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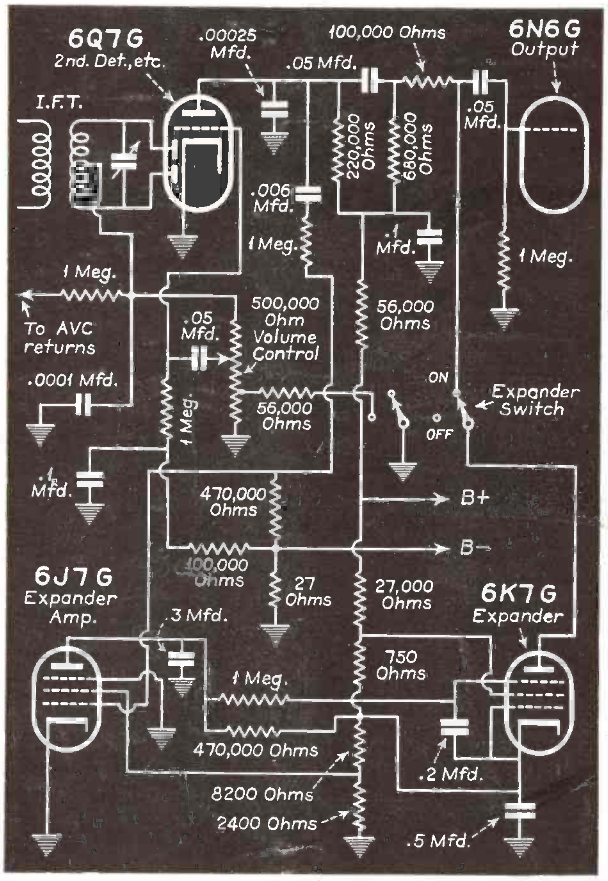

Volume Expansion

(*See Page 74*)

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SERVICE

A Monthly Digest of Radio and Allied Maintenance

Reg. U. S. Patent Office. Member, Audit Bureau of Circulations

EDITOR
Robert G. Herzog

FEBRUARY, 1937 VOL. 6, NO. 2

EDITORIAL CONTENTS

An asterisk preceding a listing indicates that a circuit accompanies the text.

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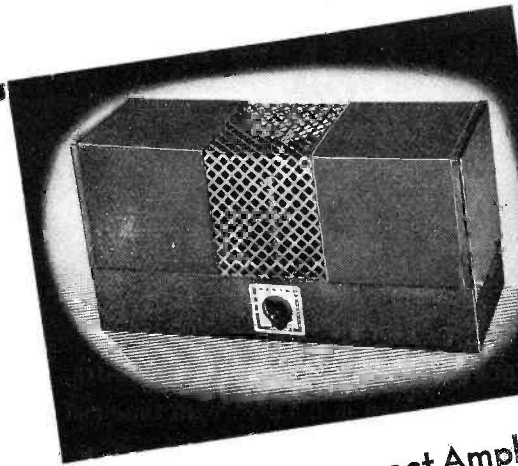

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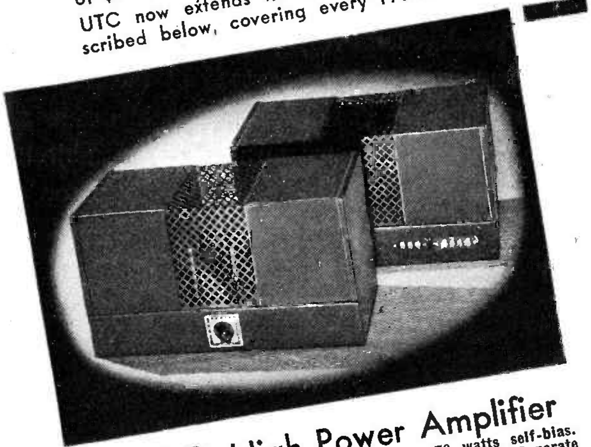
PAK-5X Same as PAK-5 but with Varimatch modulation output, net price.......... **$30**



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THE ANTENNA . . .

ADEQUATE EQUIPMENT

IN HIS SURVEY IN THIS issue, Mr. Jim Kirk, observes that the Service Men in his area with the most complete and up-to-date equipment are the most prosperous. We feel certain that this observation holds for Service Men everywhere. Every dollar sown in adequate, usable service equipment reaps a rich harvest in profitable business—made easier through the advantageous use of the equipment.

We never cease to urge the Service Man to keep his equipment complete and up-to-the-minute. We also continue to urge him to make this equipment most useful through ample study.

We need spend little time in talking about neatness of shop and workbench. The fellow who complains "I haven't the time to keep my bench clean and neat" will soon find himself with plenty of time, through the loss of profitable business to do so, but then his lack of efficiency might prevent him from cleaning up even if he had nothing else to do.

The Service Men of Oakland, California, give trade magazines much credit for help in their business. Naturally, we agree with them. Because of their frequency trade periodicals can be the greatest aid in keeping the Service Man up-to-date on the latest developments and events, in an industry, in which radical changes and improvements are a daily occurrence.

• • •

DEGENERATIVE FEEDBACK

NOW THAT HIGH-MU VOLTAGE amplifier tubes and output tubes of high power sensitivity make possible the design of audio amplifiers of low phase-shift characteristics, the higher-priced receivers for 1938 will, no doubt, include degenerative feedback in one or more of their audio stages. Many p-a amplifiers already in operation or manufacture have this feature included.

From the Service Man's standpoint, unless he spends sufficient time and effort studying the subject, degenerative feedback will be just another of those "new-fangled complications" which add to the dilemma of radio servicing. Certainly there is no rest for the weary, although the Service Man with a keen interest in radio developments undoubtedly welcomes new features. They add a zest to his work and offer a challenge to his ability.

The article on degenerative feedback in this issue is presented in language easily understood by the Service Man. We feel that the Service Man should obtain a working knowledge of the fundamentals of the subject, as early as possible, to be able to service tomorrow's receivers properly, as soon as they need servicing.

• • •

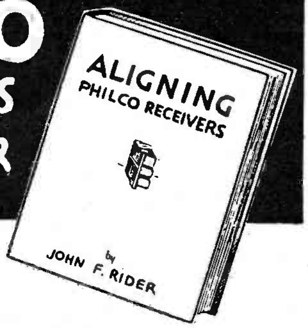
PHONO-RADIO COMBINATIONS

IN LAST MONTH'S EDITORIAL we pointed out how the Service Man could earn commissions on new set sales through some suitable tieup with a friendly local dealer. If the new set prospect is a music lover the Service Man can earn a larger return by pushing the sale of a phono-radio combination.

Opera programs, like the Metropolitan's Saturday afternoon broadcasts, or concerts of the Philharmonic Symphony Society are too few and the season too short for the music minded individual. To this type of customer, Radames' tenor voice extolling his Celeste Aida or the antics of Figaro in the Barber of Seville are more desirable than the best dance music of Guy Lombardo's Royal Canadians, Bing Crosby's most romantic love song, the ultimate in swing from Fats Waller or an hour with Jack Benny.

On a Saturday afternoon, after hearing the voice of Giovanni Martinelli or of Lauritz Melchior sing some favorite selection on the Metropolitan Opera program, if it is desired, a record of the immortal Enrico Caruso may be played for comparison. Since good recordings of famous opera stars are always available limitless possibilities suggest themselves. These customers can probably be sold on phono-radio combinations easier than on radios alone.

ALIGNING PHILCO RECEIVERS by JOHN F. RIDER



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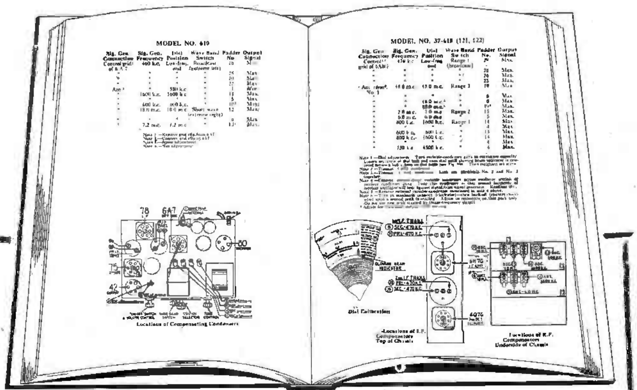

This new book presents authentic and complete instructions for fast and accurate alignment operation on ANY Philco receiver. Every trimmer is located for you—you don't have to skip around or guess at alignment frequencies. The order followed in the tables is the same order you use when aligning receivers on the bench.

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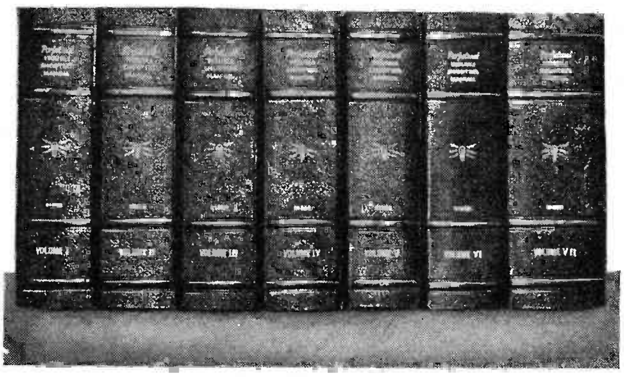

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JOHN F. RIDER, Publisher
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SERVICE

A Monthly Digest of Radio and Allied Maintenance

FOR FEBRUARY, 1937

DECIBEL METERS†

By F. H. BEST*

DURING the present century there has come into existence a new unit known as the decibel. It was employed originally as a measure of loss and gain in telephone transmission, but because of its wider utility, it has more recently been adopted by other electro-acoustic fields such as broadcasting and sound pictures, and is also used in the measurement of noise and sound in general. Regardless of its field of use, however, it remains a measure of an increase or decrease in power, but it is a unit of an unusual type, and in spite of its wide employment has remained more or less of an enigma to all but those who are initiated in its use.

In the ordinary affairs of life a change in anything would be measured either in the same units as the original quantity, or in percent of the original. If, for example, a man buys a bond for $1000 and sells it for $900, his loss might be said to be $100 or 10 percent. Both of these measures of loss are significant: the first giving the actual amount of money lost, and the second the ratio of loss to original principal. Such methods of measuring loss are also used in many other fields, such as in electric power transmision, for example.

Neither of these methods, however, is entirely satisfactory for measuring gain or loss in audio circuits. Such circuits are designed so that a given circuit element produces the same percentage gain or loss between its input and output terminals regardless of the part of the circuit into which it is inserted. Since the input in watts to such an element varies with the location of the element in the circuit, the gain or loss in watts produced differs for each position of the element, and so to measure the gain or loss in watts would be to lose the advantage of a single and constant expression for the change occasioned.

While an expression of the gain or loss in percent would not be open to this objection, it becomes inconvenient when the effect of a number of such elements in series is to be considered. If R, for example, be allowed to represent the ratio of capital after investment to capital before, or of power at the output terminals of a circuit element to power at the input terminal, the percent loss is given by the expression

$$100\,(1-R)$$

and where losses are suffered consecutively, the combined loss in percent is

$$100[1-(R_1 \times R_2 \times R_3)]$$

where R_1, R_2 and R_3 are the ratios for the various elements. The calculation of such a combination of losses is complicated by the series multiplication.

In the db system the same ratio R is employed, but the series multiplication is avoided by using the logarithm of R as the unit instead of the ratio R itself. It takes advantage of the simple mathematical fact that the log $(R_1 \times R_2 \times R_3)$ is equal to log R_1 + log R_2 + log R_3. A circuit element producing a gain or loss ratio R is said to produce a gain or loss of X bels, where X is the logarithm of R. The total produced by a number of elements is thus the sum of the gain or loss in the individual elements. More commonly the decibel is used instead of the bel, and since a decibel is 1/10 of a bel, the change in decibels is 10 log R instead of simply log R. The logarithm of ratios of 0.1, 0.01, 0.001, etc., are whole numbers, and thus the db change for these respective ratios are —10, —20, and —30 db which correspond to percentage losses of 90, 99, and 99.9.

If, for example, three circuit elements produced loss ratios of 0.5, 0.4, and 0.3, the combined ratio would be $0.5 \times 0.4 \times 0.3$ or .06 and the resultant loss would be 94 percent or 100 (1 — .06). Expressed in the db systems the individual losses would be 3.01, 3.98 and 5.23, which are ten times the respective logarithms of 0.5, 0.4, and 0.3. The overall loss would simply be the sum of the individual losses, or $3.01 + 3.98 + 5.23 = 12.22$.

In a telephone plant, losses are commonly determined by sending a predetermined amount of power over the circuit and determining the received power by measuring the amount of current flowing into a fixed terminating impe-

† "Bell Laboratories Record," January, 1937.
* Transmission Development Dept., Bell Laboratories, Inc.

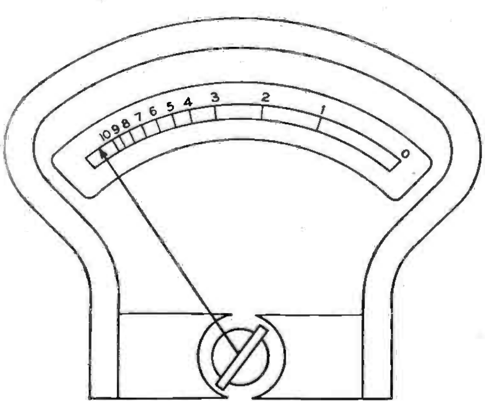
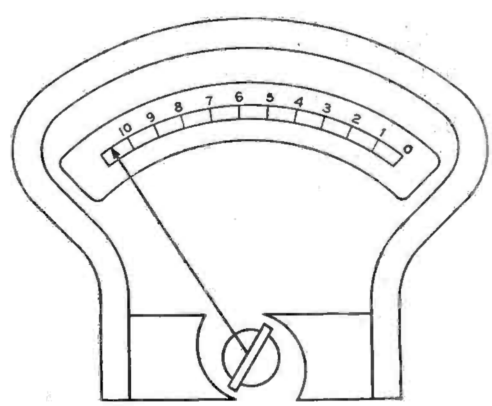


Fig. 1. Arrangement of a d-c ammeter for use as a decibel meter with no other modification except a change of scale.
Fig. 3. A d-c ammeter used for db measurement with the air gap modified to give an evenly spaced scale.



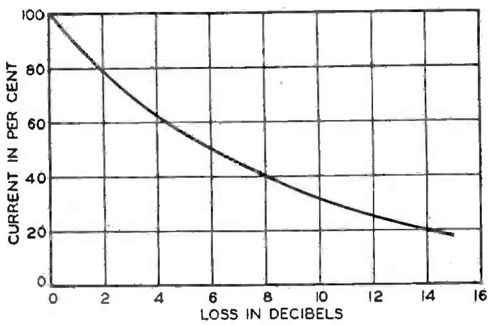


Fig. 2. Current (in percent of reference current corresponding to zero loss) for various losses in db.

dance, since with fixed input power and fixed terminating impedance, the received power is proportional to the square of the current. The output current is rectified and measured with a d-c ammeter, and the logarithm of the ratio of the squares of the currents under the two conditions is the loss in bels, and ten times the logarithm of this ratio is the loss in decibels. These measurements are facilitated by attaching a special scale to the meter so that the loss in db may be ready directly. A meter is selected that reads full scale for the amount of current corresponding to the fixed input power, and this full scale on the meter is marked zero loss. Because of the logarithm that defines the db, however, the points on the scale for subsequent units of loss in db are not evenly spaced, but are crowded together as shown in Fig 1.

The ordinary d-c ammeter is designed to have equal spacing on the scale for equal increments of current. This is secured by having the moving coil, to which the pointer is attached, rotate in an air gap of equal flux density throughout. Since the flux is constant, the torque on the coil will be proportional to the current, and since the pointer acts against a spring providing a restoring force proportional to the deflection, equal deflections are obtained for equal increments of current.

This uniformity of scale is very convenient in any meter, and it was felt desirable, therefore, to develop a db meter that would have equal increments of scale for equal increments of gain or loss in db. It was decided to modify the ammeter previously employed to bring this about. This was accomplished by varying the width of the air gap from one extreme position of the coil to the other, so that the flux, instead of being the same at all positions of the coil, would increase towards the positions of greater loss.

The right-hand end of the scale of such a meter, the position for maximum current, would be marked zero db loss. If the current corresponding to this indication be considered as unity, then the currents for various losses in db will be as shown in Fig. 2. As the current decreases the loss increases, but the decrease in current for successive db steps in loss becomes less and less. Thus from no loss to 1 db loss, the current changes 0.11 while from 14 to 15 db loss the change is only 0.02 or less than one-fifth as much. Since the movement of the pointer along the scale is to be the same for each db, the air gap must be proportioned to make the flux correspondingly larger toward the large loss end to offset the decreasing increments of current. The flux in the air gap, in fact, should follow the reciprocal of the curve of Fig. 2. The construction of such a meter would be as indicated in Fig. 3.

Since the narrowest air gap is at the position of maximum loss, this value of current and loss must be decided upon first, and from it the amount of necessary widening of the gap can be readily determined. As may be observed from the form of Fig. 2, the amount of widening of the gap increases rapidly with the range of db to be measured. Thus for a meter to read up to 10 db the narrow end of the gap would have to be such as to give more than three times as much flux as at the wide end, while for a meter with a 20-db scale, the narrow end of the gap would have nearly ten times as much flux as the wide end.

Such a meter requires a higher operating current than the ordinary ammeter because the flux is less at maximum current. The varying width of the air gap also causes a variation in the damping at various positions of the scale. At zero loss, where the flux density in the air gap is least, the damping will be least, while at large loss, where the flux density is the greatest, the damping will be greatest.

VOLUME EXPANSION

(See Front Cover)

THE diagram on the front cover shows a volume expander system used by Sparton in their 1937 phono-radio combinations. The particular parts values indicated are for the models 997X, 827X and 827XD. The circuit and parts values used in the other 1937 models differ only slightly.

The Circuit

Part of the audio signal from the plate of the 6Q7G second-detector first-audio stage is fed through a 0.006-mfd coupling condenser and a 1-meg resistor to the grid of a 6J7G expander amplifier. The 6J7G is biased slightly beyond cut-off by connecting the return of the 470,000-ohm grid load resistor to the center tap of the high-voltage winding on the power transformer. The amount of the bias is equal to the drop in the 27-ohm resistor connected from the center tap to the chassis. The cathode of the 6J7G is also connected to the chassis.

