is important to select the proper frequency at which to make a "match," and this has been attained through the use of a carefully designed output transformer. The result is a speaker which has normal and not excessive reproduction on the bass frequencies and very good highs; so that the fidelity is especially good on voice and there is an absence of the usual booming or barrel-like tone.

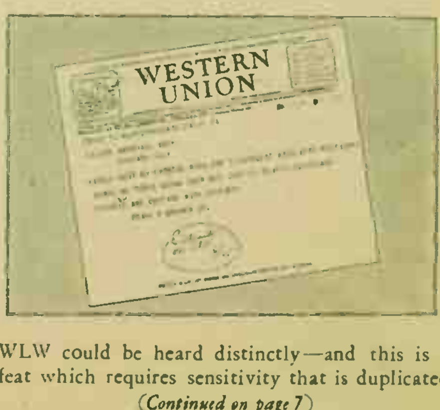
Those who have had receivers in their cars with *remote* controls are the most enthusiastic over the direct drive idea incorporated in the Auto-Set. It not only simplifies the installation problem, but provides a smooth positive drive with no backlash and no flexible cable or universal joints to bind and make tuning difficult. They also appreciate the Auto-Set, because it avoids the mutilation of the dash and makes it possible to remove the receiver and install it in a new car when the present one is replaced.

The direct drive also makes the receiver available for mounting back of the seat in a coupe, or back of the front seat in large sedans when this is desired. It goes without saying that it can be used as a regular battery-operated receiver in motorboats, aeroplanes, and at camp where the remote coupling unit would not be necessary or even advisable.

The receiver is of special interest to the installation and service man, or to the man who wishes to install his own set. Four holes drilled in the fire wall or bulk-head between the engine and front seat compartment hold the brackets which support the receiver. Four more at the side of the receiver hold the speaker, and four holes in the baseboard with tiebolts, provide support for the battery box. One or two pipe straps nailed in place to hold the cable, usually complete the mounting.

The "A" battery drain of only 2 2/10 amperes makes it unnecessary to increase the charging rate of the battery unless the receiver is operated 2 hours or more a day when the car is not in motion. The "B" battery drain of only 24 milliamperes gives a "B" battery life with intermittent discharge of approximately 200 hours. The question of "B" battery economy is a serious one, and the man who is installing a receiver should carefully determine the total battery cost of an installation and the number of hours it will operate without replacement. We have had cases called to our attention of other makes of receivers which had such a high "B" battery drain, that complete battery replacements were necessary about once a month when the receiver was used as extensively as it is in cross-country trips.

The telegram of which a facsimile is shown below is only one of many we have received. While the performance will of course vary with the antenna installation, and with location, on the screen used in SILVER RADIO (which is a foot wide and two feet long) mounted in the top of a car here at the plant, we have received WLW at Cincinnati at noon between WMAQ and WGN, who are only 20 kilocycles either side of WLW. There was some background from the locals, but



WLW could be heard distinctly—and this is a feat which requires sensitivity that is duplicated

(Continued on page 7)

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The 737 Bearcat Is Here--And How!

Interest in short-wave reception continues to grow tremendously. And no wonder—for three reasons: First, there is much more to be heard on a good short-wave receiver than there used to be. For example, WGY's short-wave transmitter at Schenectady has been rebroadcasting many an interesting program from the famous 2LO of London. In addition, the latest Citizen's Radio Call Book lists not less than 37 stations doing regular phone broadcasting on wave lengths between 17 to 200 meters, in the United States alone, and 25 such stations in other countries. Second, there is a fast-growing interest in television—for which the receiver here described is especially adapted.

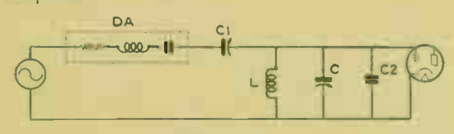

Figure 1

The third reason for recent growth of interest in short-wave reception is undoubtedly the appearance of the self-contained, all-electric, single-dial receiving set, of which the new Silver-Marshall 737 Bearcat is the first and finest representative. Convenience of operation with the performance which can only be obtained with two tuned circuits, are combined in it. Here, for the first time in a production short-wave receiver, the two main tuning condensers are operated with a single control and the advantages of all A.C. operation are maintained.

The single control feature is of principal advantage while "fishing" for distant stations, since it is difficult in the two-dial type to vary both tuning controls and keep them tuned to the same frequency over the entire band. In the two-dial type the tuning is further complicated by the necessity of keeping the regeneration control near the oscillating point—making a total of three controls which should be operated simultaneously.

With the Bearcat, the receiver is tuned to some station near the middle of the band to be covered, after which the antenna coupling condenser, which also acts as a trimming condenser for the radio-frequency stage, is adjusted for maximum signal strength and left in this position. If this adjustment is made with the vernier or "band spreader" in the detector stage near its middle position, a small band may be covered by tuning only the "spreader." For the critical tuning required for phone stations, the spreader is invaluable, and it and the regeneration control may be operated simultaneously.

The loading or padding effect of the antenna coupling condenser, which permits it to be used as a trimmer is best seen by glancing at Fig. 1 which shows the equivalent circuit for the antenna and radio frequency tube input circuits. The effective inductance, capacitance and resistance of the antenna are represented as a dummy antenna, DA, and the coupling condenser as C1, while L, C, and C2 represent the tuning inductance, capacitance and the tube input capacitance respectively. The inductance of the small antenna ordinarily used for short wave reception can be neglected, so the principal effect of C is to tune L and C1. This circuit is broad enough so the

Figure 3

misalignment between it and the detector circuit which occur in practice in tuning over the whole range of one, permit at least some signal to be received after which it can be resonated for maximum signal strength.

In short wave receivers it is extremely important to minimize the coupling between the radio frequency and detector stages. If all circuits are perfectly isolated so that the only coupling is through the radio frequency tube elements this coupling capacitance will be .01 mmfd. in the case of the 224 tube. This is much lower than even that of the 222 tube but because of the very high frequencies involved the coupling through it is about that obtained through the 201A or 226 tubes at broadcast frequencies. This coupling limits the stage gain that may be gotten in the radio-frequency stage to between about 4 and 40 over the range of from 20 to 200 meters.