The plate of the 6J7G expander amplifier is direct-coupled (through the 1-meg resistor) to the third grid or suppressor of a type 6K7G tube. The filter network—consisting of the 0.3-mfd condenser, the 1-meg resistor and the 0.2-mfd condenser—connected to this plate-grid circuit allows only the larger d-c changes at the plate of the 6J7G to affect the grid of the 6K7G. Plate voltage is applied to the 6J7G through the 470,000-ohm plate load resistor. This resistor also acts as the load for the 6K7G expander suppressor grid. The drop in this resistor caused by the plate current of the 6J7G is the bias for the 6K7G.

The plate of the 6K7G expander is connected in series with a 100,000-ohm resistor. The tube and the resistor are connected across the audio signal in the form of a voltage divider. The grid of the output stage taps into this divider at the junction of the plate and the 100,000-ohm resistor.

Operation

The 6J7G expander amplifier receives about a third (more or less) of the audio signal output of the 6Q7G from the divider circuit consisting of the 0.006-mfd condenser, the 1-meg resistor and the 470,000-ohm grid load. Since the tube is overbiased only signals of sufficient strength can affect its plate current. Any increase in the plate current of this tube will also increase the bias on the 6K7G suppressor grid.

The resistance (plate to cathode) of the 6K7G tube varies directly with the (d-c) bias on the third grid (suppressor), i. e., the plate resistance increases as the bias becomes more negative.

(Continued on page 76)

A SURVEY OF SERVICE MEN

By JIM KIRK

SUMMARY

Kirk reaches the following conclusions for his area:

Over 98 percent of the men interviewed were courteous and anxious to be helpful to reporters.

All but two of the 150 interviewed gave trade magazines much credit for developing business. The criticisms of these two are reported.

Local jobbers get about 85 percent of the business if the replies can be believed. Three biting criticisms of local jobbers were offered.

The Service Men who spend the most for test equipment have the most impressive shops and are the most prosperous. In other words, the owners of the most impressive and busy shops quoted the largest figures for the test equipment budget.

Those who volunteered the information do not carry much more than a tube tester into the customer's home and are opposed to doing bench work in the parlor.

About 90 percent of the neatest shops were men working from their homes or garages. The other 10 percent, however, were large well-financed outfits and naturally had especially neat shops.

Very few horrible examples of shiftlessness are still in the service business, only two to be seen in the Oakland area.

I HAD no intention of writing about my experiences when I interviewed every radio dealer and Service Man in the Oakland, California, area. It was originally for another purpose, but since I enjoyed the experience so much, I have decided to allow you to come along with me and meet the "boys." Perhaps you may get some tips. The men interviewed probably represent types to be found in every large city.

The city of Oakland is located on the San Francisco Bay, directly east of San Francisco, in Alameda county, California. It boasts a population of some 284,000 persons and is still growing. It ranks about thirtieth in importance when compared with the other cities of the United States. The area covered in the survey was Oakland itself—not including the suburbs.

A friendly jobber's salesman gave me a list of 250 names, which included every concern in the radio service business in Oakland for the last three years. Since this list included every name which appeared on two other lists obtained from different sources, it must have been as complete as the salesman claimed.

After running the list down, I actually interviewed 150 heads of concerns. The survey was most exhaustive and took in all Service Men working from their homes, many without advertising signs. There are probably more Service Men in Oakland, however, because some concerns employed men, several retaining quite a staff.

In many instances the man sought was out, but I went back enough times to contact everyone. The 100 men who were not interviewed had either gone out of business or moved from the Oakland area.

Upon deciding to tackle the canvass, I planned my approach to secure the information I needed without being thrown out before I could get started. It is similar to planning the best approach to a prospective customer. Does a good salesman say, "I'm here to unload all the radio junk I can. How much money have you got?"

Methods of Approach

I have often wished I could be so brutally frank (so have you) because it would simplify matters. A good salesman, however, obscures his errand with white lies like the following: "Good morning. I'm taking a radio census."

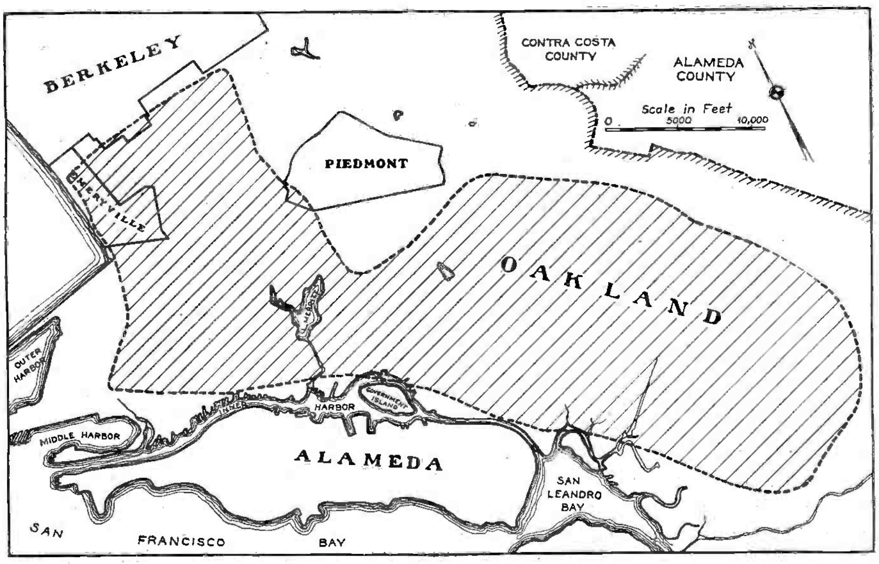
It may be a cloudy morning and you are without authority to take a census. "I'm checking up on radio noise in this neighborhood. Have you been bothered with noise?"

The Disguise

Thus you give the impression that you are some sort of a government or utility engineer empowered to run down static. You don't want to make the approach so far from the truth that it will be obviously false, and yet not blurt out the frank truth either. You must avoid frightening the prospect away. The actual query I used was, "I'm one of those inquiring reporters and I value very highly your opinion on radio subjects. You can greatly aid me in the preparation of an article by answering a few general questions while I make notes on your replies. I promise your name will not be used."

Unexpected Courtesy

I was surprised at the courtesy with which I was greeted. Some said, "Shoot; I'm ready." Others said they



City of Oakland, California, and the surrounding suburbs. Survey covers shaded area.

always wanted to be interviewed by a reporter, and asked if it were true that I was addicted to drink as your orthodox movie reporter usually is. Two fellows reversed the rules and started to ask me questions about the writing game! Only one man eyed me suspiciously and asked for credentials. It happened to be the last man on the last day and I had no credentials with me, but I wiggled out. It's a tribute to the caliber of the men in the radio game that they almost broke their necks to be of service to me in the preparation of the alleged story. One man asked me to call again at my convenience and he would take a day off and give me ideas that I could use in writing a "lot of articles."

Trade Magazines

Here is what I asked first: "Do trade magazines help you in your business?"

The ice thus broken, I could gently and gradually lead up to more important questions, putting the most embarrassing one last, of course. The majority gave magazines much credit and praise for aiding business. I shall list three unusual replies. One self-satisfied Service Man said: "No magazine is helpful. I, myself, am the greatest help in this business. I built it up from scratch to the commanding position it enjoys today by my own merit."

Another man ventured a criticism of all magazines: "Trouble with magazines is—no really big shot ever writes for 'em. If a guy can make the dough, he's too busy raking it in to write about it. Now take me, for instance. I get good, high prices for my work and I could write an article on how to make the heavy sugar—but why should I? My competitors would then be as wise as I am."

An answer that struck me as being brilliant follows: "I can truthfully say that all the magazines are a help in my business. It is impossible to single out one particular magazine for all the praise. I take all the leading trade journals (here he named the list he subscribed to). One month a certain magazine will have a peach of a helpful story in it and I'll start thinking what a dandy magazine it is and how far it is above the others and then the next issue will not be so hot and some other magazine wins the prize of my best attention. One or two, however, are good almost consistently."

Local Jobbers

The next question I asked was: "What percentage of your merchandise do you buy from local jobbers?"

A large majority in this area said they bought almost exclusively from the local jobbers. The local jobbers in these parts must be getting wealthy. Three men, however, had criticisms to offer. Criticism number one follows: "All the blankety-blanks are in competition with us and take our customers away. They take our customers for sets, tubes and parts and some even take away our service customers. There is one who actually advertises over the air somewhat in this fashion, 'Why buy at retail when we give you sets and tubes at wholesale? Remember—prices are 40 percent lower here,' etc. They want to plough us under."

Another man said the local jobbers did not carry big enough stocks and one man complained: "The local jobbers carry cheap, inferior parts. I guess none of them has capital enough to stock worth-while merchandise. I should be glad to patronize them if they would carry better merchandise, but they won't, so I send off for my supplies. I insist on the very highest quality parts for my customers. Price is secondary."

Test Equipment

By the time I have allowed them to weep on my shoulder and sympathized with them, the Service Men were in condition for the next question I asked them. "How much test equipment do you buy in a year?"

One concern allows a large amount of money in its budget for new test equipment and makes it a point to keep its equipment up to the minute. When the manager named the large amount they spent each year for test equipment, I could credit the statement because superb, complete, laboratory equipment was easily evident. This concern does more service work than any other in this area. I noticed, in general, that those who spend the most on test equipment have the most business. One lone Service Man, however, had this to say: "If I was a sap, I'd buy a lot of test equipment and lose this business by bankruptcy. I've only bought what little I had to have and thought twice about buying that. It's easy to spend money for test equipment, but money is not earned as easily. I intend to buy no test equipment in the coming year except possibly adapters to test metal tubes. I take the cream of the repair jobs. It's surprising how many sets can be fixed with a screwdriver. Anything that stumps me I send out and add on my profit."

While on the subject of test equipment, I obtained ideas on the proper amount of test equipment to take into the customer's home. The overwhelming majority take only a tube-tester and tools to remove the chassis. I heard many sound arguments in favor of this course. One man said Service Men who take laboratory equipment into the customer's home are spoiling that customer for themselves and everyone else. Most customers in the future, after such treatment, will expect everything to be repaired in the twinkling of an eye right in the parlor—from an all-wave alignment job to a power-pack repair.

Appearance

While on this survey, I was struck with the neat appearance of most shops. The men who worked from their homes or garages seemed to have the neatest shops, strange as that may seem. One Service Man had a skylight installed right over his bench and the large amount of light thus obtained made examining small parts a pleasure.

I saw but two horrible examples on my tour. One man had letters, magazines, clothing and small parts piled on his writing desk and the whole place was so littered that I did not see how he could ever find anything.

The other "horrible example" had his feet up on the bench and was reading a detective magazine when I came in. His clothes and beard were unkept and a beer bottle protruded from a box of radio parts.

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VOLUME EXPANSION

(*Continued from page 74*)

If the resistance of the 6K7G were reduced to zero the grid of the output stage would be effectively grounded and no signal would be heard from the speaker. If, however, the resistance of the expander were infinite the effect of the 100,000-ohm series resistor would be negligible and full volume would be heard from the speaker.

With a very small signal on the 6J7G expander-amplifier grid, the tube acting at cut-off draws little or no current and the suppressor grid of the 6K7G is practically at cathode potential. For this condition the 6K7G has a minimum of resistance.

The 6K7G maximum plate resistance limit is determined by the characteristics of the 6J7G expander amplifier with the particular bias, plate load, screen voltage and plate voltage.

To keep the same level of signal in the speaker when switching the expander on or off, without requiring manipulation of the volume control, a 56,000-ohm resistor is connected across a 100,000-ohm tap on the volume control when the expander is in its off position. This reduces the signal by an amount equivalent to the general increase caused by switching the expander from the circuit.

The amount of expansion can be controlled (in design) by proper selection of the two resistors (1 megohm and 470,000 ohms in the circuit shown) in the grid circuit of the 6J7G expander amplifier.

REDUCING HUM IN RECEIVERS AND AMPLIFIERS

By EMIL BUCHWALD

TO the discerning radio listener hum in the loudspeaker is an annoyance, especially at low volume where it is apt to conflict with musical notes in the 60- or 120-cycle range. A receiver with properly filtered and balanced power supply circuits should attract no attention when it is turned on with the volume control on the low or off position.

The Service Man has undoubtedly heard receivers that hum with a vigor that dwarfs the whine emanating from the local power house. This type of set placed in a cabinet that resonates at a low frequency is quite disagreeable, acoustically speaking.

For the Service Man who wants to remove the last vestige of hum, it may become a vexing problem unless the underlying causes for hum are known. A glance at some of the fundamentals will help to clarify matters and solve some of the most severe cases.

The Filter System

The filter system taking the brunt of the job in removing hum is naturally the first line of attack. The conventional filter consists of one or more choke coils connected in one leg of the direct-current line, with two or more condensers connected across the line. Choke coils that carry too much current for their size will reduce the filtering action due to a loss of inductance. The particular duty of the choke is to cut off the peaks of the rectified component, and if the inductance is lowered some portion of the pulsating current will find its way through, causing hum. The condenser, on the other hand, functions to fill in the spaces between pulsations. It holds a charge, much in the same way as a storage battery and during that period of time when the rectified current is at an ebb the condenser gives up its charge which is absorbed by the load. If the load is of such proportions that the condenser discharges completely before the next pulsation arrives, a hum will surely result. In other words, if there is a lack of sufficient capacity in the circuit the filtering action will be impaired. The choke tends to lower the peaks of the pulsation and the condenser tends to fill in the spaces between; the two must be properly proportioned so that pure direct current will result.

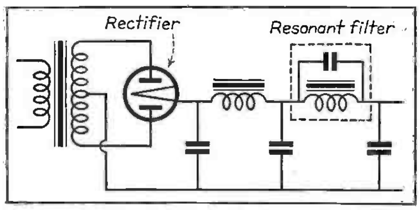


Fig. 1. Resonant filter.

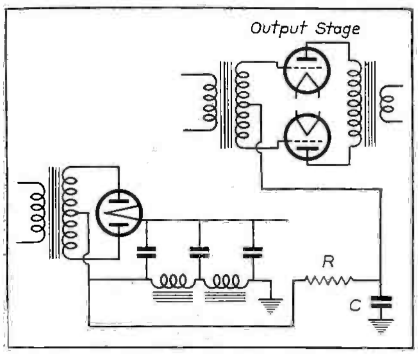


Fig. 2. Negative grid-return filter.

The Parallel Resonant Filter

For greater filtering efficiency we may borrow a circuit from the radio-frequency amplifier; namely, the parallel resonance circuit. The effective resistance of this circuit to the resonant frequency is infinitely great and when used in the filter will offer considerable opposition to the discordant cycles. A small fixed condenser connected across one of the choke coils in the filter comprises a parallel resonance circuit. The value of the condenser is a matter of experiment, since the inductance of the choke varies with the current flowing therein. For the conventional choke, condenser values from 0.01 to 0.1 mfd may be tried; that is, under actual working conditions, until a suitable value for minimum hum level is found. This method is also applicable to the field coil of the loudspeaker, if that unit is used as a reactor in the filter. Fig. 1 will serve to illustrate the position of the resonant circuit in the filter.

Hum From the Negative Return

To realize every available volt from the power transformer, the potential drop across the choke coil in the filter is occasionally utilized for grid bias on the audio output tubes.

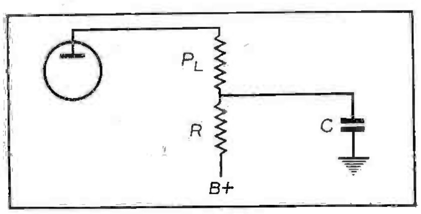


Fig. 3. Detector plate filter.

In this case the choke is connected in the negative lead of the filter and bias voltage taken from the high-voltage center tap of the power transformer. To prevent the alternating current from reaching the grid of the power tube, a small auxiliary filter is necessary as illustrated in Fig. 2. The resistance R should be about ten times higher in value than the reactance of the condenser C. For instance, if the value of C is 0.1 mfd which has a reactance of 26,660 ohms at 60 cycles, the resistance of R should be 266,600 ohms, or in round figures abut 275,000 ohms. This is more than twenty times the reactance of the condenser at 120 cycles and will amply take care of that component of the current.

Inductive Pickup

Incorrect physical relationship between the audio transformer and power transformer might result in inductive pickup unless these units are exceptionally well shielded. It requires but a few lines of force to create a voltage (in the coils of an audio transformer) large enough to swing the grid of the following tube. Multiply this by the gain of the succeeding stages and a sizable hum voltage may develop across the voice coil.

As a matter of experiment, remove the bolts holding the first stage audio transformer to the chassis, but leave the wiring intact. Turn on the radio and with the volume control turned to minimum, rotate the audio transformer slowly and note carefully any difference in the intensity of the hum in the speaker. If the hum level varies with rotation, it is a sign that inductive pickup is taking place, either from the power transformer or the choke. The remedy is obvious; either more shielding is used or the transformer should be bolted down in the position where the least hum is noticeable. This applies also to impedances used in audio amplifiers.

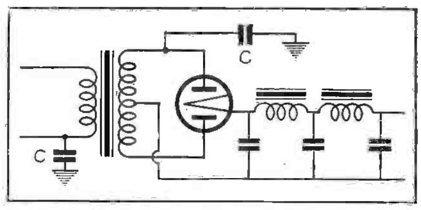


Fig. 4. Modulation hum filter.

Hum in Detector Circuit

Generally speaking, the receiver with low r-f gain and high a-f gain requires

(*Continued on page 117*)

General Data . . .

Crosley 1316

The Crosley model 1316 radio is a 13-tube receiver featuring high fidelity, volume expansion which is accomplished by the phantom conductor tube and automatic frequency control which is known as the mystic hand. It is available either with a standard 110-volt 60-cycle power transformer or with a universal power transformer.

A circuit diagram of the 1316 is shown in Fig. 1 with the tubes used, their functions and the various voltages encountered on the socket prongs lettered on the diagram.

The tube socket voltages are measured from the tube socket contacts to the chassis with a 1,000-ohm-per-volt, 500-volt d-c meter (except filaments) with the receiver in operating condition and no signal input. The filament voltages should be measured with an accurate low-range a-c voltmeter. Readings may vary plus or minus 10 percent of the values given.

The tuning range of the receiver is from 540 to 18,000 kc and is divided into three bands as follows: the blue band from 540 to 1800 kc; the red band from 1.8 to 5.5 mc; and the green band from 5.5 to 18.0 mc.

The Auto Expressionator

The auto-expressionator tube (phantom conductor) is connected across the voice coil of the speaker. When it is operating its resistance varies so as to increase the volume of loud tones, thus giving a wider volume range to reproduced music, which tends to compensate for the electrical limitations of broadcasting equipment.