The electrostatic shielding between the tuning circuits may be seen in Fig. 2, which shows a top view of the "Bearcat." This also shows the shield between the power section and the radio frequency circuits. To make this shielding effective unusually complete circuit isolation from the power supply unit has been resorted to as can be seen in the schematic wiring diagram, Fig. 3.

After careful experiments with both the 227 and 224 type detectors in this receiver the 227 type was adopted. Experiments with the 224 type detector in regenerative circuits were started over a year ago when the preliminary work on the 735 "Round the World Six" was done, and indicate that the tubes are not sufficiently uniform for a good regenerative detector. Because of their erratic performance they were discarded in favor of the 227 type detector, and the slight loss in output more than compensated for in the audio end.

In addition to the other causes of hum which are now generally recognized it was found that the magnetron effect was important in causing a "fringe" hum as the detector tube went into oscillation. This modulation of the electron stream by the magnetic field from the power transformer was more serious in the 224 than the 227 type tube and added weight to the decision to use the latter.

Careful isolation of the oscillator circuits which include even the precaution of a common ground and careful filtration of the power supply have resulted in a hum which is low enough to permit the phones to be operated in the speaker output terminals. This filtering problem was made more acute by the determination to filter enough current to supply a real power tube and not just an inter-stage voltage-amplifier tube.

The hum is not reduced by cutting off the lows in the audio end since resistance coupling and a

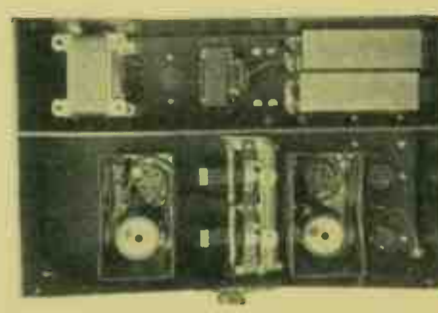

Figure 2

224 first audio tube are used. The 245 output tube insures adequate output for speaker operation where this is desired.

Summarizing, the design includes the features we feel to be important in a short wave receiver: namely high gain in the radio-frequency end, which can only be secured by complete circuit isolation; a stable, uniform regenerative detector with a minimum fringe and modulation hum; a high gain audio end with a characteristic which makes good fidelity possible and an output tube which will handle adequate undistorted output for a speaker. To all of these must be added simplicity of operation and the ability to secure the extremely close tuning that is necessary for phone stations and the ability to spread a small band such as one of the "ham" bands over 100 to 180 degrees of a tuning control.

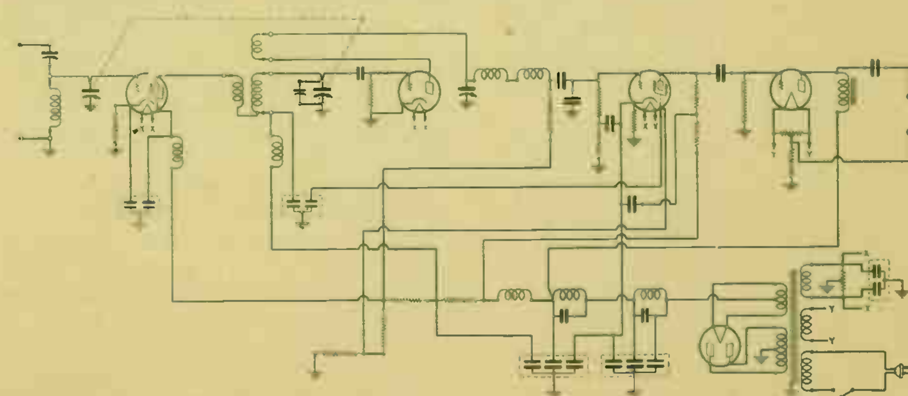

Figure 3

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assembly by a cable is the remote control box, carrying an auxiliary volume control, two "DX tuning" buttons, and a nine-position selector knob, which selects any one of nine predetermined stations as it is rotated. It is essentially a switch, closing the motor circuit thru the commutator and one of its nine contacts, which has been previously set to keep the motor circuit closed only until the dial has been turned to the proper point for the desired station. A small transformer, stepping the 110 volt a.c. line down to 21 volts for the remote control motor, is mounted on the speaker shelf of the cabinet. A knob on the left end of the cabinet serves to operate the switch, turning on the motor power and shifting from the set to the remote volume control. In its second position, it reverses these operations and also disengages a clutch, releasing the motor from the condenser shaft.

Curves Tell the Story

The performance story of the 1930 models is best told by the curves herewith, which depict the sensitivity, selectivity, audio quality and fidelity of the 34A and 35A chasses.

Fig. 1 shows the sensitivity of the Type 34A, seven-tube receiver, which ranges from about 20 to 90 microvolts absolute in order to produce an arbitrary standard 50 milliwatt test output. As sensitivity is always figured on the basis of microvolts per meter of effective antenna height, and as typical standard antenna height is assumed as four meters, the sensitivity of the 34A chassis is seen to be from about 5 to 22½ microvolts per meter, a value amply high, when a forty to sixty foot antenna is used, to assure reception of all stations sufficiently above the prevailing noise level to be intelligible. The relative flatness of this curve is quite interesting.

Fig. 2 shows the sensitivity of the Type 35A nine-tube receiver, which is seen to vary from about 28 to 170 microvolts, or from 7 to about 42 microvolts per meter—which, again, is adequate to bring in any signal intelligibly above the average noise level with a forty to sixty foot antenna (or even smaller under favorable conditions). The *slope* of this curve is unusually interesting, being directly opposite to that of the majority of receivers, in that sensitivity is ***highest*** where it is ***most needed***—on the high waves, where all the best stations and programs are found. This curve shape is attained through the aperiodic r.f. stage, which slopes even more steeply than the overall curve shown. This type of curve was very diligently sought after for the highest-priced model, since it is known that the noise level increases with frequency in the broadcast band, and as practically every radio owner has, at one time or another, complained of the excessive noise on the lower wave lengths. As a matter of fact, in direct comparative tests under typical residential conditions, side by side with a set of about 3 microvolts per meter sensitivity at 200 meters, actually more enjoyable programs (freeer from noise) could be had on the much less sensitive model 35A than on the very "hot" 3 microvolt set. From the user's standpoint, the decreased noise observed when tuning thru the low waves is indeed a blessing.

Fig. 3 depicts the selectivity of the Type 34A chassis at three typical broadcast frequencies. It will be noted that an interfering signal 1000 times as strong as a desirable signal would not be heard at equal strength unless closer than 70 kc. to the desired program at the least selective point of the set. It is very seldom, indeed, that even a powerful local is that much stronger than any weak distant station if the latter is sufficiently above the noise level to be intelligible. This is, in general, a higher order or selectivity than is found in any other American receiver having four tuned circuits, due to the selector circuits of the 34A and general careful engineering design.

Fig. 4, showing selectivity of the Type 35A, is really remarkable, showing as it does not probably the highest order of selectivity ever attained by any American commercial radio receiver. Even if an interfering signal is 1000 times as strong as a desired one, it would have to be less than 30 kc. away to be heard at equal volume. This curve depicts, in fact, a set which could safely be advertised as having "10 kilocycle selectivity," since the ratio of strength of interfering to desired signal for entertainment purposes is seldom greater than ten to one in practice. This curve indicates, for example, that the Type 35A is far more selective than was the famous Sargent-Rayment 710, which two years ago set a record then unequalled for selectivity, and which was accepted everywhere as exemplifying practical 10 kc. selectivity.

Figure 5

Fig. 5 shows the actual audio tone fidelity of the Type 34A chassis at both ends of the broadcast band. It is substantially flat to within 2 DB, (the minimum sound difference barely perceptible to the average ear) from 30 to about 3000 cycles, or flat to 4 DB up to 4000 cycles—a truly unusual fidelity, and one not equalled by any competitive receiver known to the S-M laboratories.

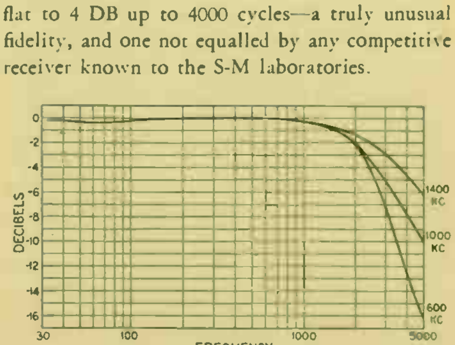

Figure 6

Fig. 6 shows the actual audio tone fidelity of the Type 35A. The higher frequencies will be seen to be cut a bit more than in the 34A, due to the greater selectivity. The curve is still flat, for the average of the broadcast wave band, to within 5 DB, a figure generally considered close to perfect in engineering circles, up to about 3400 cycles—amply high to give faithful and realistic reproduction of the human voice and all musical instruments. The low frequency fidelity is very unusual, it being customary practice in commercial receiver design to cut off at from 100 to 150 cycles to suppress hum without costly, carefully-engineered filtration.

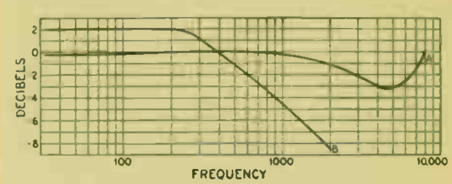

Figure 7

The Singing Automobile

(*Continued from page 1*)

only with production receivers which are as sensitive as SILVER RADIO.

The spontaneous enthusiasm on the part of those who have installed the 770 Auto Set means a new source of immediate income to those who are equipped to install Auto Sets. Those who are entitled to trade discounts, with the very nominal investment required for one receiver, can solicit this very lucrative business now during the summer months when other lines are relatively inactive.

Moreover, radio service men who have ever attempted the interesting and sometimes lucrative job of clearing up interference from "man-made static" in a neighborhood will appreciate the importance of having better and more convenient equipment for this job. Until the advent of the auto-set, it was necessary to carry about, usually in a car, an ordinary battery set, not designed to take the wear and vibration of such treatment. The Silver-Marshall auto-set, on account of its extreme sensitiveness accompanied with ruggedness when installed in a car, forms an ideal means of exploring interference conditions anywhere, and opens up limitless possibilities of increasing sales of radio receivers in many so-called "bad spots" which are merely awaiting a serious effort to clear up their interference.

The receiver's performance speaks eloquently for itself. Have you heard and operated one?

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....No. 21. 737 Short-Wave Bearcat
....No. 22. 770 Auto-Set

World Radio History

Fig. 7, the fidelity curve of the detector and audio amplifier, is shown principally to illustrate the effect of the overtone control. Curve A is with it in the high position, and is seen to be flat to within 4 DB over the range of 30 to 8000 cycles. Curve B is with the overtone control at the extreme low position, and shows the gradual suppression of the high tones. This is rather an extreme condition, justified only by conditions of excessive static or other noise inteference. In general, personal taste would seem to dictate a setting which would begin to cut at about 1500 to 2000 cycles—in effect, to shift the bend of curve B over to 1500 or 2000 cycles, and increasingly suppress all higher frequencies. This is done in practice by the simple turn of the overtone control knob on the cabinet front.

Four cabinets of four different styles and prices are available to house the two different receivers, at prices, including sets complete, but less tubes, of $135.00, $160.00, $185.00, and $225.00 list, known respectively as the Princess, Queen Anne Seven, Queen Anne Nine, and Elizabethan.

The Princess is an open-faced lowboy model, of Victorian design, with a four-way matched butt walnut top, walnut center panel and African mahogany side panels, finished in a brown walnut to a high gloss, piano finish.

The Queen Anne models are identical in appearance but different in size, the Nine being 13 per cent larger than the Seven to accommodate the Model 35A, nine tube chassis. Both have French folding doors, matched butt walnut tops, walnut sides and legs and butt walnut door and side panels and center panel. Both are piano finished to a high gloss and were outstanding models at the R.M.A. Trade Show, introducing as they did a new note in radio cabinet design.

The Elizabethan is a highboy model, of walnut throughout with the now popular linen fold decorations, and finished in a dull antique dark walnut.