Universal Power Transformer

The model 1316 chassis for use on other than 110 volts and 60 cycles is supplied with a universal power transformer designed to operate on a power supply of from 95 to 267 volts and any commercial frequency of 25 cycles or above. To adapt the set to a different line voltage, it is necessary to remove the chassis from the cabinet, locate the terminal strip on the bottom of the power transformer and locate the wire leading from the power switch to the terminal strip. After careful measurement of the maximum values of line voltage, unsolder the wire described above, from the lug on the terminal strip and solder it to the correct lug. The correct lug will be the one marked so as to cover or nearly cover the maximum line voltage. The maximum line voltage should not exceed the highest voltage stamped on the terminal strip beside the lug to be used by more than 3 percent.

Phonograph Pickup

Chassis equipped with a universal power transformer also have three terminals on the back for connecting a phonograph pickup. These terminals are marked P C S and the pickup is connected through a double-pole single-throw switch to these terminals as shown in Fig. 4.

Alignment Procedure

This model receiver should be turned on and allowed to "warm up" for about 15 minutes before aligning its circuits.

It is a high-fidelity receiver and in order to secure maximum performance the alignment should be done with precision instruments. The alignment condensers should not be readjusted just to determine if they are properly tuned.

The alignment of the afc circuit may be checked by means of a modulated signal generator and output meter as follows:

(a) Connect one terminal of the output meter to P2 of one of the 6N6 output tubes and the other terminal through a 0.1-mfd, or larger, condenser—not electrolytic—to P2 of the other 6N6 output tube.

(b) Connect the output of the signal generator through a 0.00025-mfd condenser to the top cap of the 6A8 oscillator-modulator tube, leaving the tube's grid clip in place. Connect the ground lead from the signal generator to the "Gnd" terminal of the receiver chassis.

(c) Rotate the phantom control to the left-hand position (normal).

(d) Adjust the frequency of the sig-

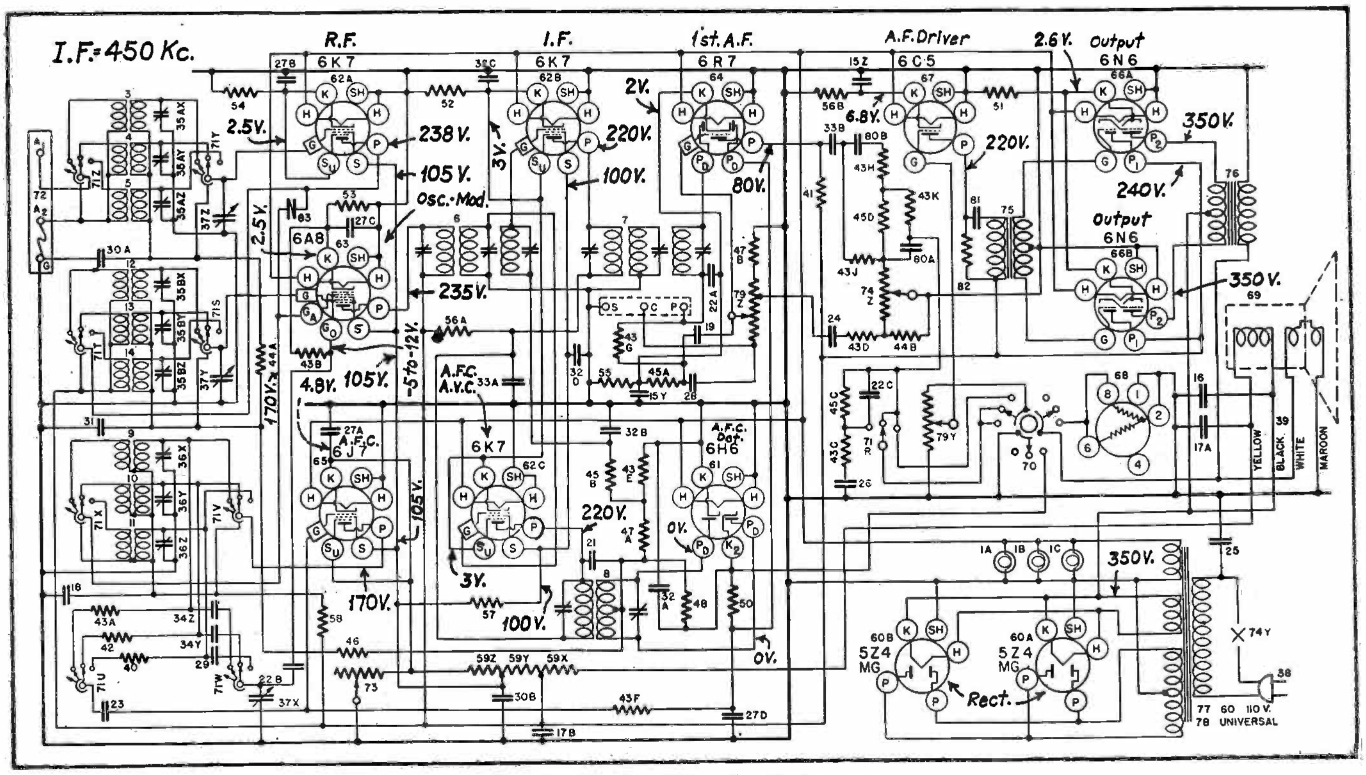


Fig. 1. Crosley 1316 circuit diagram.

nal generator in the region of 450 kc for maximum reading on the output meter.

(e) Without altering the connections or adjustments of the signal generator or output meter connect an antenna to the antenna terminal "A1" and tune in a local broadcasting station. Turn off modulation of signal generator. Adjust station selector slightly for zero beat.

(f) Rotate the phantom control to its middle position and listen to the beat note. If the note is less than 200 cycles, or the equivalent of some tone below middle C on the piano, the afc alignment is satisfactory.

(g) If the beat note is higher than middle C realignment is necessary.

(h) In cases where the beat note is not more than about two octaves above middle C or from 1000 to 1500 cycles the afc circuit may be aligned for zero beat by making a slight adjustment of the rear trimmer condenser on the afc i-f transformer (Fig. 2, item No. 8). This circuit is very critical and a slight adjustment will produce a great change in the beat note.

(i) Where the afc is considerably out of alignment as evidenced by a beat note of higher than 1500 cycles the standard alignment procedure outlined below should be followed.

No.	*Condensers Capacity*
15Z	12 mfd 25 v electrolytic
15Y	25 mfd 25 v electrolytic
16	35 mfd 400 v electrolytic
17A	40 mfd 300 v electrolytic
17B	40 mfd 300 v electrolytic
19	.00001 mfd (molded)
21	.00005 mfd (molded)
22A	.0001 mfd (molded)
22B	.0001 mfd (molded)
22C	.0001 mfd (molded)
23	.00005 mfd (molded)
24	.003 mfd 400 v tubular
25	.01 mfd 400 v tubular
26	.017 mfd 200 v tubular
27A	.02 mfd 160 v tubular
27B	.02 mfd 160 v tubular
27C	.02 mfd 160 v tubular
27D	.02 mfd 160 v tubular
28	.02 mfd 200 v tubular
29	.048 mfd 200 v tubular
30A	.05 mfd 200 v tubular
30B	.05 mfd 200 v tubular
31	.05 mfd 200 v tubular
32A	.05 mfd 200 v tubular
32B	.05 mfd 200 v tubular
32C	.05 mfd 200 v tubular
32D	.05 mfd 200 v tubular
33A	.05 mfd 400 v tubular
33B	.05 mfd 400 v tubular
80A	.0014 mfd 200 v tubular
80B	.0014 mfd 200 v tubular
81	.3 mfd 160 tubular
83	1.9 mmfd coupling

No.	*Resistors Ohmage*
40	20,000 ohm ¼ w insulated
41	40,000 ohm ¼ w insulated
42	50,000 ohm ¼ w carbon
43A To 43K	100,000 ohm ¼ w insulated
44A	300,000 ohm ¼ w insulated
44B	300,000 ohm ¼ w insulated
45A	500,000 ohm ¼ w insulated
45B	500,000 ohm ¼ w insulated
45C	500,000 ohm ¼ w insulated
45D	500,000 ohm ¼ w insulated
46	750,000 ohm ¼ w insulated
47A	1. megohm ¼ w insulated
47B	1. megohm ¼ w insulated
48	1.3 megohm ¼ w insulated
50	3. megohm ¼ w insulated
51	40 ohm ¾ w flexible
52	165 ohm ½ w flexible
53	275 ohm ½ w flexible
54	350 ohm ½ w flexible
55	500 ohm ½ w flexible
56A	1100 ohm ¾ w flexible
56B	1100 ohm ¾ w flexible
57	2000 ohm 1¼ w flexible
58	15000 ohm 1 w wire wound
59Z	4000 ohm candohm
59Y	4000 ohm candohm
59X	200 ohm candohm
82	20,000 ohm 1 w carbon

I-F Alignment

The i-f amplifier employs two triple-tuned signal i-f transformers and one double-tuned afc i-f transformer. The alignment procedure follows:

(a) Connect the output meter and signal generator as outlined above in (a) and (b) except that the signal generator should be connected through a 0.02-mfd condenser to the top cap of the 6K7 i-f amplifier tube, leaving the tube's grid clip in place.

(b) Set the band-selector switch to the broadcast band and rotate the station selector to approximately 60 on the dial. Turn the volume-control knob to the right (On), turn the fidelity control to its middle position and turn the phantom control to the left (Normal).

(c) Set the signal generator to 450 kc.

(d) Close the middle trimmer condenser of the second i-f transformer (Fig. 2, No. 7) so that it is moderately tight. (Do not force the adjustment screw.)

(e) Adjust the top trimmer and then the bottom trimmer (Sec. and Pri.) of the second i-f transformer for the maximum output. Do not readjust the middle trimmer. Always use the lowest signal generator output that will give a reasonable reading on the output meter.

(f) Transfer the output lead of the signal generator from the 6K7 tube to the top cap of the 6A8 Osc.-Mod. tube, leaving the tube's grid clip in place.

(g) Open the middle trimmer of the first i-f transformer three or four turns of the adjustment screw, from the closed position. (Care should be taken that the adjustment screw does not become dislodged from the nut.)

(h) Adjust the top trimmer and then the bottom trimmer of the first i-f trans-

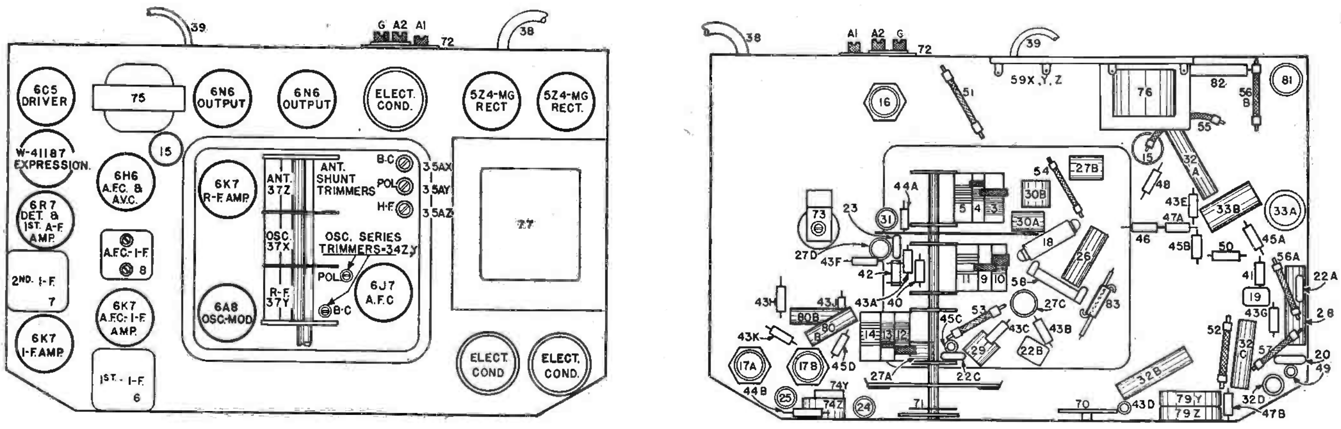


Fig. 2. Crosley 1316 chassis views showing tube and trimmer locations.

former for maximum output.

(i) Transfer the output lead of the signal generator from the 6A8 tube to the antenna terminal "A1" of the receiver and increase the output of the signal generator if necessary.

(j) Adjust the middle trimmer of the second i-f transformer, by opening it, until maximum output is obtained. Do not readjust the top and bottom trimmers.

(k) Adjust the middle trimmer of the first i-f transformer by closing it until maximum output is obtained. Do not readjust the top and bottom trimmers.

(l) To adjust the afc system it will be necessary to remove the signal generator lead from the receiver and adjust the 6J7 cathode bias to 4.8 volts by means of the variable control in this cathode circuit. The cathode voltage is measured between the cathode terminal and chassis.

(m) Turn the phantom control to the left (Normal); connect the generator output lead through a 0.02-mfd condenser to the top cap of the 6A8 oscillator-modulator tube, leaving the tube's grid clip in place.

(n) Adjust the signal generator to 450 kc.

(o) Adjust the front trimmer (plate winding) of the afc i-f transformer for minimum reading on the output meter. It will be necessary to retard the volume control of the receiver in order to prevent avc action. A fairly strong i-f signal will be required. (An insulated screwdriver should be used for aligning the afc i-f amplifier system.)

(p) Insert an 0 to 5 milliammeter in series with the lead to the cathode terminal of the 6J7 socket and note the current reading.

(q) Turn the phantom control to its middle position and increase the output of the signal generator to approximately 100,000 microvolts.

(r) Transfer the output lead of the signal generator from the 6A8 tube to the top cap of the 6K7 afc i-f amplifier tube, leaving the tube's grid clip in place.

(s) Adjust the rear trimmer of the afc i-f transformer for the same value of cathode current as obtained in (p) above. This value of current will be obtained with the trimmer closed, with it open and at some intermediate position. A very slight adjustment while in the intermediate position will cause the meter to read from 0 to 1.5 milliamperes. This is the setting that should be used.

(t) To check on the afc adjustment, disconnect the equipment and tune in a fairly weak broadcast station in the region of 1500 kilocycles. Turn the afc on and off. If reception is the same in both positions and will automatically tune in strong stations within approximately plus or minus 20 kilocycles of the station selector setting with the afc on, the afc is properly aligned. If distortion is noted and the set will not automatically tune in stations as described, the afc alignment should be rechecked.

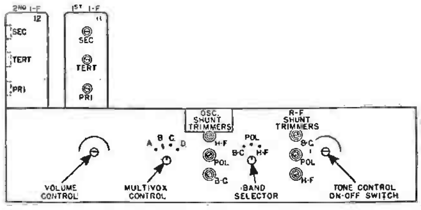


Fig. 3. Trimmer locations.

R-F Alignment

When aligning the r-f amplifier the output lead of the signal generator is connected to the "Ant" terminal of the receiver. For the blue and red bands a 0.00025-mfd condenser must be connected in series with the output lead of the signal generator and for the high-frequency band a 400-ohm carbon resistor should be used in place of the condenser.

Each band should first be shunt aligned and then series aligned, where provision is made for series alignment (blue and red bands). The band selector switch should be set for the band being aligned and the station selector and signal generator should be set to the frequency indicated (c) for each adjustment.

(a) Adjust the "Osc," r-f and "Ant" shunt trimmers in the order given for maximum output. Readjust the station selector slightly so that the generator signal is tuned-in with maximum output and then check the adjustments of the r-f and "Ant" trimmers. Do not readjust the "Osc" trimmer.

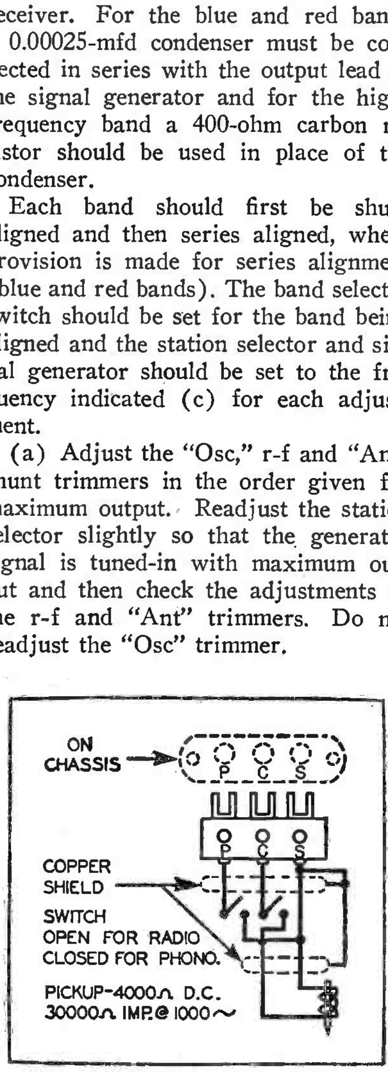


Fig. 4. Phonograph pickup connections.

Note: When shunt aligning the red and green bands care must be exercised so that the circuits will be aligned on the correct frequency rather than on the image frequency which is approximately 900 kc less than the fundamental. To check on this, increase the output of the signal generator ten times or more and try to tune-in the signal both at the generator frequency as indicated on the station selector dial and at approximately 900 kc less than the correct frequency. If the circuits have been properly aligned the signal can be tuned-in at both positions, but much stronger at the correct position.

(b) To align the series trimmers (34Z and 34Y Fig. 2) set the signal generator to the frequency indicated (c) and then tune-in this signal with the station selector for maximum output. To obtain the best adjustment for each series trimmer it will be necessary to rotate the station selector back and forth slightly while adjusting the trimmer for maximum output.

(c) Signal input frequencies for alignment follow: blue-band shunt alignment, 1400 kc; series, 600 kc; red-band shunt, 5000 kc; series, 2000 kc; green-band shunt, 18,000 kc; no series alignment.

Frequency Conversion Chart

The chart on the opposite page should prove useful to the Service Man in converting from wavelength to frequency or from frequency to wavelength.

For example, it is desired to determine the frequency of 150 meters. The ordinate (vertical line of graph paper) above 150 meters on scale C intersects the curve on an abscissa (horizontal line of graph paper) which when followed to the left indicates 2000 kc.

Similarly if the wavelength of a given frequency, say 300 kc, is required, the abscissa alongside 300 kc on scale D intersects the curve at the ordinate for 1000 meters.