All models are conservative in design, to fit any type or style of interior decoration, yet rich in finish, and of extremely solid construction, being made of unusually heavy lumber instead of the usual thin woods, which result not only in solidity and life-long durability, but unusually good baffling, insuring extremely pleasing acoustic effects.

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This issue of the RADIOBUILDER, running to 8 pages, is the largest issue ever printed, and exemplifies the larger scale on which Silver-Marshall hopes to present during the coming season the technical facts from our laboratories.

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New Silver-Marshall Complete Receivers Exemplify a Year's Technical Progress

By McMURDO SILVER

When SILVER RADIO was introduced in May, 1929, the reputation built up by S-M parts and kits for the top notch of quality and performance was so great that nothing less than the impossible was expected by the many thousands of S-M fans from Silver-Marshall's first completely factory-built broadcast receiver. With the 1929 season passed, it is possible to say that SILVER RADIO was in no way a disappointment, for it proved to be, by a wide margin, the most sensitive receiver ever put on the American market, with selectivity adequate for its tremendous sensitivity, and tone quality that left nothing to be desired to those familiar with previous S-M audio developments, such as the 220 transformer and the later 225, 226, 255 and 256 Clough-system transformers. It is safe to say that the really superlative performance of the 1929 SILVER RADIOS built an even higher degree of expectation among those anticipating the 1930 Silver-Marshall Radio developments, and in presenting these new sets, it is felt, to say the least, that they will prove no disappointment to such expectations.

"Catching Up With Silver"

Before describing these new sets, it is not out of place to call attention to at least four new features introduced by the 1929 Silver Radio which it was predicted would become practically standard for the entire radio industry by 1930, so great was their merit, and to note that this prediction has actually been realized. These four features, all introducted to the public originally by the Silver-Marshall laboratories, were screen-grid r.f. amplification, screen-grid power detection, tone control, and selector tuning. 1930 finds probably 99 per cent of all other radio manufacturers converted to the essential merit and worth of screen-grid r.f. amplification, and practically half to screen-grid power detection, while a large but still indeterminate number have been forcefully convinced of the merits of overtone control—two large manufacturers going so far as to base their entire selling campaign for 1930, so far as apparent at this time, on the tone control feature that S-M pioneered in 1929. Selector tuning, or the use of two critically coupled tuned circuits in place of one to obtain a steep-sided resonance curve, is also widespread this year—a feature that was practically exclusive with Silver Radio in 1929.

Can a Radio be Too Sensitive?

One of the most talked-of features of the 1929 Silver Radio, made possible by its extreme sensitivity of 1 to 3.5 microvolts per meter or better, was its ability to operate without any type of external antenna at all,—requiring only the use of a small wire screen contained in the set cabinet as a signal collector. This was a very valuable feature, but it was found that many users felt that if the set would reach out several thousand miles with such a tiny antenna, then it would certainly reach out even farther if a nice big 100 to 200 foot antenna was substituted for the diminutive screen. The net result of this wide and general practice of using a large antenna was that when the very sensitive receiver was coupled to a large antenna, it did reach out farther, but the noise level also came up to a point which rendered the extreme sensitivity almost useless, so that the average distance range remained about constant for large or small antenna. But to the uninitiated, the increased noise level found between programs, as the receiver was tuned from station to station when at full gain appeared as a drawback, few recognizing that the high sensitivity that brought with it the high noise level also accounted for the reception of more programs than could be had on a less sensitive, and consequently more quiet, set. The final conclusion, however, was that the original 1929 sets had appreciably more sensitivity than could beneficially be used by the majority of listeners, and as a result the 1930 models were designed with a sufficiently lower sensitivity to provide exactly the same performance using a forty foot antenna as did the first 1929 model when using the self-contained, or a ten foot external, antenna,—and to do so with an appreciably lower noise level.

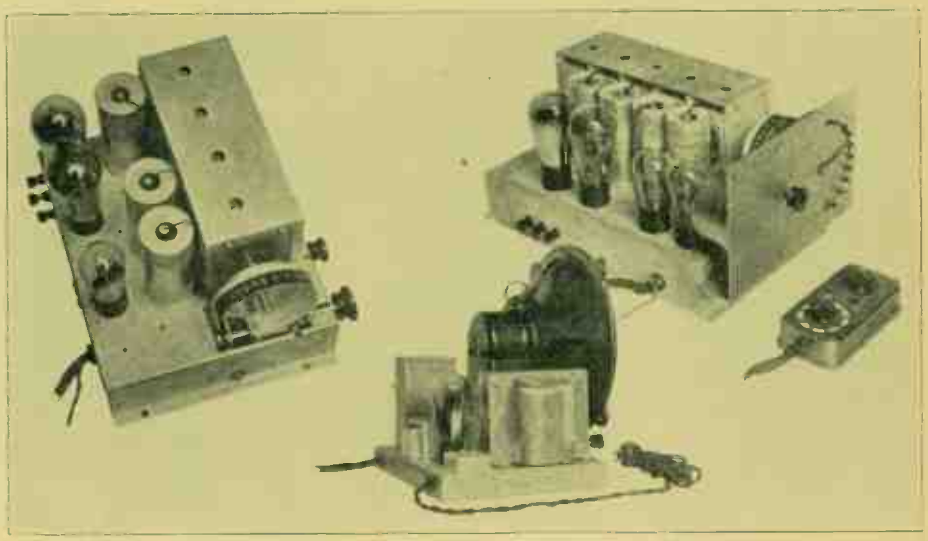
Features of the New Silvers

For 1930-31, two chassis models have been developed, in four different cabinet models. The essential performance difference lies in selectivity, and a minor difference in sensitivity. The more selective set has, also, automatic volume, or "fading," control. Both use an identical power and speaker unit, only the receiver chasses being different.

Type 34A chassis is a seven tube set (including rectifier), employing two screen-grid tuned r.f. stages, four tuned circuits, screen-grid power detector, resistance-coupled 227 first audio stage, and push-pull 245 power stage with Clough-system tuned audio transformer.

Type 35A chassis is a nine tube set (including rectifier), employing two tuned screen-grid r.f. stages, an aperiodic screen-grid r.f. stage, five tuned circuits, screen-grid power detector, and exactly the same audio system as the 34A. It incorporates a 227 automatic volume control tube.

Type 33A is the combined power and speaker unit used with either the 34A or 35A receivers.



Chassis Models: 34A and 35A — with 33A Power Unit

It contains an oversize power transformer, 280 rectifier tube, triple-section filter with self-healing electrolytic condensers, and a special nine inch electro-dynamic speaker unit giving excellent bass and treble response without cutting off either end of the needed frequency range to favor the other, as do so many dynamics.

Since the electrical design of both the 34A and 35A chasses is essentially similar except for the extra tuned circuit, aperiodic r.f. stage, and automatic volume control found only in Model 35A, it is convenient to consider them together. Both receivers employ a dual selector antenna input circuit, consisting of an r.f. antenna transformer having two taps on its primary so proportioned that antennas of up to 100 mmf. may be connected to it on the "short antenna" tap and up to 500 mmf. on the "long antenna" tap, without any derangement of the ganging of the tuning condensers. More simply, this means that

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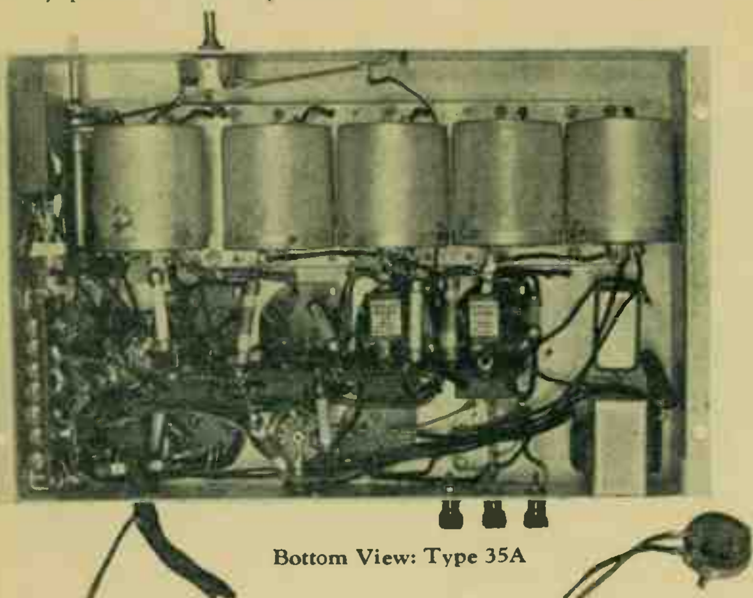
average antennas of from 20 to 200 feet in length will have no deganging effect on the circuit. The two primary taps are brought out to the antenna binding posts on the rear of the receiver chassis. This first tuned circuit is coupled to a second coil, identical with the antenna transformer secondary, by a condenser of value *greater* than that necessary to obtain a double-humped resonance curve (or band selector), in order to provide the greatest possible selectivity and the steepest possible sides to the resonance curve. As a matter of fact, it can be seen from the over-all fidelity curves that this has no serious effect on high audio frequency response, while it has a very beneficial effect on r.f. selectivity. The second tuned circuit feeds the grid circuit of the first '24 r.f. tube, which is biased 2½ volts negative. This high bias, plus the two tuned circuits preceding this first tube, effectively and completely eliminates any possibility of crosstalk or cross modulation, even tho the set be operated very close to an extremely powerful broadcasting station.

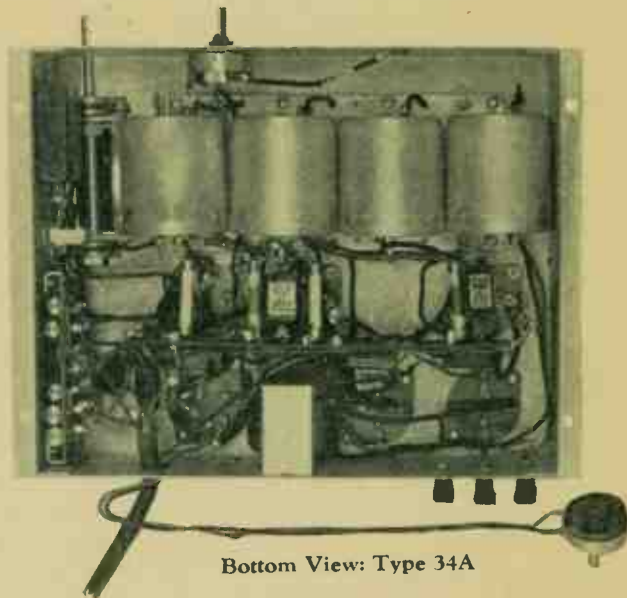
effects are obtained from this aperiodic stage: the first an appreciable increase in over-all r.f. gain, and the second an r.f. gain characteristic sloping in a direction opposite to that of the other r.f. stages, to an extent tending to perceptibly *equalize* static or noise at all frequencies—a contrast to the majority of receivers, which show r.f. gain curves sloping down very noticeably from short to long waves, when, as a matter of fact, discrimination is desirable of an exactly opposite order. This aperiodic tube (or, in the case of the seven-tube Type 34A chassis, the second r.f. tube) is coupled to the detector by a tuned r.f. transformer essentially similar to the unit coupling the first and second r.f. tubes in the 34A seven tube chassis. The r.f. amplifier of both receivers is inherently stable, due to individual shielding of r.f. coils and condenser sections, and the judicious use of isolation in the form of r.f. bypass condensers and chokes. The r.f. tubes are, of course, shielded, as is the detector, by individual covers.

A Far Simpler Automatic Volume Control

In the past, automatic volume control has almost universally been effected by rectifying a portion of the signal appearing in the power detector circuit and using this rectified d.c. to shift the r.f. amplifier grid bias, thereby cutting down input to the detector until a state of equalization was reached. One of the disadvantages of this method is that quite high detector outputs are required, tending to operate the detector in a range often permitting overloading. A further disadvantage is that the time-constant of the automatic-volume-control circuit may be such that it will fall in the audio frequency range, and may cause the control to operate at audio frequencies, thus flattening off the sound peaks and badly distorting the output. Such systems are usually found in sets having but one audio stage, when the detector signal voltage is adequate to operate the control tube.