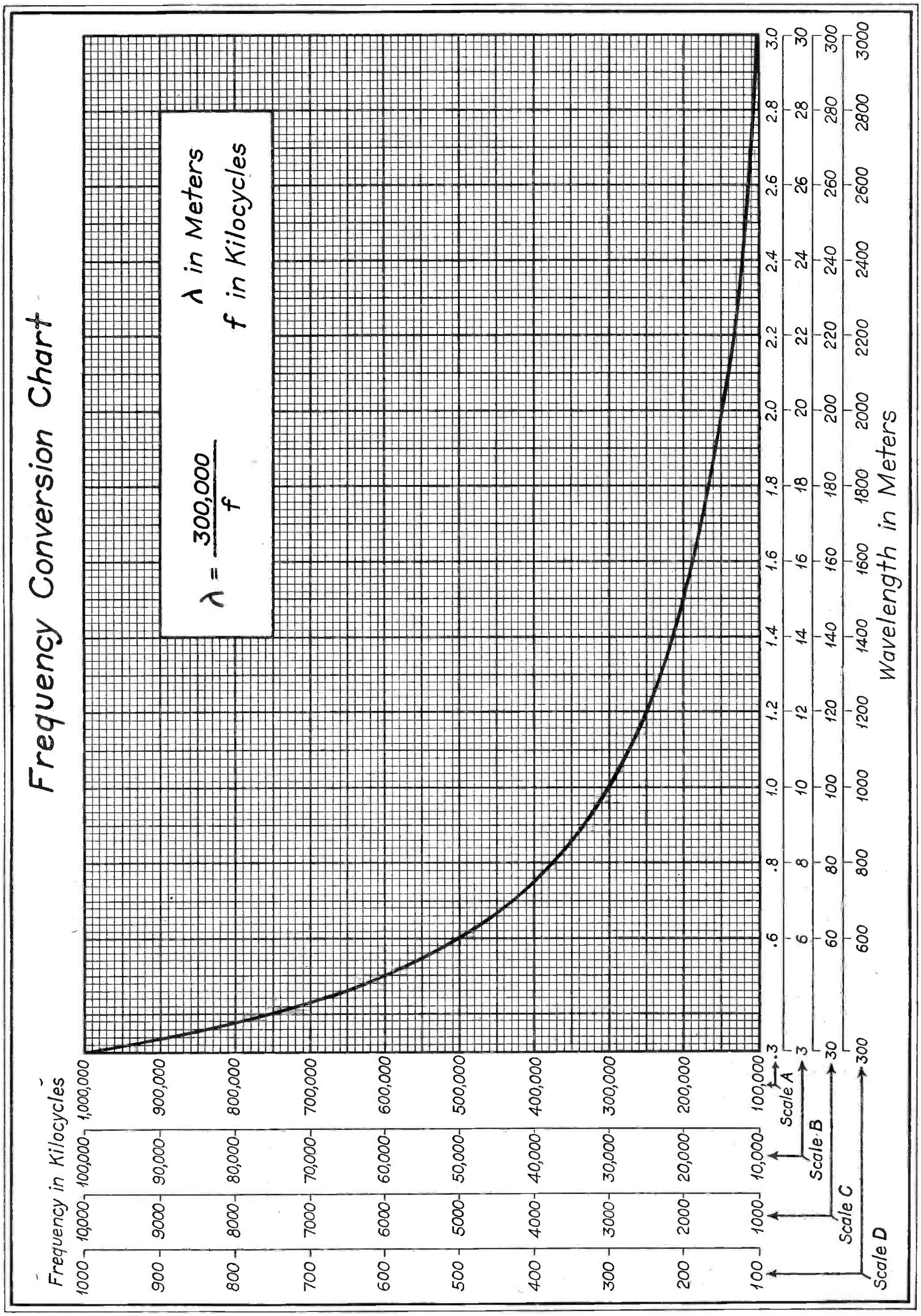
Although the chart ostensibly only extends from 100 to 1,000,000 kc, it has no limits since by suitable manipulation of the decimal point any conversion can be accomplished, e. g., 0.6 meter will give 500,000 kc and 0.06 meter will give 5,000,000 kc.

Sentinel-Erla 67-L

The Sentinel-Erla model 67-L is a six-tube superheterodyne using glass tubes and covering the ranges from 540 to 1720 kc and from 2.3 to 6.3 mc. The receiver is designed to operate directly from a 32-volt, d-c supply.

The Circuit

A complete circuit diagram of the


Frequency Conversion Chart
λ = 300,000 / f
λ in Meters
f in Kilocycles
Wavelength in Meters
Frequency in Kilocycles
.3 .6 .8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0
3 6 8 10 12 14 16 18 20 22 24 26 28 30
30 60 80 100 120 140 160 180 200 220 240 260 280 300
300 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000
100,000 200,000 300,000 400,000 500,000 600,000 700,000 800,000 900,000 1,000,000
10,000 20,000 30,000 40,000 50,000 60,000 70,000 80,000 90,000 100,000
1000 2000 3000 4000 5000 6000 7000 8000 9000 10,000
100 200 300 400 500 600 700 800 900 1000
Scale A
Scale B
Scale C
Scale D

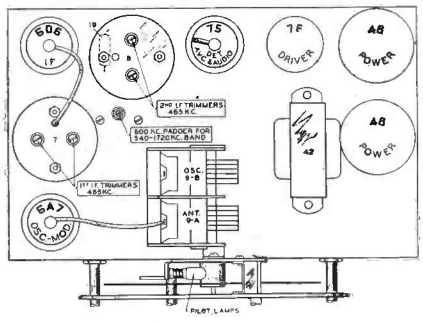


Fig. 2. Tube and i-f trimmer locations.

model 67-L is given in Fig. 1, with the tubes used, their functions and the various voltages encountered on the socket prongs. The voltages indicated (except heaters) were measured with a 1000-ohm-per-volt voltmeter from the points indicated to the receiver chassis. The heater voltages are those encountered at the various sockets with the tubes in place and the set in operating condition. The volume control was at maximum and the antenna and ground wires shorted together during the measurements.

A series antenna wave trap (2A-2B) is used to minimize interference of signals equal to the intermediate frequency. A two gang condenser with separate antenna and oscillator coils for each stage is used to cover the range specified above. A single i-f stage, using a 6D6 tube and two doubly tuned i-f transformers, amplifies the signal and feeds the type 75 second detector, avc, and first audio amplifier. The full avc voltage developed at the second detector is applied to the grid returns of the 6D6 i-f and the 6A7 (pentode section) antenna stage. The triode section of the 75 tube is resistance coupled to a type 76 tube which is transformer coupled to a pair of 48s operating in push pull.

Plate, screen and filament supply for the receiver is taken directly from the 32-volt line.

Alignment Procedure

Connect the output meter across the primary of the speaker transformer, or across the voice coil. Turn on the set and test oscillator. Allow both to warm up for about 15 minutes before attempting adjustments.

Connect the receiver antenna wire to the receiver chassis and ground the chassis.

I-F Alignment

Connect the ground lead of the test oscillator to the chassis or set ground lead. Connect the other lead to the grid cap of the 6A7 tube through a 0.02-mfd condenser; do not remove the grid clip. Set test oscillator to exactly 465 kc and turn receiver volume control on full. Peak each of the second i-f transformer trimmers. Peak each of the first i-f transformer trimmers.

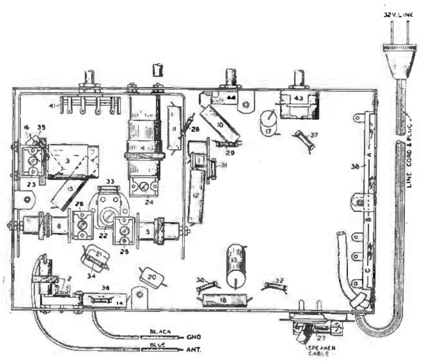


Fig. 3. Under-chassis trimmer locations.

Repeat the adjustments for greater accuracy.

Wave-trap Alignment

Connect the high output side of the test oscillator through a 0.00025-mfd condenser to the receiver antenna lead and the low side to the set ground. Set test oscillator frequency to exactly 465 kc and adjust the 465-kc wave-trap trimmer condenser mounted on and accessible through hole in rear of chassis for minimum 465 kc signal response.

Broadcast Band Alignment

Adjust band selector switch for operation on 1720- to 540-kc band and

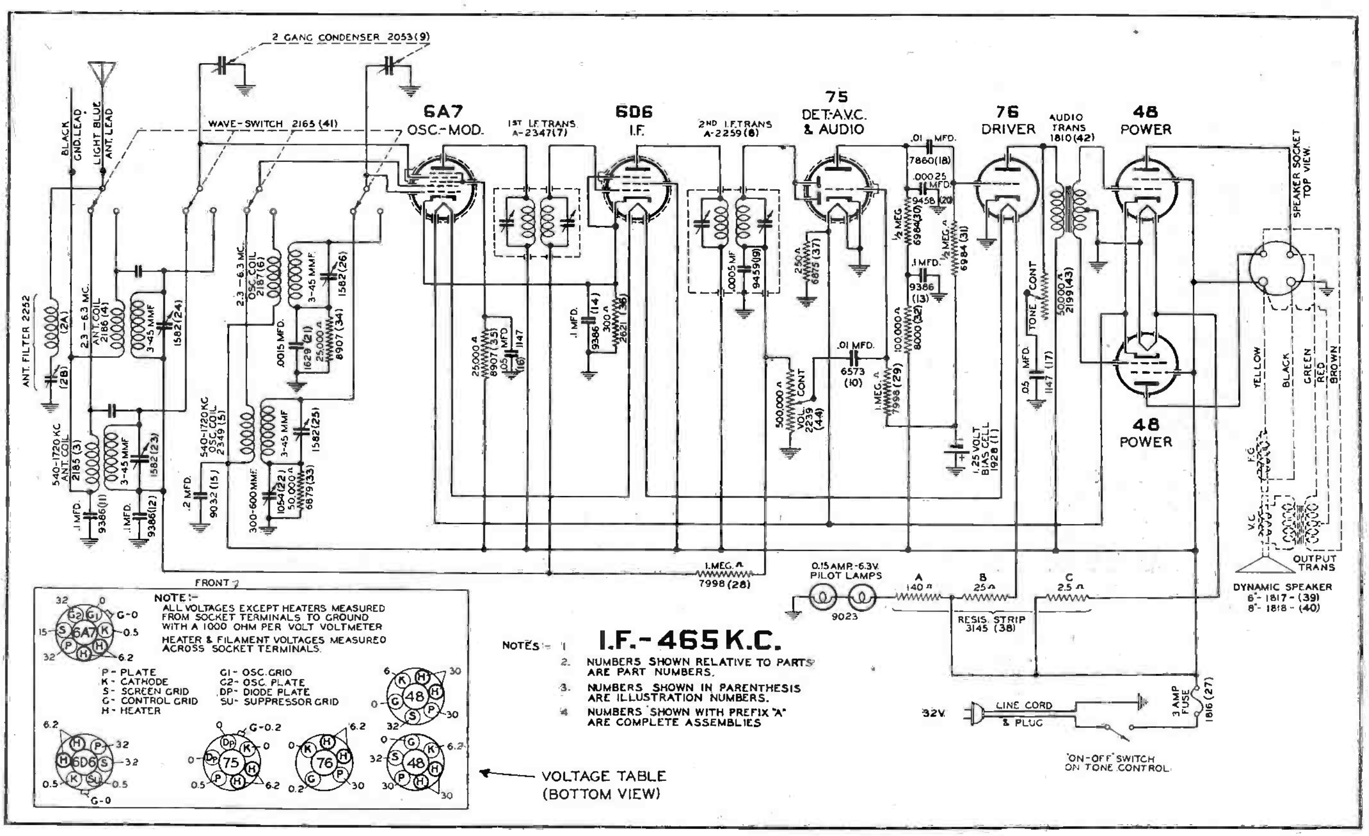


Fig. 1. Sentinel-Erla 67-L circuit diagram.

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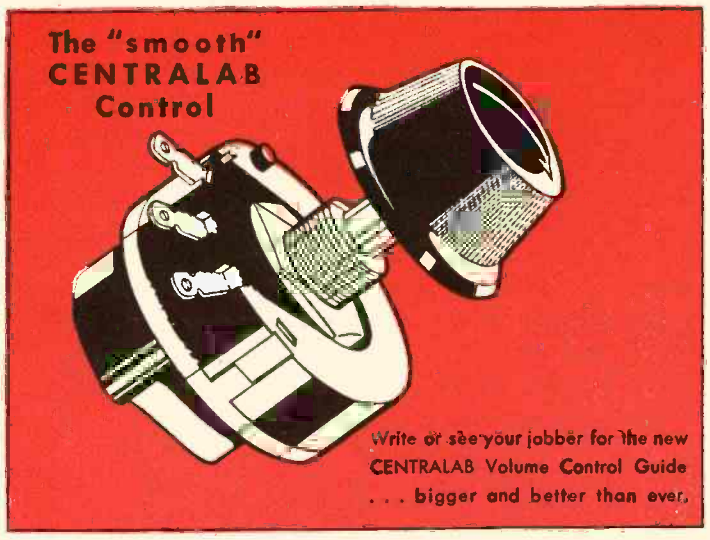

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Technical Features of 1937 Stewart-Warner Radio Receivers**

Model Numbers	1441 to 1449	1451 to 1459	1461 to 1469	1471 to 1479	1481 to 1489	1491** to 1499	1601 to 1609	1611-D to 1619-D	1621-D to 1629-D	1631-D to 1639-D	1641-D to 1649-D	1671 to 1689	1691 to 1695	1711 to 1719	1721 to 1729	1731 to 1739
Power Supply	A.C.	A.C.	A.C.	A.C.	A.C.	A.C.	6V.	Battery	Battery	6V.	6V.	A.C.	A.C.	A.C./D.C.	A.C.	A.C.
No. of Bands	2	3	3	3	3	4	1	2	3	2	3	2	3	2	3	3
Range (Kc.)	–	530 Kc. to 18 Mc.	530 Kc. to 18 Mc.	530 Kc. to 18 Mc.	530 Kc. to 18 Mc.	140 to 400 Kc. 527 Kc. to 18 Mc.	–	530 to 1700 Kc. 2.4 to 6 Mc.	140 to 400 Kc. 530 to 1700 Kc. 2.4 to 6 Mc.	530 to 1700 Kc. 2.4 to 6 Mc.	140 to to 400 Kc. 530 to 1700 Kc. 2.4 to 6 Mc.	–	530 Kc. to 18 Mc.	535 to 1720 Kc. 2.3 to 6 Mc.	530 Kc. to 18 Mc.	530 Kc. to 18 Mc.
I.F. Peak (Kc.)	456	456	456	456	456	456	177.5	456	456	456	456	456	262	456	262	456
Dynamic Speaker	5"	8" or 12"	8" or 12"	12"	12"	One 10" and One 12"	6"	6"	6" or 8"	6" or 8"	6" or 8"	5" or 8"	6" or 8"	5"	8" or 12"	8" or 12"
Tone Control		Yes	Yes	Yes	Yes	Yes			Yes		Yes		Yes		Yes	Yes
Music-Speech Control						Yes		Yes		Yes		Yes				
Doublet Connections		Yes	Yes	Yes	Yes	Yes										Yes
High-Low Speed Tuning			Yes	Yes	Yes	Yes										
Bass Compensation		Yes	Yes	Yes	Yes	Yes										Yes
Wave Trap	Yes	Yes	Yes	Yes	Yes	Yes						Yes	Yes		Yes	
Variable Condensers	2	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2
Number of Tuned Circuits	6	7	7	7	7	9	6	6	6	6	6	6	6	6	6	6
Tuning Eye				6G5	6G5	6G5										6G5
R.F.			6K7	6K7	6K7	6K7	6D6									
1st. Det.-Osc.	6D6	6A8	6A8	6A8	6A8	6A8	77	1C7G	1C7G	1C7G	1C7G	6K7G	6A8G	6A7	6A8G	6A8
Intermediate Freq.	6D6	6K7	6K7	6K7	6K7	6K7	6D6	1D5G	1D5G	1D5G	1D5G	6K7G	6K7G	6D6	6K7G	6K7
2nd. Det.	6C6	6H6	6H6	6H6	6H6	(2) 6H6* and 6J7	75	1H6G	1H6G	1H6G	1H6G	6J7G	6Q7G	75	6Q7G	6H6
AVC																
1st. Audio		6F5	6F5	6F5	6C5	6C5										6F5
2nd. Audio					6C5	6C5		1H4G	1H4G	1H4G	1H4G					
Output	41	6F6	6F6	6L6	(2) 6L6	(2) 6L6	41	(2) 1H4G	(2) 1H4G	(2) 1H4G	(2) 1H4G	6K6G	6K6G	43	6K6G	6F6
Rectifier	84	5Z4	5Z4	5Z4	5V4G	5V4G	84			Sync. Vibrator	Sync. Vibrator	6X5G	5V4G	25Z5	5V4G	5Z4
Ballast								1R1G	1R1G							
Chassis No.	R-144AS	R-145	R-146	R-147	R-148	R-149	R-160	R-161	R-162	R-163	R-164	R-167-S and R-168	R-169	R-171	R-172	R-173

* Double AVC

** Variable Selectivity Models

leave test oscillator lead connected to receiver antenna lead through the 0.00025-mfd series condenser. Set test oscillator frequency and receiver dial to exactly 1720 kc. Adjust 1720-kc oscillator trimmer to bring in 1720-kc test oscillator signal to maximum output.

Tune receiver dial and set test oscillator frequency to exactly 1400 kc. Adjust 1400-kc antenna trimmer for maximum sensitivity. Set receiver dial and test oscillator frequency to approximately 600 kc. While rocking gang condenser slightly to right and left adjust 600-kc padder for maximum sensitivity.

Short-wave Band Alignment

Replace 0.00025-mfd test oscillator lead series condenser with a 400-ohm resistor. Adjust band selector switch for operation on 6.3 to 2.3-megacycle band, and tune receiver dial and set test oscillator frequency to exactly 6.3 megacycles. Adjust 6.3-mc oscillator trimmer to bring in 6.3-mc test oscillator signal to maximum output.

Tune receiver dial and set test oscillator frequency to 5.8 mc, and while rocking gang condenser slightly to right and left adjust 5.8-mc antenna trimmer for maximum sensitivity.

No adjustment is required at low-frequency end of this band as a fixed oscillator pad is used.

To assure more accurate trimmer setting repeat all above adjustments several times always using lowest possible test oscillator output consistent with readable output meter scale deflection.

•

Zenith 5516 (5S-119, 5S-126, 5S-127, 5S-150, 5S-151, 5S-161)

The Zenith chassis 5516 is a 5-tube superheterodyne using metal or metal-glass tubes in a conventional all-wave circuit which covers the frequency range from 538 to 19,250 kc in 4 bands. The chassis is used in the model 5S-119 compact; in the 5S-126 and 5S-127 table models and also in the 5S-150, 5S-151 and 5S-161 consoles. A complete circuit diagram is given in Fig. 1, with the tubes used, their functions and the voltages encountered on the socket prongs lettered on the diagram. These voltages were measured with a 1000-ohm-per-volt voltmeter from the points indicated to the receiver chassis. The antenna was shorted to the ground and the volume control was on maximum during the measurements. The line voltage measured 112 volts. The total power consumption of the 5516 is 55 watts; the power output is 3 watts.