Bottom View: Type 35A



Bottom View: Type 34A

The first r.f. tube is coupled to the second '24 tube, in the 34A chassis, by a single tuned transformer having a very high r.f. gain—ranging from 40 to 70 with the first tube. In the 35A chassis the first and second tubes are coupled by a dual selector circuit essentially similar to the antenna input selector, except that its first transformer is bifilar, giving a 1:1 coupling ratio and practically unity coupling. In this, as in the antenna selector, capacity coupling is used between the two coils of the selector, with the net result that *high-frequency selectivity* is almost equal to low-frequency selectivity—a sharp and pleasing contrast to other broadcast receivers with which it is seldom possible to adequately separate low-wave stations.

Gain Well Equalized

In the nine tube Type 35A chassis, the third tube is an aperiodic r.f. amplifier, coupled to the preceding r.f. tube by a small aperiodic bifilar-wound r.f. transformer of 1:1 ratio. Two valuable

A special advantage of the capacity-coupled selector circuits is that no section of the gang condenser need be disconnected while the other section in a given selector is being aligned, as is necessary with all selector circuits so coupled as to produce a double-humped, or "band selector" response curve.

The dial of the gang condenser is calibrated directly in kilocycles, for simplicity of tuning, and covers the range of 550 to 1500 k.c. Volume control is effected in the r.f. amplifier by varying the negative bias on the r.f. tubes—a smooth and simple method having no reaction on tone quality, as screen-grid voltage variation sometimes has. The screen-grid power detector is essentially the same as found in the 1929 Silver Radio, no better detector having yet been found. It is automatically biased in a manner which causes the detector to act as a limiting device for signal values appreciably greater than necessary to load the audio amplifier to its full capacity of 4.5 watts undistorted power output.

Due to the high sensitivity of the '24 detector in the Type 35A chassis, and the fact that the detector is normally operated at an output so low as to prevent overloading, such a system was not applicable, even had it been desirable. An entirely new type of automatic control was developed, employing a d.c. amplifier tube to operate from the varying d.c. bias of the automatically biased detector, the output of this tube shifting the bias on the r.f. tube grids in a manner tending to produce constant r.f. input to the detector over wide ranges of signal field strength. The initial bias on the r.f. tubes is set at 2.5 volts, and an extra resistor is included in the common r.f. grid return. Since no direct current (d.c.) normally flows thru this resistor, it has no effect on the bias potential. It is, however, included in the plate circuit of the volume-control tube, and when the detector grid bias is shifted less negative by a strong signal, plate current of the volume control tube flows thru this resistor, setting up a voltage drop which is applied to the r.f. grids

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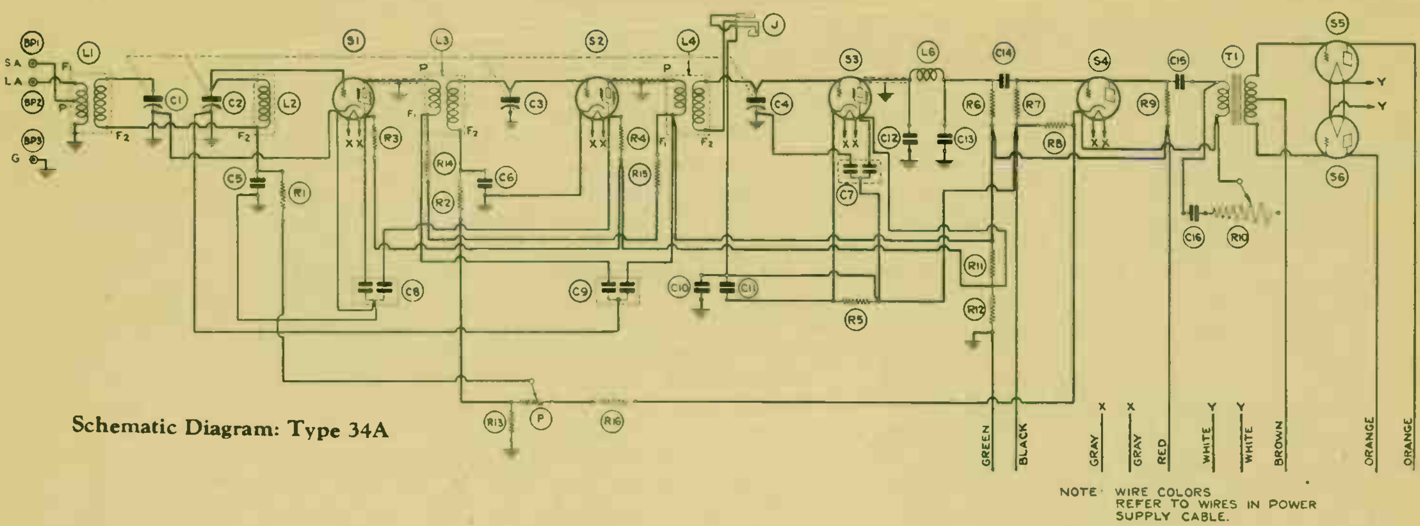


Schematic Diagram: Type 34A

in addition to the initial 2.5 volts, thus cutting down the r.f. gain. In operation, once the desired volume level has been set by the volume control, any signal strong enough to operate the volume control tube, and all stronger signals, are held to substantially the same volume, and slightly weaker signals are lifted up to this level.

The normal volume control is a resistor tending to make the bias on the control tube more or less positive, exactly as would a strong signal. As the grid goes positive, the plate current increases the drop across the plate resistor, which is applied to the r.f. tube grids. The volume control knob can be operated either to set a desired volume level for all stations, or to vary volume in the ordinary manner. This is in distinct contrast to previous types of automatic volume controls, where there was an r.f. sensitivity control, plus a straight volume control, necessarily in the a.f. amplifier, this combination easily permitting detector overloading with consequent signal distortion. Such systems have also required the use of a visual tuning meter with consequent further complication of the tuning operation. This is not necessary on the S-M system, tuning being done by ear, in the usual manner.

The '24 detector is coupled to the '27 first audio tube by two 300,000 ohm. resistors and a 0.1 mfd. condenser, giving a flat frequency characteristic over the audio range.

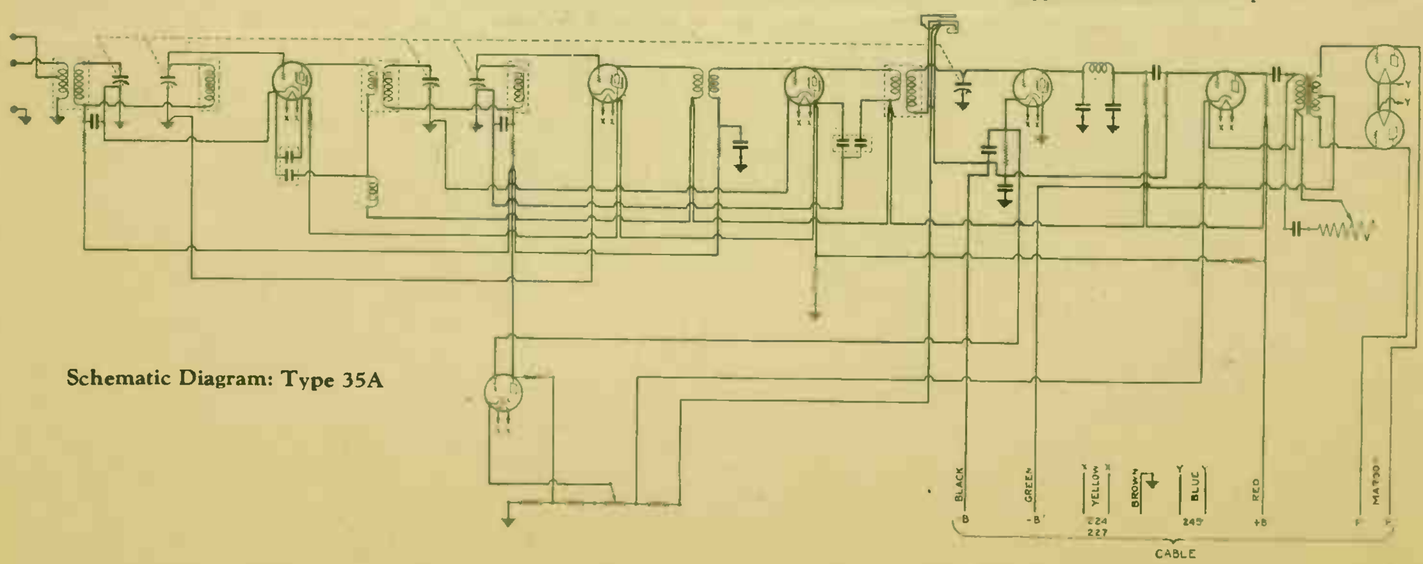
No Hysteretic Distortion

The '27 first audio tube is coupled to the '45 push-pull output tube by a Clough-system tuned transformer of approximately 1:1 ratio. The primary circuit of this transformer is resonated to provide an overall a.f. curve flat to 30 cycles, and thus insure absolutely faithful reproduction. As no d.c. plate current is allowed to flow thru the Clough a.f. transformer primary (all d.c. being confined to the plate resistor), all possibility of hysteretic distortion is eliminated; that is, distortion due to unsymmetrical magnetization of the transformer core steel. This is a valuable feature, definitely contributing to purity of reproduction, as all who have used the Clough audio system can testify.

For phonograph record reproduction, a jack is placed on the left end of either type of set chassis, which allows a magnetic record pickup to be connected into the detector grid circuit. So plugged in, the a.f. pickup output is amplified by the '24 detector tube (which under such conditions acts as an a.f. amplifier) before it reaches the regular a.f. channel of the receiver thus insuring ample volume together with unusually clear and beautiful tone quality.

True Overtone Control

Theoretically, if a radio receiver reproduces all audio frequencies from below 100 cycles to 4000 without appreciable discrimination, it would be practically perfect, and would leave nothing in the way of tone to be desired. Actually, such is not the case, and such a receiver would not satisfy all tastes nor all conditions of home acoustics. In the matter of taste only, it has been found that the majority of listeners have a distinct aversion to really faithful treble reproduction, and definitely prefer accentuated bass, or slightly suppressed treble. Two factors account for this—high notes are *felt*, rather than heard, so that a loud high tone really causes irritation, or even pain, and the fact that static and interfering noises are most prevalent on the higher audio frequencies. It was found, in connection with the 1929 Silver Radio, that fully 90 per cent of all listeners usually preferred to listen with the overtone switch in the "low" position where notes above 2000 cycles were appreciably subdued. Despite all theoretical



Schematic Diagram: Type 35A

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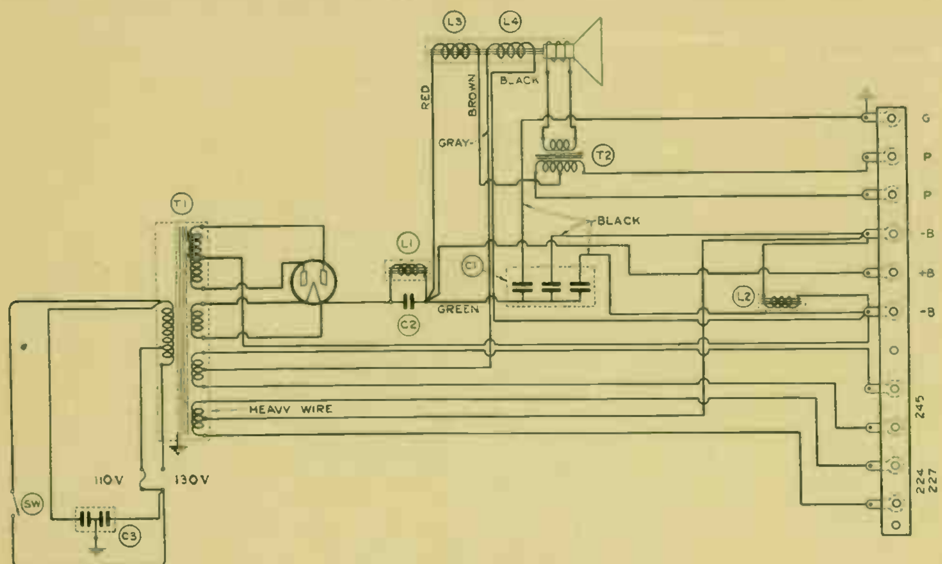
contentions to the contrary, the facts definitely establish the desirability of manual tone control—or, more accurately, *overtone control*—on radio receivers which are initially capable of reproducing a full a.f. range, something, incidentally, which most sets not possessing such a control do not do. The overtone control of the 1929 Silver has, therefore, been retained in 1930, and improved so that instead of there being only two tone choices at the listener's disposal, a continuously variable range from very deep to very brilliant tone may be had at the turn of a knob.