Alignment Procedure

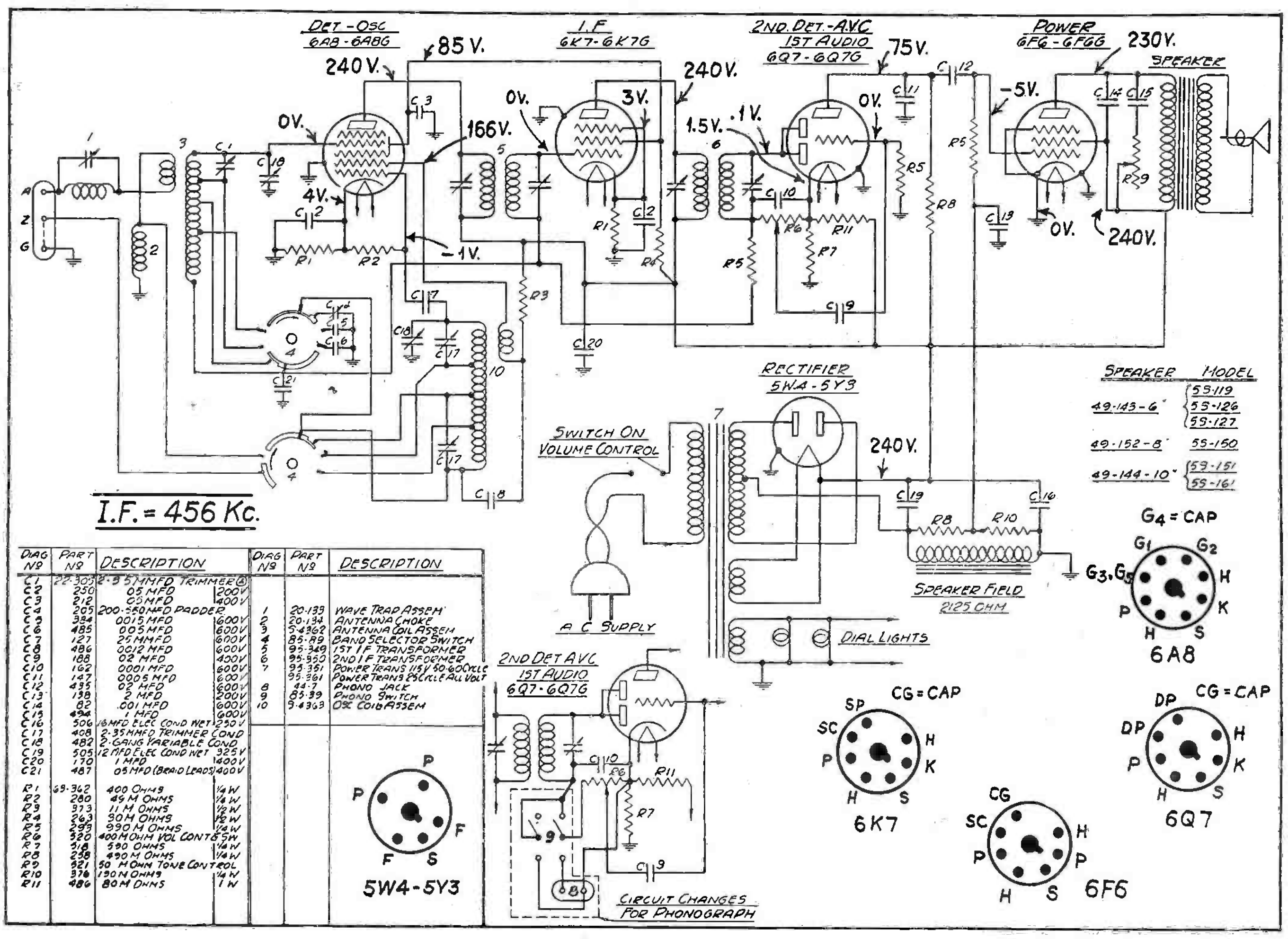
During alignment the receiver volume control should be turned to maximum and the signal generator control so adjusted to give as weak a signal as possible in order to prevent the avc from affecting the output readings. The signal in the speaker should be just audible.

During the i-f alignment the antenna should be shorted to the ground and the dial set at a position giving the least interference.

Both receiver and signal generator should be given sufficient time (about a half hour) to warm up before adjustments are attempted.

I-F Alignment

Connect the output leads of the signal generator to the grid of the first detector



Diag No.	Part No.	Description	
C1	22-305	2-35 MMFD Trimmer (A)	
C2	250	.05 MFD	200 V
C3	212	.05 MFD	400 V
C4	205	200-550 MMFD Padder	
C5	384	.0015 MFD	600 V
C6	485	.005 MFD	600 V
C7	127	25 MMFD	600 V
C8	486	.0012 MFD	600 V
C9	188	.02 MFD	400 V
C10	162	.0001 MFD	600 V
C11	147	.0005 MFD	600 V
C12	435	.02 MFD	600 V
C13	138	.2 MFD	200 V
C14	82	.001 MFD	600 V
C15	494	.1 MFD	600 V
C16	506	16 MFD Elec Cond Wet	250 V
C17	408	2-35 MMFD Trimmer Cond	
C18	482	2-Gang Variable Cond	
C19	505	12 MFD Elec Cond Wet	325 V
C20	170	.1 MFD	400 V
C21	487	.05 MFD (Braid Leads)	400 V
R1	63-362	400 Ohms	1/4 W
R2	280	49 M Ohms	1/4 W
R3	373	11 M Ohms	1/2 W
R4	263	30 M Ohms	1/2 W
R5	293	990 M Ohms	1/4 W
R6	520	400 M Ohm Vol Cont & Sw	
R7	518	590 Ohms	1/4 W
R8	258	490 M Ohms	1/4 W
R9	321	50 M Ohm Tone Control	
R10	376	190 M Ohms	1/4 W
R11	486	80 M Ohms	1 W

Diag No.	Part No.	Description
1	20-133	Wave Trap Assem
2	20-134	Antenna Choke
3	S-4362	Antenna Coil Assem
4	85-89	Band Selector Switch
5	95-349	1st I F Transformer
6	95-350	2nd I F Transformer
7	95-351	Power Trans 115 V 50-60 Cycle
	95-361	Power Trans 25 Cycle All Volt
8	44-7	Phono Jack
9	85-39	Phono Switch
10	S-4363	Osc Coil Assem

Fig. 1. Zenith 5516 circuit diagram.

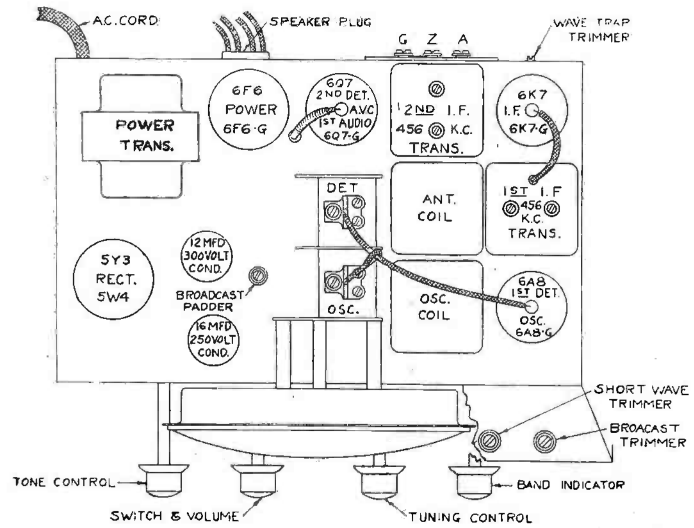


Fig. 2. Zenith 5516 tube and trimmer locations.

and receiver chassis. Also connect an output meter across the speaker transformer leads.

Set the signal generator at 456 kc and carefully adjust the four i-f trimmers to the point giving the highest reading on the output meter. The output transformers are of a very high gain, selective type and these adjustments should be repeated several times in order to secure maximum accuracy.

R-F Alignment

Change the signal generator leads to the antenna and ground terminals of the receiver.

Adjust the wave trap (located on rear of chassis) for *minimum* output reading.

Set signal generator at 6 mc. Switch receiver to band B, and adjust oscillator trimmer on gang for correct dial reading.

Set signal generator at 1400 kc. Switch receiver to band A and adjust broadcast trimmer (located in front of 6A8 tube, see Fig. 2) for correct dial reading. Also adjust antenna trimmer on gang to resonance.

Set signal generator at 18 mc Switch receiver to band C, and adjust the short-wave trimmer while rocking the pointer past 18 mc on the dial to the combination giving the greatest output.

Set signal generator at 600 kc. Switch receiver to band A, and rock pointer past 600 on dial while adjusting the broadcast padder (located adjacent to gang condenser) to combination giving the greatest output reading.

Readjust broadcast and ant. trimmers at 1400 kc.

Wells-Gardner OEL

The Wells-Gardner model OEL is an 11-tube superheterodyne using metal tubes. A frequency range from 528 to 18,300 kc is covered in three bands with ample overlap. The average sensitivity on the broadcast band is 1.0 microvolt

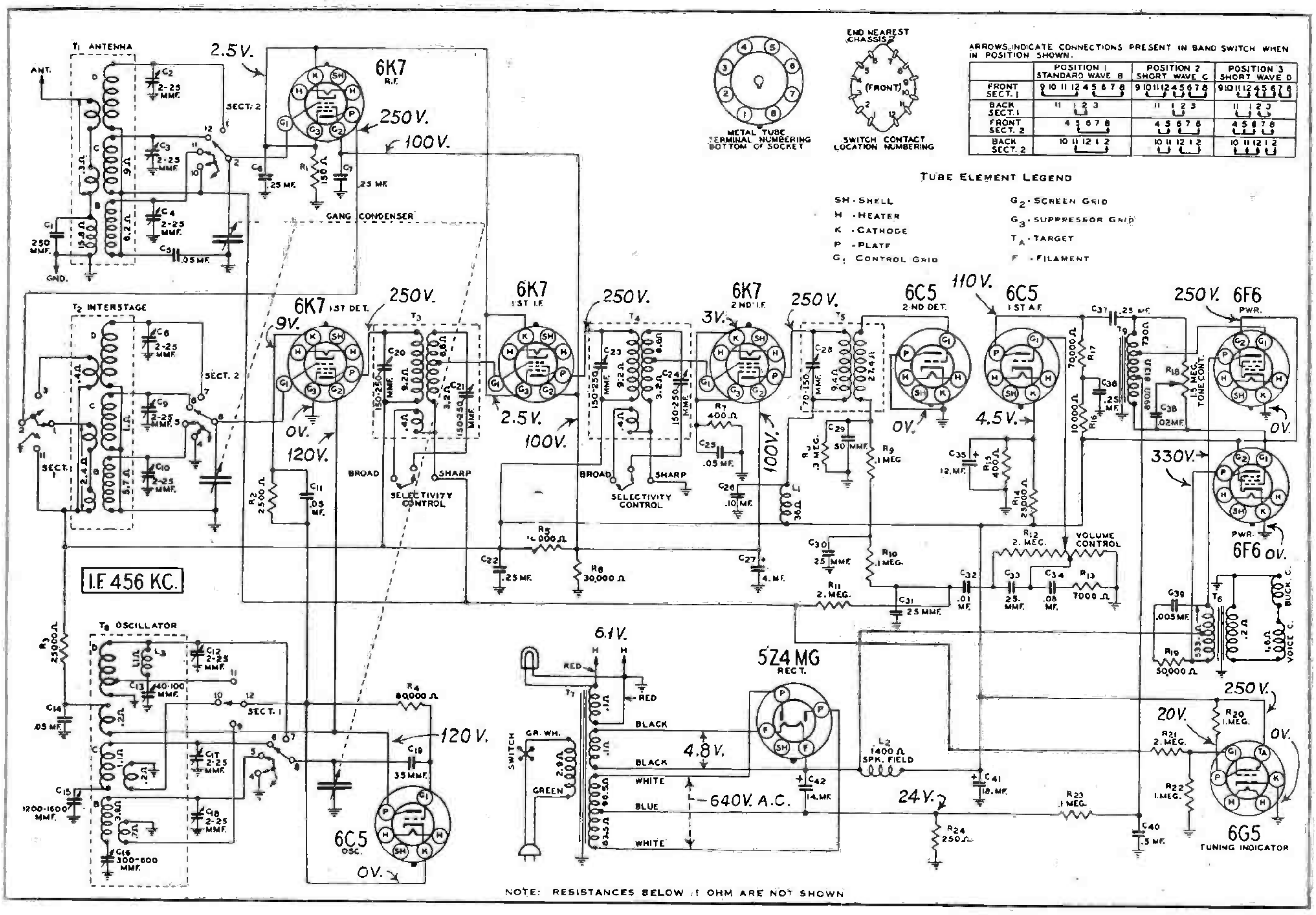


Fig. 1. Wells-Gardner OEL circuit diagram.

absolute, with sensitivities on the other bands varying between 1.0 and 3.0 microvolts absolute. The higher values hold as the frequencies increase. With the selectively control in the sharp position the selectivity is rated 22 kc broad at 1000 times the signal. An undistorted power output of 8 watts is available. With a normal line voltage of 115 volts, the power consumption of the OEL is 115 watts.

The Circuit

Three band coverage is accomplished by means of three sets of r-f and oscillator coils and a two-section triple-throw switch. Referring to the schematic diagram, Fig. 1, T1 and T2 are the antenna and interstage r-f transformer assemblies and T8 is the oscillator coil assembly. The standard-wave, first and second short-wave coils in each assembly are indicated by the letters B, C and D respectively. The band switch is designated as section 1 and section 2.

The band switch completes connections to the coils in use. It also short circuits the r-f transformer secondaries and oscillator coil of lower frequency not in use (also interstage r-f transformer primaries of lower frequency in range D position).

The antenna transformer with tuned secondary feeds into a type 6K7 r-f amplifier tube. The output of this tube is fed through the interstage r-f transformer with tuned secondary into another 6K7 tube which functions as the first detector.

A separate type 6C5 tube is employed in the oscillator circuit. The oscillating circuit is always resonant at 456 kc above the frequency to which the r-f amplifier is tuned.

The oscillator potential is fed into the cathode circuit of the 6K7 first detector tube. This results in the intermediate or beat frequency of 456 kc in the plate circuit of this tube.

Two stages of i-f amplification are employed using 6K7 tubes. The primaries and secondaries of the first and second i-f transformers and the primary of the third i-f transformer are tuned by small trimmer condensers.

Referring to the first and second i-f transformers T3 and T4 in Fig. 1, it will be noted that there are coupling windings shown below the primaries in the illustration.

When the selectivity control is in the sharp position, the coupling windings are open-circuited and the loose coupling which exists between the primary and secondary of these transformers results in high selectivity.

When the selectivity control is in the broad position, the coupling winding

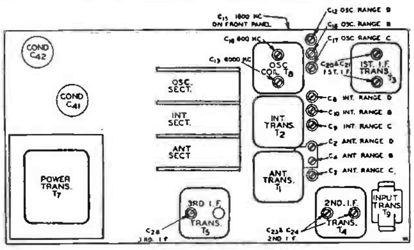


Fig. 2. Wells-Gardner OEL tube and trimmer locations.

which is wound under the primary is connected in series with the secondary. This provides overcoupling which results in a greatly widened resonance curve. Passage of a wide range of audio frequencies is thus obtained.

A type 6C5 tube functions as a diode second detector; avc voltage is applied through isolating resistors to the control grid circuits of the r-f and first i-f tubes. The audio voltage developed across volume control resistor R12 is applied through the movable arm to the control grid of the 6C5 first a-f tube.

Across the volume control resistor R12 is a filter composed of condensers C33 and C34 and resistor R13. A tap connection near the low potential end of the volume control is connected between the two condensers. At high volume settings, the filter is not effective. At the low volume settings as the movable arm approaches the tap, the higher frequencies are by-passed through condenser C34. Very high frequencies are transmitted through condenser C33 to compensate for the reduction of these frequencies. At low volume settings the low-frequency amplitudes are increased as a result.

Transformer coupling is used between the first audio stage and the output stage which employs two type 6F6 output pentode tubes in a stage of push-pull amplification. A type 5Z4MG (metal-glass tube) full-wave rectifier is used in the power unit.

The 6G5 tuning-indicator tube is wired as shown in the schematic. This tube contains a triode and cathode-ray section in one envelope.

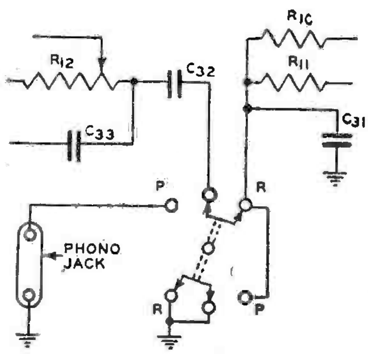


Fig. 3. Wells-Gardner OEL phonograph connections.

The cathode ray is produced by the attraction of electrons from the upper end of the cathode to the coated target or anode, which is operated at a high positive potential. When this electron stream strikes the target the coating glows. The electron stream is controlled by an additional element, or control electrode, in the tube.

As a signal is tuned in, the control grid of the triode section of the 6G5 cathode-ray tube becomes increasingly negative, the negative bias voltage being taken from the avc line. The avc voltage is reduced to a suitable value by the potentiometer arrangement of the 1- and 2-megohm resistors. The increased bias voltage reduces the triode plate current. This reduces the voltage drop across the 1-megohm plate resistor and raises the triode plate voltage. The triode plate is connected to the control electrode of the cathode-ray section of the tube.

The shape and size of the area on the target struck by the cathode ray is governed by the voltage of the control electrode. When the signal is tuned to resonance, practically no plate current flows and the voltage of the control electrode is the same as that of the target. There is no opposition to the flow of electrons to the target. Tuning off resonance decreases the control electrode voltage and causes the darkened sector of the target to widen, because of the opposition to the flow of electrons in the direction of the control electrode.

It is advisable to allow both set and signal generator a period of at least 15 minutes to warm up before adjustments are attempted. Set the signal generator to 456 kc. Connect the output of the signal generator through a 0.1-mfd condenser to the grid of the first detector tube. Connect the ground lead of the receiver to the ground post of the signal generator. Connect an output meter across the primary of the speaker transformer through an 0.1-mfd, or larger, condenser, or across the voice coil. Turn the band switch to the range B position (standard-wave band). Turn the selectivity control to the sharp position and keep it in this position for all adjustments. Turn the volume control to the maximum position. Reduce the attenuator on the signal generator until the signal on the output meter is just readable. The signal in the speaker should be audible but not loud.

I-F Alignment

Adjust the five i-f trimmers individually, starting with the primary trimmer on the last i-f transformer and working towards the primary trimmer on the first i-f, for maximum output. Reduce the signal generator output as each stage

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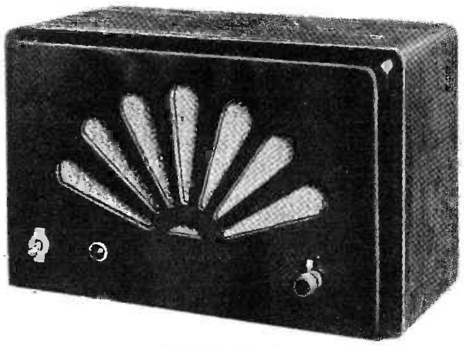

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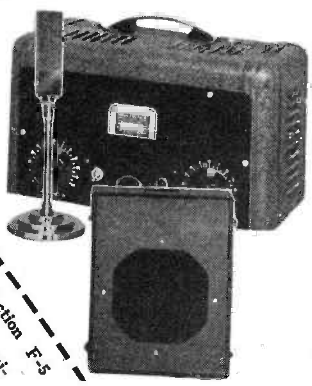

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is brought into alignment by means of the attenuator to keep the signal in the speaker just audible and prevent the leveling off action of the receiver's avc.

Repeat the i-f adjustments to assure greater accuracy.

Range B Alignment

After the procedure for each range, as explained below, is completed it is advisable to repeat the procedure as a final check.

1730-*kc adjustment*: Set the signal generator for 1730 kc. Turn the rotor of the tuning condenser to the full open position. Keep the band switch in the standard-wave position. Connect the antenna lead of the receiver through a 200-mmfd condenser to the output of the signal generator.

For this and all subsequent adjustments keep the volume control at the maximum position and attenuate the signal at the generator to prevent avc action.

Adjust the oscillator range B trimmer (C18) until maximum output is obtained. The location of this trimmer is shown in Fig. 2.

1500-*kc adjustment*: Set the signal generator for 1500 kc. Turn the rotor of the tuning condenser carefully until maximum output is obtained.

In sets using pointers, loosen the set-screw of the large pointer and set the pointer at the 1500-kc mark on the standard-wave band scale. Retighten the screw.

In sets using the moving beam of light, there is a moving light assembly held to the front of the drive drum by means of a screw. Loosen this screw and move the light assembly until it is at the 1500-kc mark on the dial. Retighten the screw.

Adjust the interstage range B trimmer (C10) and antenna range B trimmer (C4) to maximum.

Do not change the setting of the oscillator range B trimmer.

600-*kc adjustment*: Set the signal generator for 600 kc. Turn the tuning condenser rotor until maximum output is obtained.

Turn the rotor slowly back and forth at the same time adjusting the 600-kc trimmer until the peak of greatest intensity is obtained.

Range C Alignment

Caution: When aligning the short-wave bands be sure *not* to adjust at the image frequency. This can be checked as follows: Let us say the signal generator is set for 5000 kc. The signal will then be heard at 5000 kc on the dial of the radio. The image signal, which is much weaker, will be heard at 5000 less 912 kc, or 4088 kc. It should be necessary to increase the input signal to hear the image.

5800-*kc adjustment*: Set the signal generator for 5800 kc. Connect the antenna lead of the receiver through a 400-ohm resistor to the output of the signal generator. Turn the rotor of the tuning condenser to the full open position. Turn the band switch to the range C position (first short-wave band).

Adjust the oscillator range C trimmer (C17) until maximum output is obtained. See Fig. 2 for location of this trimmer.

5000-*kc adjustment*: Set the signal generator for 5000 kc. Turn the rotor of the tuning condenser carefully until maximum output is obtained. Adjust interstage range C trimmer (C3) until maximum output is indicated.

Do not change the setting of the oscillator range C trimmer.

1800-*kc adjustment*: Set the signal generator for 1800 kc. Turn the tuning condenser rotor until maximum output is obtained. Turn the rotor slowly back and forth at the same time adjusting the 1800-kc trimmer until the peak of greatest intensity is indicated.

Range D Alignment

18,000-*kc adjustment*: Set the signal generator for 18,300 kc. Connect the antenna lead of the receiver through a 400-ohm resistor to the antenna post of the signal generator. Turn the rotor of the tuning condenser to the full open position. Turn the band switch to the range D position (second short-wave band). Adjust the oscillator range D trimmer (C12) until maximum output is obtained.

15,000-*kc adjustment*: Set the signal generator for 15,000 kc. Turn the rotor of the tuning condensed carefully until maximum output is obtained. Adjust the interstage range D trimmer (C8) and antenna range D trimmer (C2) to maximum.

When adjusting the interstage and antenna range D trimmers, it will be necessary at the same time to turn the tuning condenser rotor slowly back and forth until the peak of greatest intensity is obtained.

Do not change the setting of the oscillator range D trimmer.

6000-*kc adjustment*: Set the signal generator for 6000 kc. Turn the tuning condenser rotor until maximum output is obtained. Turn the rotor slowly back and forth at the same time adjusting the 6000-kc trimmer until the peak of greatest intensity is obtained.

Phonograph Connections

Phonograph connections can be made as shown in Fig. 3. Knockouts are provided in the back panel of the chassis for mounting the phono jack and phono switch.

The connections are made by opening the diode return circuit at the volume control. This is done by removing the white wire connected to the insulated lug of the terminal strip on which one end of condenser C32 is also connected. The terminal strip is located at the back of the volume control. This wire is then connected to the phono switch as shown in Fig. 3. A wire should be connected from the lug on the above-mentioned terminal strip to the phono switch, as shown in Fig. 3. Both of the above wires are connected to the switch terminals nearest the chassis base and should be twisted together as far as possible and run as close to the back of the chassis base as possible.

The lead to condenser C32, after turning away from the back of the chassis base, should be run close to the 6C5 tube sockets.

Complete the other connections as illustrated in Fig. 3, using the lugs in the chassis base, located near the phono switch and jack, for grounding purposes.

The control-grid lead of the 6F6 power tube nearest the back of the chassis should be removed and a longer lead substituted. This lead is run from the tone control of the back of the chassis, along the lower edge and is then brought to the grid terminal by being routed between the speaker socket and the tubular condenser next to it.

If a hum is heard when the phono pickup is touched, reverse the two pickup leads.

Planetary Drive Assembly

The planetary assembly is the unit that is integral with the tuning shaft.

If the nut on the back of this assembly is too tight, the drive will be jerky and will turn hard in high speed. If this condition exists, back off this nut one or two turns and note the effect.

If this nut is too loose, the drive will slip in slow speed. The remedy in this case, of course, is to tighten the nut.

Should the condenser drive cord slip when the planetary pulley is turning, inspect the tuning condenser, drive drum and gears to see if they are turning properly or if they are being obstructed in some way.

If the drive turns unevenly (rough in spots), this may mean that the planetary assembly is defective or damaged internally and a new unit will be required.

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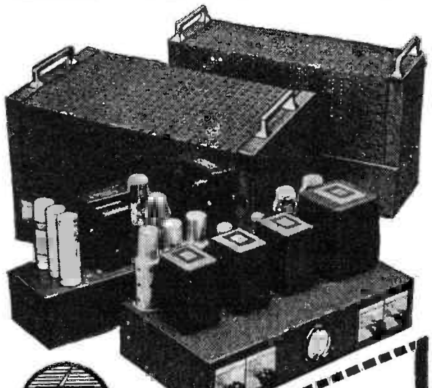

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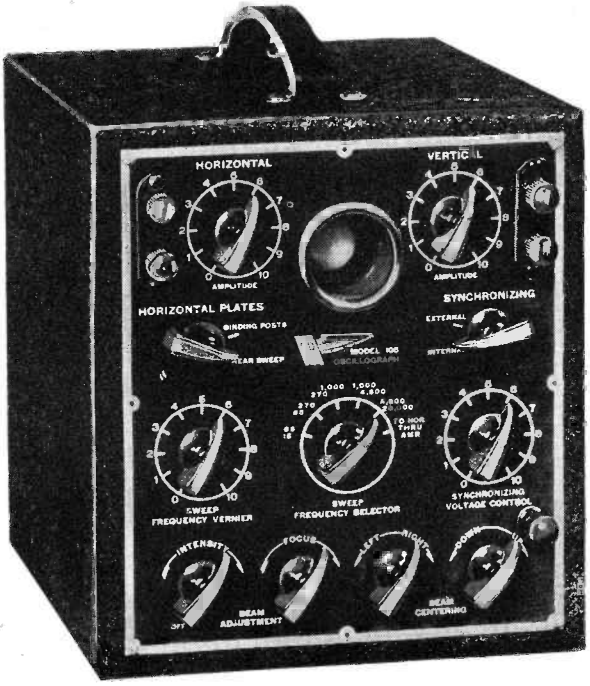

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Emerson V-155

The Emerson model V-155 is an 8-tube auto-radio receiver using glass tubes in a conventional superheterodyne circuit. The V-155 uses an external speaker which is plugged into the receiver chassis by means of a special 5-prong plug. The current drain of the receiver and speaker, at 6.3 volts, is 7.2 amperes. The frequency range is from 540 to 1530 kc.

The Circuit

An r-f stage using a 6D6 variable-mu pentode tube is employed ahead of the 6A7 combination first-detector-oscillator. A special cut center section of the tuning condenser maintains the frequency between the incoming signal and the local set oscillator. A single i-f stage is employed using the pentode section of a 6B7 tube and two doubly tuned i-f transformers. The diode section of the same tube is used as the second detector and avc rectifier. A type 76 is employed as first audio amplifier with a second 76 as a phase inverter stage. These in turn feed a pair of 41s operating in resistance-coupled push-pull.

A vibrator and step-up transformer arrangement is used to supply a-c to the 84 rectifier and its associated filter network which, in turn, supplies the plate and screen currents required in the receiver.

Alignment Procedure

Before removing the chassis from the case the speaker plug should be pulled from its socket. The speaker plug, however, should be replaced before the receiver is turned on. The tone control must also be removed from the case before the chassis can be removed. The large knob is forced over a knurled bushing on the tone control shaft and may be removed by pulling the knob away from the case.

It should be noted that one side of the speaker field is grounded to the speaker frame.

A small fuse is located in a tubular holder in the battery lead. To replace this fuse, remove the cap, insert the fuse and replace the cap. The fuse is intended to protect the receiver and in no case should one larger than 10 amperes be used.

I-F Alignment

To align the i-f transformers use a good modulated test oscillator set for 262.5 kc. Allow both the set and test oscillator to warm up for about a half hour before attempting adjustments. Rotate the variable condenser to the minimum capacity position. Turn the volume control on full. Ground the antenna to the chassis.

Connect the test oscillator output lead to the grid cap of the 6A7 oscillator-modulator tube through a paper condenser (0.02 mfd or larger). Do not remove the grid clip from the tube. Connect an output meter across the primary of the speaker transformer or across the voice coil. Use the smallest possible output from the test oscillator that will give a readable signal on the output meter reducing it as each stage is brought into alignment. Adjust the trimmers on the i-f transformers, starting with the secondary trimmer of the second i-f and working toward the primary trimmer on the first i-f, for maximum output. Repeat these adjustments.

R-F Alignment

Connect the test oscillator lead through a 0.0002-mfd condenser to the antenna connector. Rotate the variable condenser to the minimum capacity position (plates all out). Tune the test oscillator to 1530 kc and adjust the oscillator (center) trimmer, on the gang condenser, for maximum output. Set the test oscillator to some frequency near 1400 kc and tune the set until this signal

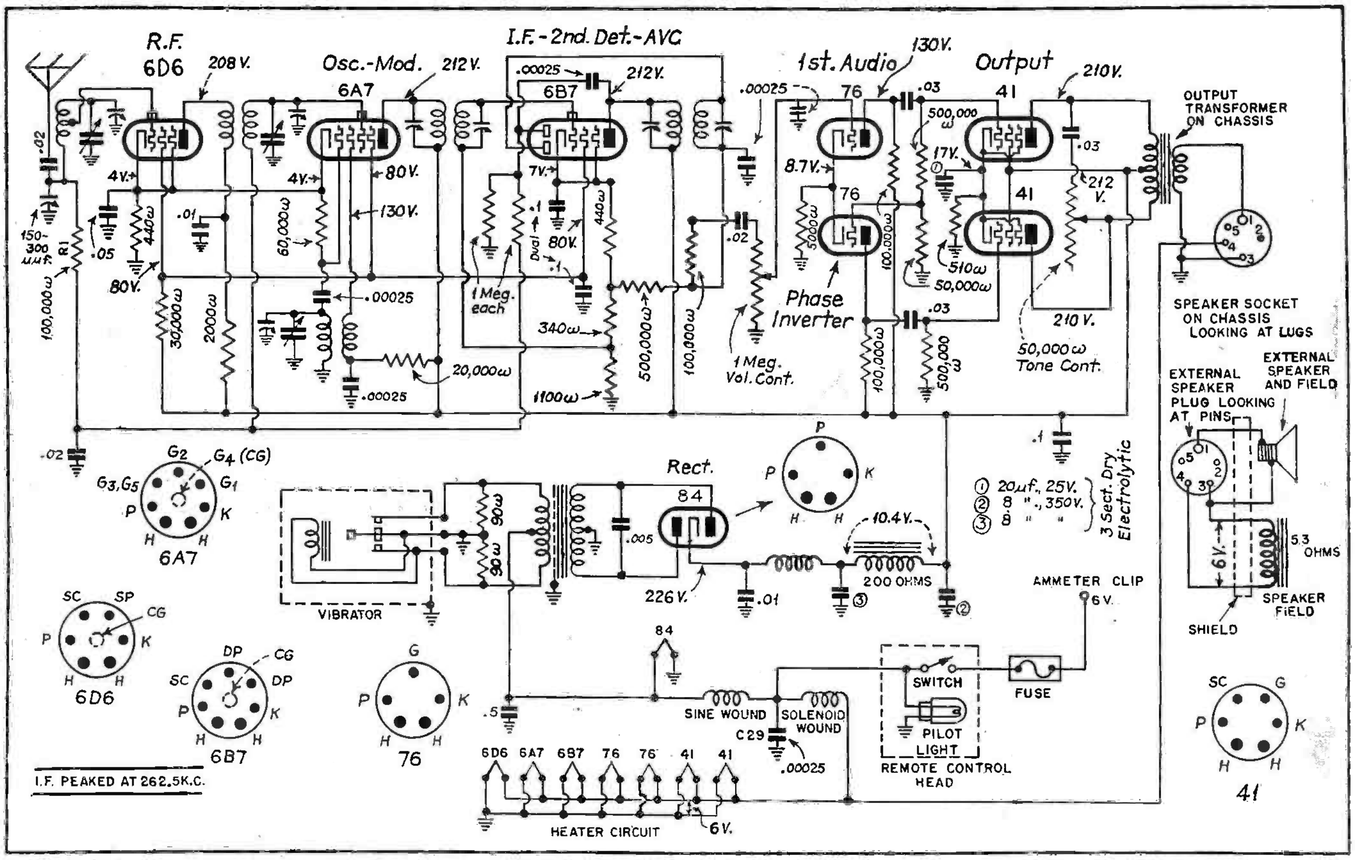

Fig. 1. Emerson V-155 circuit diagram.

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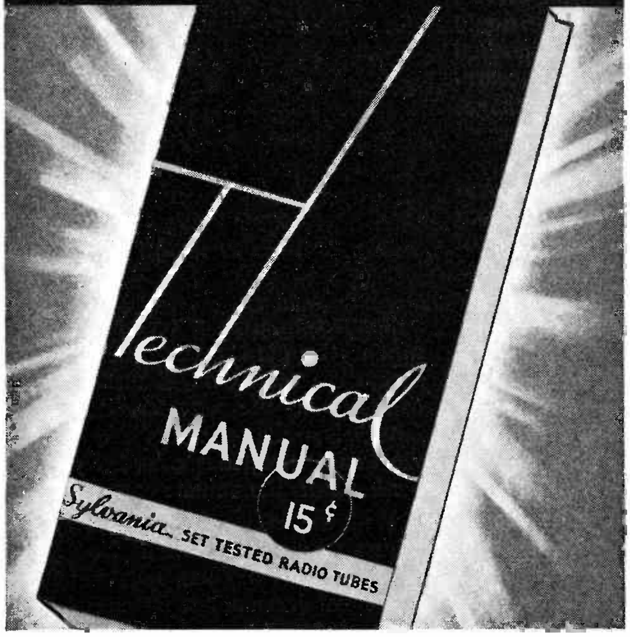

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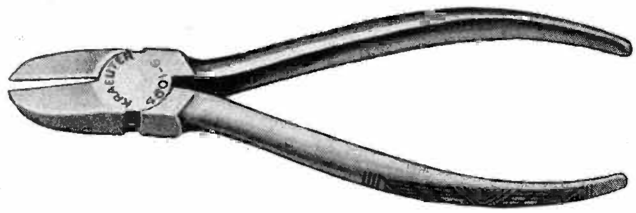

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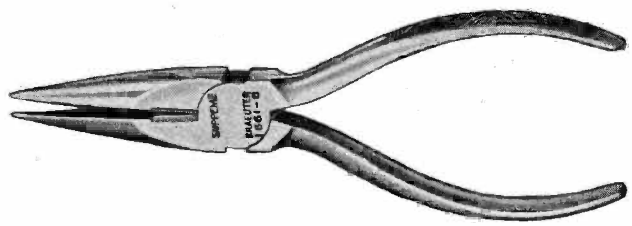

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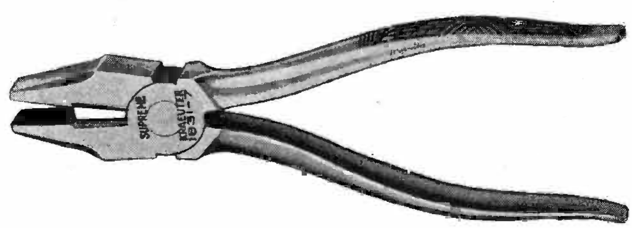

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The antenna padder should be readjusted after the receiver is installed in the car.

Arvin 29

The Arvin model 29 is a six-tube auto-radio receiver using "G" type tubes (glass tubes with octal bases) in a superheterodyne circuit. The frequency range from 540 to 1575 kc is covered with an available undistorted audio output of 4.5 watts. A complete circuit diagram is given in Fig. 1, with the tubes used, their functions and the voltages encountered on the socket prongs lettered on the diagram. The voltages were measured with a 1000-ohm-per-volt voltmeter with the antenna shorted to the chassis and the volume control on full. The input battery voltage was 5.8 volts when the measurements were made. The normal voltage present on the heaters should be 6.3 volts with a fully charged battery and is indicated as such on the diagram. It is assumed, however, that the average battery used on the service bench without constant charging would not show more than the 5.8 volts used in making the measurements. A corresponding increase in all the voltages should be expected if a fully charged battery is used.