Electrically, the overtone control takes the form of an a.f. filter consisting of a 10,000 ohm rheostat and a 0.1 mfd. condenser in series shunted across the primary circuit of the a.f. transformer. As the rheostat is cut out, the higher tones are increasingly suppressed—yet the listener who really desires tone reproduction that faithful which



Schematic Diagram: Type 33A Power-and-Speaker Unit

LINE 50 TO 60 ~ A C

can be had only through full coverage of the a.f. range from below 100 cycles to 4000—the full useful musical and voice range—has only to turn the knob so as to cut in the whole rheostat.

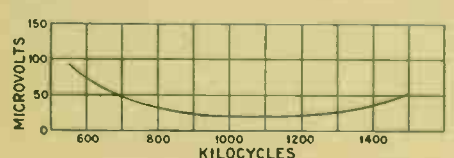


Figure 1

Speaker Fidelity, Too

The loud-speaker unit is of a new and improved design giving an electrical to acoustic conversion curve flat to within a couple of decibels over the range of 50 to *above* 4000 cycles. It has a cone of about 9 inches diameter, freely supported, and capable of the great movement necessary to produce quite considerable volume on low tones. Its field is excited with about 6 watts of d.c. in a unique manner. The field is split into two 800 ohm sections, one included in the '45 grid return, where the voltage drop across it provides C bias to the '45 push-pull tubes, and the second section is included in the '45 plate return. This second field provides some filtration, but more especially, its retarding effect allows the push-pull stage to develop a greater power output without annoying distortion than is possible to similar push-pull stages not employing such a choke.

The speaker and power supply are built as one unit, separate from the receiver chassis, for several reasons. First is the fact that if the weight of the power supply is included on the receiver chassis, there is a real possibility of receiver-cabinet-shelf warpage, or strains in shipment, tending to strain, or even warp, the chassis to an extent unfavorably affecting the gang condenser. The second advantage of separate units is the greater separation possible between power transformer and audio equipment, with consequent greater ease of filtration and lower a.c. hum. A third and less important feature is the greater ease of servicing of a two unit assembly.

The power supply and speaker unit are combined also for simplicity, as no disadvantages result therefrom—rather the advantage of short concentrated wiring. The power supply consists of a large, oversize, conservatively rated transformer supplying all necessary a.c. operating voltages. The transformer is followed by an '80 rectifier, operating into an open-ended filter; that is, a choke input filter. This absence of a filter input condenser reduces strain on the rectifier tube and power transformer, and is very desirable, tho requiring a higher a.c. input voltage for a given

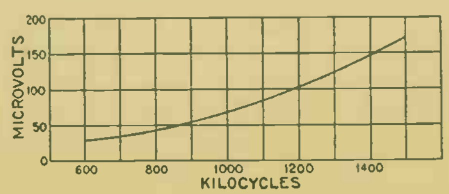


Figure 2

d.c. output than does a condenser input filter. Following this choke is a 4mfd. dry electrolytic condenser, and at this point is taken off the voltage for the push-pull tube plates. There follows a second choke of very high inductance, followed

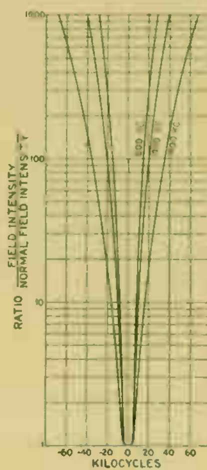


Figure 3

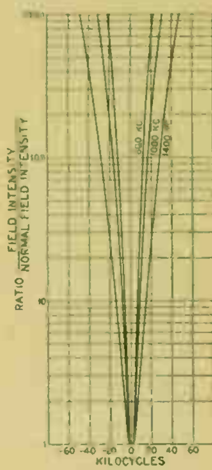


Figure 4

in turn by a second 4 mfd. dry electrolytic condenser which completes the filter circuit, and from which point r.f., detector, and first a.f. plate and grid voltages are taken off. A small 0.25 mfd. condenser shunts the first filter choke, effectively tuning the first filter section to 120 cycles, and greatly increasing the effectiveness of filtration. The dry electrolytic condensers have a life so great as to be indefinite, and in addition are self-healing in case of breakdown at normal voltages. They are operated well below rated working voltages, and have a leakage current so low as to be negligible.

The whole power unit is mounted on a pressed steel chassis, provided with a removable bottom plate, and having an on-off switch included directly in the chassis to satisfy a new Underwriters' requirement. The power transformer primary is fused, and is suited to operation from 105 to 120 volts a.c. when the fuse is in one set of clips, and to 120 to 135 volts a.c. when the fuse is in a second set of clips, thus effectively taking care of all ordinary line-voltage variations found in the United States and Canada. A 25 to 40 cycle model is also made, essentially the same otherwise as the 50 to 60 cycle model described above.

The receiver is connected to the power unit by a cable carrying a terminal strip on its end which is simply pushed down over screws on a similar strip in the power unit, on which nuts are then placed and tightened down.

Remote Control is Here

For those who desire it, Utah remote control is optional. The control system consists of a plate, bolted to the left, or dial, end of the set chassis, carrying a motor, and a commutator switch with nine contacts adjusted by small buttons—the motor shaft is coupled by a flexible coupling to the gang condenser shaft. Connected to this

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