In the Arvin model 29 the signal is first fed into a "phantom filter" which is designed to improve the efficiency of the car antenna and reduce the noise-to-signal ratio. A 6K7G r-f amplifier stage feeds the 6A8G first-detector-oscillator. A single i-f stage uses two Arvin "permaset" prebalanced intermediate-frequency transformers with another 6K7G tube. A 6Q7G is used as a second detector, avc rectifier and first audio stage. A 6V6G beam power tube is used to drive the dynamic speaker.

Alignment Procedure

The Arvin 1937 models are equipped with "permaset" prealigned i-f transformers which require no adjustment whatsoever. It is, therefore, necessary to adjust only the three screws located on the tuning condenser. Allow both the set and the test oscillator to warm up for about a half an hour before attempting any adjustments.

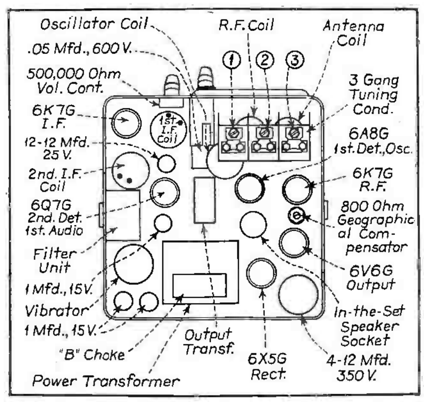

Fig. 2. Arvin 29 trimmer locations.

Connect the output meter across the primary on the speaker transformer or across the voice coil. Connect the test oscillator to the antenna and ground terminals of the "phantom filter." Rotate the tuning condenser completely out of mesh. Turn the volume control on full.

With the test oscillator set at 1575 kc adjust trimmer condenser No. 1 (see Fig. 2) for maximum output, keeping the signal just audible by means of the attenuator on the test oscillator.

Reset the test oscillator to 1400 kc. Rotate the tuning condenser until this signal is tuned to resonance (maximum deflection of output meter). Reduce the output of the test oscillator until the

(*Continued on page* 123)

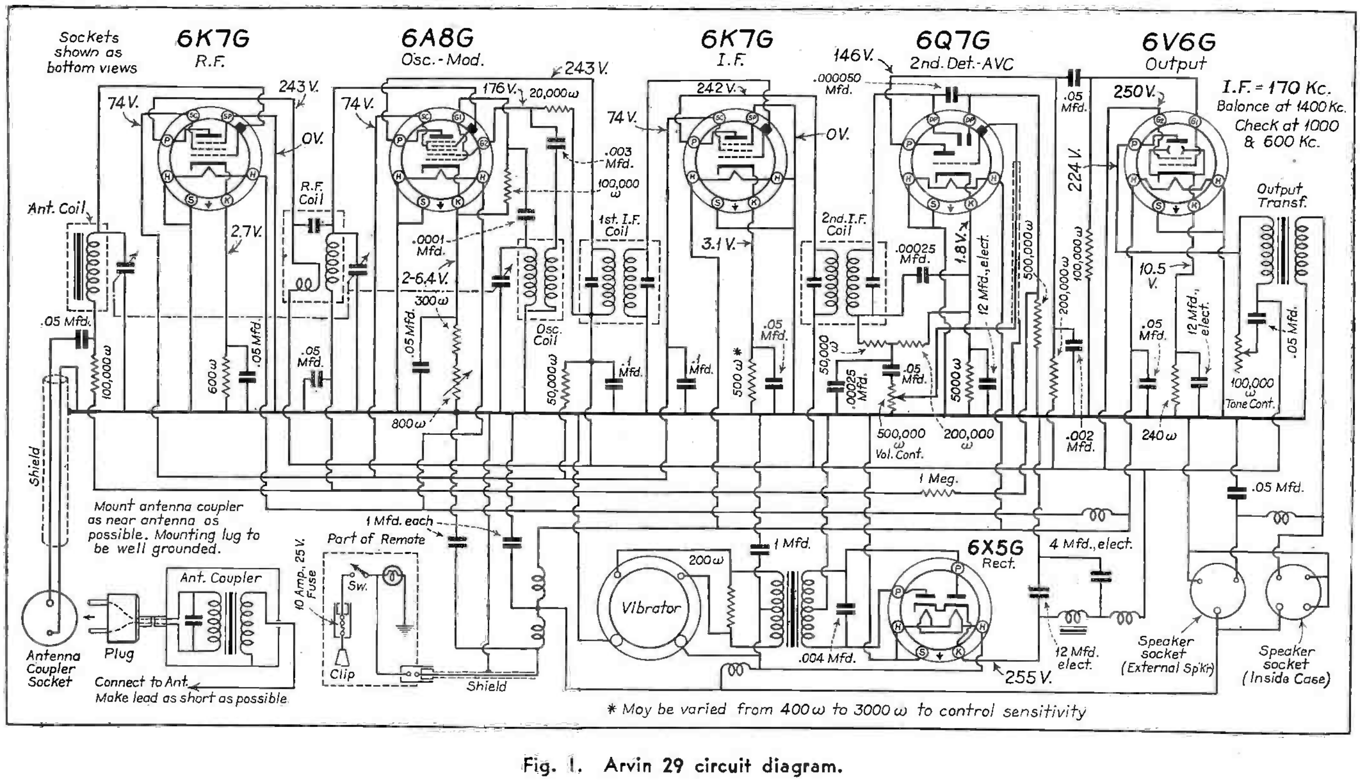

Fig. 1. Arvin 29 circuit diagram.

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ON THE JOB DEPARTMENT

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Testing Octal Tubes with Supreme Testers

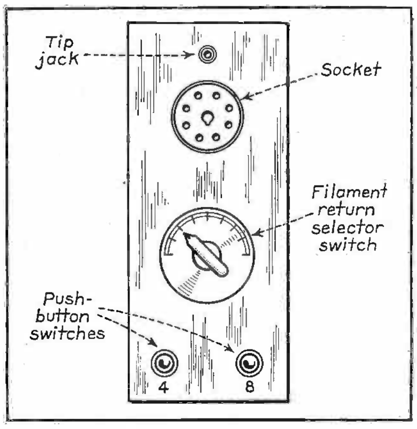
The more recent Supreme testers, not already adapted for testing octal-based tubes, may easily be adapted for these tests. Making the changes indicated may be more convenient than the use of numerous adapters.

The material required is 1 octal socket, button type; 2 single-pole single-throw push-button switches; 1 special circuit-opening 8-position switch; 1 tip-jack and 1 large and small grid-cap connector.

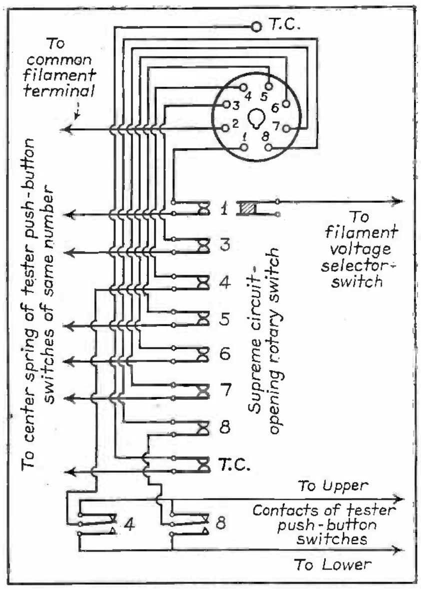
As there is insufficient room on the panel of the tester for the additional apparatus it is necessary to make a small auxiliary panel. This can be mounted in the cord compartment of the tester. Only half of the compartment need be used for the panel, leaving plenty of room for the attachment cord. The socket, switch, tipjack and push-button switches are mounted as shown in the sketch.

To date the No. 2 terminal of the octal tubes is always a heater connection. The other heater connection may be any other terminal. This is the purpose of the special filament return selector switch. No. 2 terminal is connected to the common heater terminal of the tester. The other seven connections and the grid cap are connected to their respective push-buttons through the filament return selector switch.

The buttons on the tester are numbered 1, 2, 3, 5, 6, 7 and TC. (top cap). This leaves terminals 4 and 8 of the octal socket without buttons. These are mounted on the new panel.



Auxiliary panel for tester.



Octal tube tester circuit addition.

To test the octal tubes determine from a tube chart the filament terminal numbers. For example: No. 2 and No. 7 for the 6K7 tube. Set the filament return selector to No. 7; allow the tube to heat. From the tube chart we find that the cathode terminal of the 6K7 is No. 8 Pressing button No. 8 causes the meter to read. Now adjust the quality selector knob on the tester until the meter reads about 70. Assuming the tube under test is known to be good, this method should be followed for several of each type of octal base tube and a table made showing the setting for the filament return switch and an average for the quality selector knob and also the number of the cathode button.

The principle of these testers is probably known to all who will have occasion to make the above changes. They are of the emission type. All tube elements are tied together by means of the various push-button switches. Pressing the cathode button of the tube under test puts the cathode in series with the meter, test voltage (value determined by the setting of the quality selector) and all the rest of the tube elements through the electron stream and back to the cathode

Robert P. Walters.

•

A-F from Dayrad 330

A 1-megohm rheostat connected between the "Neut" binding post and the ground post of the Dayrad Model 330 test oscillator will provide considerable range of audio-frequency variation. The rheostat may be mounted in the small lead compartment with the knob outside near the carrying handle. For lower frequency range a lower value grid leak may be substituted for the 6-megohm leak originally employed.

Few commercial tapers will give uniform control of the a-f range, the greatest variation will usually be bunched in about a quarter turn of the rheostat. The instrument is excellent, however, for locating rattles and buzzing.

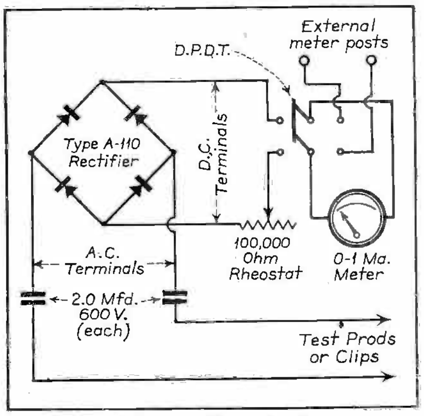
H. M. Bell

•

Meter Rectifier

The Kuprox type A-110 disc rectifier, or any similar low voltage disc rectifier may be used with a sensitive milliameter as an output meter in the manner indicated in the accompanying diagram.

The a-c terminals of the rectifiers are connected to the test leads through two 2-mfd, 600-volt condensers. The d-c terminals of the rectifiers are connected to an 0-1 milliameter with a 100,000-ohm rheostat and switch in series.



Meter rectifier circuit.

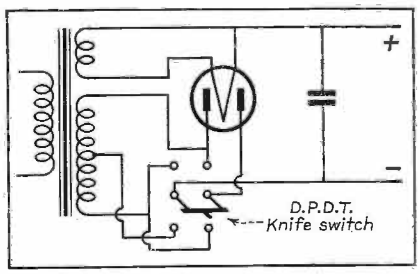
The instrument will thus work over a wide range of signal strength and the switch leaves the meter free for other uses.

H. M. Bell

Experimental Power Supply

The diagram given below illustrates a method of easily obtaining either low or high voltages from the same power supply for test and experimental purposes.

L. Baw



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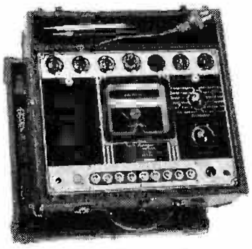

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Public Address . . .

DEGENERATIVE FEEDBACK AMPLIFIERS

By MAURICE APSTEIN

ALTHOUGH the general principle of degenerative feedback (also called inverse, stabilized, or negative feedback) was first advanced several years ago, it has been only recently that this system has been suggested for use in high-fidelity audio amplifiers. As originally developed it was intended for use in carrier-current telephony, and involved the feeding of a portion of the output voltage of an amplifier back to its input circuit in such a way as to cause the amplifier to become degenerative.

SIMILAR TO NEUTRALIZATION

Fundamentally, this is a special case of the generally familiar idea of neutralization; i.e., the control and stablization of the action of an amplifier circuit, or the neutralization of its undesirable characteristics, by the introduction of a feedback voltage possessing those undesirable characteristics in such a way that this voltage appears in the output circuit equal in magnitude, and out-of-phase with the original unwanted components. Such a feedback system will result in the cancellation in the output circuit, of the original undesirable characteristics of the amplifier and can be so arranged that the desired output remains essentially unchanged.

EARLIER ATTEMPTS

Earlier attempts to apply the principle to "wide-range" audio frequency amplifiers met with indifferent success for two easily understandable reasons.

Since the system depends for suitable action upon the proper phase relationships between feedback and signal voltage, an amplifier of variable phase shift does not possess uniformly degenerative characteristics. Thus the feedback might easily be out-of-phase at one frequency and in-phase at another causing oscillation or at least regeneration.

Like all other degeneration this feedback causes a loss in gain roughly proportional to the improvement of other characteristics and until recently this loss in amplification involved a sacrifice too great to be tolerated.

The advent of hi-mu voltage amplifier tubes and output tubes of very high power sensitivity made practical the design of high-gain resistance-coupled amplifiers of low-phase shift characteristics. With the two major objections to degenerative feedback removed, a flood of technical information has been released on the subject of feedback amplifier design. It has been the author's impression that these articles, although completely and technically correct from the *mathematical* point of view, have neglected to translate their quantitative data into a reasonably clear qualitative analysis of the action taking place in a degenerative feedback amplifier and have thus deprived a goodly portion of their readers, of a clear physical picture of what actually takes place in amplifiers of this type. It is with this expressed purpose that the present explanation of controlled degenerative action is offered. In an effort to divorce the treatment as far as possible from all mathematics except simple arithmetic, certain of the assumptions and analyses which follow may not be quantitatively exact; however, treatments from a mathematical standpoint are available from several sources.

IMPROVEMENTS CAUSED BY FEEDBACK

It has been said that degenerative feedback results in improved frequency response in the amplifier itself; reduced effect of a variable load on response; reduced distortion, and reduced hum and noise level. These improvements are mainly attained at the cost of a loss in gain which must be made up by additional amplification. Some further advantages of degenerative feedback seem possible. These are: the possibility of utilizing specially designed loads to control frequency response and increased stability of operation where tubes actually have too high a power sensitivity and have a tendency toward oscillation and transient phenomena. Examination will show how all of these effects can be obtained.

Fig. 1 is a conventional circuit of a single-tube amplifier without feedback. The gain of the stage at some middle frequency (say 1000 cycles) is 10. Fig. 2 is the same circuit with a feedback voltage tapped off the divider R_1 R_2 and introduced in series with the input voltage, by putting it in series with the secondary of the input transformer. Since grid and plate of an amplifier are normally opposite in phase with respect to voltage, this feedback voltage will be out-of-phase with the grid or input voltage. If the voltage developed across R_2 is 10 percent of the output voltage (or if $R_2 = 10$ percent of $R_1 + R_2$) we have 10 percent feedback. Neglecting the condenser C_1,

$$\text{Percent feedback} = \frac{R_2}{R_1 + R_2} \times 100.$$

Suppose in Fig. 1, there is 1-volt input to the grid of the tube. The voltage across the primary of the transformer will be 10 volts. Now considering Fig. 2: if 10 percent or 1 volt of this output is fed back to the grid circuit, it will cancel out the 1-volt input and there will be no output. Suppose, however, that in order to get the same output as in Fig. 1 the input voltage is increased to 2 volts. The effective input voltage is 1 volt again and the output voltage 10 volts, but the effective gain has been cut in half, since Fig. 2 requires 2 volts input to give the same output as Fig. 1.

NEUTRALIZING FREQUENCY RESPONSE

Analyses of Fig. 2 at some other frequency besides the representative 1000-cycle frequency will show how frequency variations are neutralized. Suppose at 50 cycles the response of the amplifier falls off 10 percent. This means that the gain at 50 cycles is 9 instead of 10, and 9 volts appears across the output. Feeding back 10 percent of this cancels out only 9/10 volts of the original signal, leaving 1.1 volts to be effective at the grid. 1.1 volts times 9 gives 9.9 volts in the output which is only 1 percent less than the 1000-cycle output. Thus a 10 percent gain variation in the amplifier results in only a 1 percent variation in output by virtue of the fact that the feedback voltage tends to increase the effective gain of the amplifier to compensate for falling off in response.

REDUCING DISTORTION

In analyzing the circuit from the standpoint of the reduction of distortion, we must remember that the feedback voltage contains not only the original signal but whatever distortion the amplifier has introduced. Since the signal voltage has no distortion in it (theoretically) when the 1-volt feedback cancels 1 volt of signal the distortion component of the feedback is left over and the resultant effective input voltage is really 1 volt plus this distor-

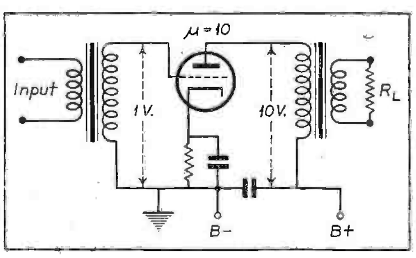

Fig. 1. Single-stage amplifier.

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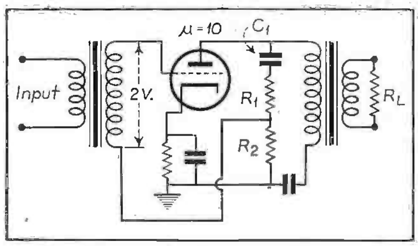

Fig. 2. Single-stage amplifier with feedback.

tion. Since the feedback voltage is in phase with the output voltage, by the time it gets back through the tube and into the plate circuit, its phase has been changed by the tube with the result that it reappears in the plate circuit in opposition to the original distortion and the two tend to cancel each other.

Referring to Fig. 2, the 2-volt, 1000-cycle signal would contain, say, 10 percent distortion. In the 10 percent, or 1-volt, feedback there would be included 0.1-volt distortion. The feedback voltage in cancelling a part of the input voltage has this 0.1-volt of distortion left over with the balance of the input voltage applied to the grid of the tube. Being amplified 10 times by the tube, it would appear in the plate circuit as 1 volt or equal in magnitude and out-of-phase with the original distortion voltage from which it was obtained. Thus in this particular case of an amplifier whose normal gain was 10, 10 percent distortion would be reduced to a negligible value by 10 percent degenerative feedback.

Of course, as previously mentioned, the actual numerical values indicated here would not hold exactly since complete cancellation of the distortion in the output would also eliminate it from the feedback voltage and the distortion would be allowed to return. Obviously some balance condition obtains.

When the feedback is accomplished, as in Fig. 2, the distortion and frequency response of the output transformer have little or no effect on the feedback voltage. Consequently, the circuit would compensate only for frequency discrimination due to the tube itself and tube distortion. If the feedback voltage were taken off after the output transformer, as in Fig. 3, it would tend to counteract frequency and amplitude distortion due to the transformer also.

From the above may be drawn the generalization that feedback can only reduce frequency and amplitude distortion originating in the circuits between the points of feedback.

It can be seen that everything that has been said about distortion will also hold true with respect to the cancellation of hum, noise or any other component of the output (and therefore the feedback voltage) which is not present in the signal voltage. It is however equally true that hum or tube noise from stages previous to the feedback points will not be affected by feedback.

Limitations

From the previous paragraphs it would seem that the advantages to be derived from degenerative feedback are too good to be true. There are however certain definite limitations on the introduction of feedback which determine where it can be applied and limit the amount of degeneration possible in a given amplifier. During analysis of feedback action we have assumed that if we fed back a representative (1000 cycles) frequency, in such a way that it was opposite in phase to the signal voltage, all other frequencies would likewise be opposite in phase. This is un-

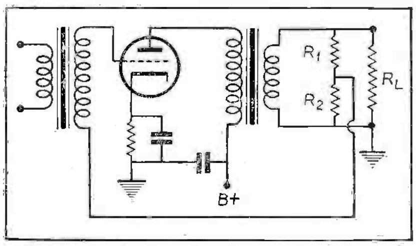

Fig. 3. Feedback from transformer secondary.

fortunately not true. Phase shift in amplifiers varies to some extent from one end of the response band to the other. Obviously if the phase shift at one end of the response band is more than 180 degrees with respect to the 1000-cycle frequency, some feedback at this frequency will come back in phase with the input and result in regenerative action or oscillation. As long as the phase shift is less than 180 degrees, however, feedback will remain degenerative and the amplifier will remain stable. Phase shift characteristics of conventional single-stage amplifiers are as follows: Resistance or impedance coupling up to 90 degrees; transformer coupling up to 180 degrees.

It is also generally true that those amplifiers which have the least phase shift have the best frequency response. Unfortunately, this means that circuits which need frequency stablization most are limited in the extent to which they are applicable to feedback.

The drawbacks do not become serious, however, unless attempt is made to feedback across more than one stage. In general, two-stage feedback should not be attempted with transformer coupling unless specific design has limited the total phase shift to less than 180 degrees. Resistance-coupled stages may permit two-stage feedback, but usually offer difficulty in introducing the feedback voltage so that it is effectively in series with the signal. Two possible compromises suggest themselves.

A two-stage amplifier with resistance coupling between stages, but an input transformer to which to feed the signal (Fig. 4). Here the maximum possible phase shift is 180 degrees and in practical circuits could be made much less. If the phase shift were made inherently low in the amplifier itself the feedback divider R_1 R_2 could be shifted to the secondary of the output transformer with the additional beneficial results previously noted.

A multi-stage amplifier with any type coupling in which some feedback is accomplished in each stage. (From each plate circuit to its own grid). While this system does not allow large percentages of feedback except at extreme sacrifice in gain, it should result in very stable operation and far less frequency and amplitude distortion than would be possible without feedback.

Cathode Degeneration

There remains for consideration only two other major aspects of the feedback situation—feedback by means of cathode degeneration and the effect of feedback on plate resistance. It is convenient to consider these two aspects simultaneously.

In the previous circuits degeneration has been obtained by tapping off a suitable feedback voltage from the output. This type of feedback should be termed plate feedback. Aside from the previously mentioned effects plate feedback reduces the effective plate resistance of

(*Continued on page* 104)

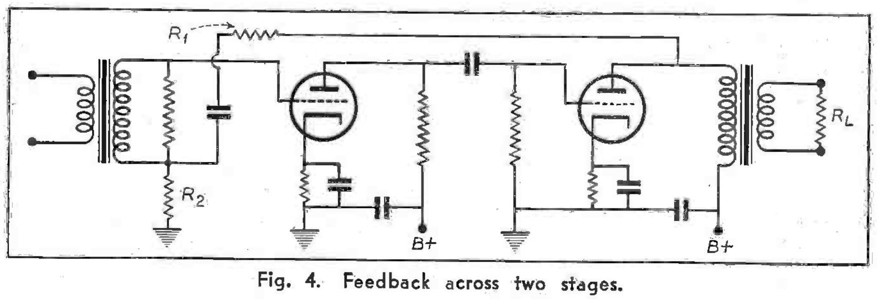

Fig. 4. Feedback across two stages.

RECEIVER CASE HISTORIES

Belmont 777 (Series B)

Intermittent loud hum: This has been caused by the 0.25-mfd condenser (C-18 on diagram) which connects from the junction of resistors R-12 and R-13 to ground opening intermittently. This condenser is one section of a dual condenser, tubular in form, and has the common connection of a metal band which also acts as a support.

As such, at first glance the condenser may not be recognized as a dual one.

Inoperative: Terminal of 19,000-ohm resistor (R-5) in plate circuit of type 76 oscillator tube, has been found to make direct contact with terminal of 100-ohm resistor (R-14), also in oscillator plate circuit, thus shorting out oscillator coupling coil. This condition may be remedied by forcing resistor leads to different positions.

Howard J. Surbey

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Chevrolet 1935 Auto Radio

Weak: Voltages and tubes check O.K. Adjusting the first i-f transformer trimmers has no effect on signal. Check the transformer for excessive wax. Remove the wax by heating in an oven and drying, or replace the unit. Realignment of course is necessary; i-f peak 262 kc.

Allan Siepman

•

DeWald 617

Ignition intereference: This receiver has been designed to operate without the use of either sparkplug or distributor suppressors. If the ignition system is faulty, or if the set is installed in an older model automobile where the ignition system radiates badly, it may be necessary to place a suppressor at the distributor in series with the main high tension lead. If sparkplug interference is still noticed it may also be necessary to place a suppressor on each plug.

It is important that all items and connections in the electrical system of the car be in good condition.

•

Emerson 108, 110 (Chassis U5A)

Loud hum: If these models hum loud ly, after checking the filter condensers, rectifier tube, etc., look for a short circuit between the pilot light resistor (R-10) and the chassis. This resistor may be replaced by a 25-ohm, 10-watt wire-wound unit well insulated from the chassis.

E. M. Prentke

•

Emerson C-134, C-136, C-138, C-139, C-140, C-142

Production changes: On early receivers the r-f and oscillator trimmer condensers (C4 to C12) were air trimmers (part No. 3AC-252). Clockwise rotation of the screws on these trimmers decreases the capacity.

On receivers with serial numbers above 880,050 the short-wave antenna and detector coil trimmers (C6 and C9) for the 5.5- to 18.0-mc band are mounted on their respective coils. The antenna stage trimmer (C6) is connected directly across the secondary of the short-wave antenna coil (T-3) and is not returned to ground as shown in the schematic.

•

Firestone-Stewart-Warner R-1431 (Chassis R-143)

Inoperative, no voltages: Voltage readings across the plate-to-cathode circuits of the rectifier tube, but none across the plates. This is probably a shorted 0.01-mfd, 1500-volt condenser (No. 21) connected across the transformer secondary. This condenser is located right on top of the transformer. It is not necessary to disconnect the transformer from the chassis as first inspection might suggest. The transformer can is held in place by four nuts. Removing these, and then the can, exposes the transformer. The condenser can be replaced without disconnecting any other leads.

G. D. Allen

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Ford-Philco 1937

Ignition interference: These receivers use a coupling transformer between the antenna and the lead-in. This transformer is located behind the header board. When the lead-in is disconnected from the set the noise will stop. If the antenna lead is disconected from the coupling transformer the noise will continue.

The lead-in shield is soldered to a lug rivetted to the transformer can. The rivetted connection is often unsatisfactory. The shield should be soldered directly to the can.

L. M. Lorenzen

•

Grunow 821 (Chassis 8B)

Volume cannot be reduced on local stations: Check second detector cathode bias condenser for short or open. Replace if necessary; value 8 mfd, 25 volts.

E. J. Bancroft

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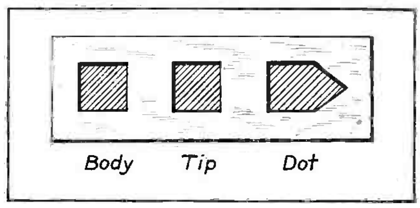
Midwest 16 to 34

Color codes: Resistance values in this and other Midwest receivers may be determined by considering the painted markings on the resistors as shown on



the sketch above, and applying same to the standard RMA color code. That is, use the color on the pointer section of the resistor as the dot; the color next to the pointed section as the tip, and the remaining color as the body.

Howard J. Surbey

•

Philco 19, 89

Failure of oscillator between 550 and 900 kc: The failure of the oscillator in this model over part of the tuning range is often caused by too high a bias on the cathode. Reducing the cathode resistor on the 36 tube from 10,000 (or 12,000) ohms to 8,000 ohms will remedy the trouble. Defective or loose connections on the oscillator coil lugs or the tuning condenser stator can also cause this difficulty. It is advisable to clean and resolder these connections in all cases where trouble in the oscillator circuit exists.

Everett Roberson

•

RCA 9K, 10T, 10K

Cuts on and off at long intervals: When the set cuts off tests show the equivalent of an open antenna coil. The defect, however, is in the band switch. The contact with the blue r-f coil lead works loose. Tightening the contact springs at this point should clear the trouble.

Arthur N. Fonskov

•

RCA 128, 224

Inoperative: Tests show no screen voltages. This is caused by a shorted 4-mfd screen by-pass condenser (C-16).

Motorboating: Check the 4-mfd screen by-pass (C-16) for open circuit.

Weak for first hour, or so, of playing: Check 6B7 plate coupling condenser (C-39, 0.02 mfd) for partial open while cold.

E. J. Bancroft

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Silvertone 1320, 1322, 1324, 1326, 1386, 1450

Wiring diagram: In servicing these models, if the wiring does not follow the diagram check against the diagram for the Colonial 47, 48.

G. D. Allen

(*Continued on page 106*)

the tube in the following manner:

Plate resistance may be defined as the ratio between a given small change in plate voltage and resulting change in plate current, or

$$R_p = \frac{\text{change in } E_p}{\text{change in } I_p}$$

If in Fig. 2, the plate voltage increases, the feedback voltage increases making the grid more positive than before. The positive grid tends to increase plate current still further. Hence the same change in plate voltage will accomplish a greater change in plate current with feedback than without. By our definition of plate resistance, this means that R_p has been reduced. The effect of lower plate resistance on performance will be discussed later.

If we remove the cathode by-pass condenser in Fig. 1, when a signal is applied to the input an a-c voltage appears across the cathode resistor due to the variation in plate current. The voltage is opposite in phase to the signal voltage and is effectively in series with it with respect to the grid and cathode of the tube. This cathode degenerative action results in some distortion cancellation, but it is not as effective as the previously described plate degeneration.

Since the feedback voltage is dependent upon the *variation in plate current* and not upon the characteristic of the load impedance or the voltage developed across it, the only distortion contained in the feedback is that due to a nonlinear plate current characteristic. Such a circuit is beneficial only to the extent that it reduces plate circuit distortion, but does not equalize frequency response or reduce distortion due to the coupling network, since these distortion components are not present in the feedback voltage. In certain circuits, notably resistance-coupled voltage amplifiers frequency discrimination and distortion due to the plate coupling network is negligible over the operating range and in such cases cathode degeneration provides a simple and effective method of reducing the remaining distortion due to nonlinear operation of the tube.

It cannot be emphasized too strongly, however, that cathode degeneration does not improve frequency response nor reduce distortion introduced by the output coupling network. A serious disadvantage is that it increases (unlike plate degeneration) effective plate resistance. An increase in plate voltage increases plate current, causing the feedback voltage to increase. In this case, however, increased feedback means a more negative grid which tends to reduce plate current. Thus a larger increase of plate voltage is necessary with cathode feedback to produce the same change in plate current than is necessary without feedback. Obviously, R_p is therefore effectively increased. The results of relatively high or low-plate resistance upon frequency response can be appreciated by an examination of Fig. 5. If the load resistance is less than three times the plate resistance

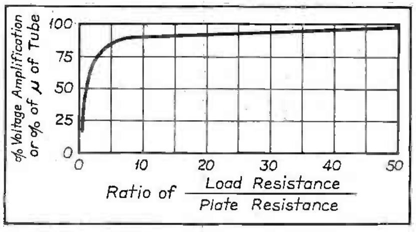

Fig. 5. Percentage of available amplification vs. ratio of load resistance to plate resistance.

$$\left(\frac{R_L}{R_p} < 3\right)$$

it can be seen that any slight variation in load resistance will greatly affect the amplification. If the load resistance is more than three times the plate resistance, wide variations in load resistance have little effect on amplification (and therefore response). In general the greater the ratio of R_L to R_p the less effect variations in load resistance will have upon the response.

High-mu pentodes and tetrodes when used as output tubes, are operated with a load impedance which is a small fraction of the plate resistance. Moreover, in practical circuits this load resistance takes the form of the primary of the output transformer whose impedance is determined by the speaker load on its secondary. The impedance of a conventional speaker varies between wide limits and consequently this variation has a tremendous effect upon the load impedance which the output transformer presents to the output tube, with a consequent large and variable effect upon frequency response. Since plate degeneration reduces effectve plate resistance it minimizes the effect of variations in load impedance. Conversely, because it increases effective plate resistance, cathode degeneration tends to increase frequency discrimination due to variable load impedance and is therefore generally unsuitable for the output stage.

Cathode degeneration has been suggested as a method of reducing distortion in single tube pentode or tetrode output stages. Results in this application may be very misleading, depending upon the level at which measure-

(*Continued on page* 123)

Sparton 67, 68, 68-XS, 685, 691

Inoperative: Voltmeter tests immediately indicated a shorted plate return by-pass. The original condenser (C9) was marked 0.2 mfd, 600 volts. Replace with a 0.25-mfd unit 600-volt rating if an 0.2-mfd unit is not available.

L. Baw

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Stewart-Warner R-149

For modulation hum: (On stations only) Make these changes even though no modulation hum is heard in the shop. Connect the 6J7 screen grid to the 6K7 i-f screen grid. Remove the 0.01-mfd condenser and 110,000-ohm resistor connected to the i-f screen grid. Add a 0.01-mfd, 1,500-volt line buffer condenser from chassis to the side of the power transformer primary not already connected to original line buffer.

For residual hum: (Between station hum) Locate the red-blue wire running from the 5V4G socket heater terminal to the speaker socket. Disconnect one end of the wire and re-route the wire along the back of the chassis so that it is at least two inches above the 6H6 and 6C5 sockets when the chassis is upside down. Re-connect the wire.

Locate the long blue wire running from the power transformer to the front 6L6 socket. Cut this wire so that the part from the power transformer is about 7 inches long and connect it to the grounded heater terminal of the 6K7 r-f socket (see diagram). *Remove the balance of this wire which goes to the 6L6 socket.*

A twisted pair should be placed along the front of the chassis so it can be used to connect the heater terminals of the 6K7 r-f and the 6L6 sockets.

Remove the input audio transformer mounting screw nearest the front of the set. Rotate the transformer around its other mounting screw so that the free end can be fastened by one of the output transformer mounting screws. Pull the transformer leads away from the tube sockets.

Tighten down the power transformer mounting bolts, preferably when the set is hot.

Check the set for residual hum and if there is still too much install a filter choke and condenser as explained below.

Mount and connect the filter choke (part No. 110058) as follows:

(a) Drill two holes in the back of the chassis so that the choke can be mounted in the position shown in the diagram.

(b) Connect the red-blue choke lead to the unused 5V4G socket terminal.

(c) The long red-blue wire from the speaker socket should be unsoldered from the 5V4G heater terminal and connected to the unused 5V4G socket terminal to which the red-blue choke lead is connected.

(d) Connect the red choke lead to the 5V4G heater terminal which is connected to the input electrolytic condenser by a red-blue wire.

Mount and connect the 8-mfd, 450-volt electrolytic condenser (part No. 110057) as follows:

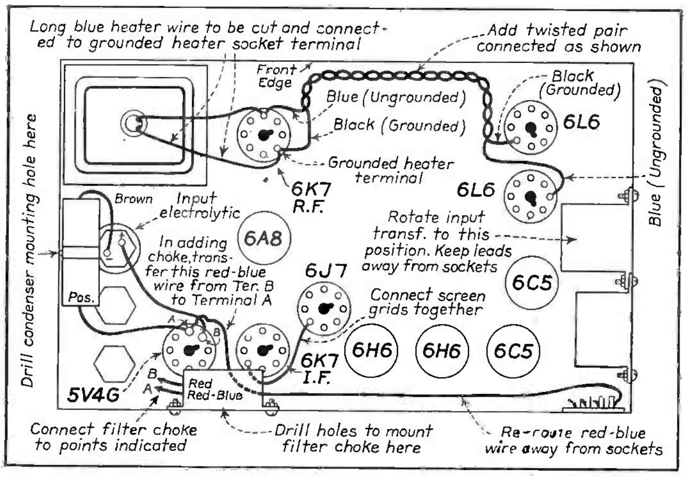
(a) Drill a hole in the end of the chassis, 5¼ inches from the front and ⅜ inches from the bottom, and mount the condenser as shown, so that the brown lead is towards the front of the chassis.

(b) Connect the brown condenser lead to the negative terminal of the input electrolytic condenser (the condenser nearest the power transformer).

(c) Connect the red-white condenser lead to the dead 5V4G socket terminal to which the red-blue choke and speaker socket wires were connected.

Important: If to much hum still exists after making the above changes, it is most likely caused by defective tubes. Although any of the tubes can cause hum, the 6L6s should be checked first by noting whether they heat up equally. This can be done by touching them after the set has been turned on a few minutes. If the temperatures are obviously unequal, try replacing both the hot and the cold tubes, first one, then the other. Unbalanced rectifier tubes can also be the reason for hum.

J. N. Golten
STEWART-WARNER CORP.



Stewart-Warner service change.

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Wells-Gardner OF, 2DL

Trimmer replacement: If one trimmer of the gang trimmer strip used in this model should become defective, it is not necessary to replace the entire strip. A single trimmer (part No. P-17A36) 150 to 250 mmfd may be used.

Disconnect the lead from the coil side (side not grounded) of the defective trimmer in the strip. Connect this lead to the single trimmer. Connect to the side not in contact with the adjusting screw. The other side of the single trimmer should then be connected to a good ground, using a heavy wire to support the trimmer adequately. In replacing the trimmer be sure to keep both leads as short as possible and keep the ungrounded lead as far from ground as possible.

The defective trimmer can be left in place in the gang but without connection.

•

Wells Gardner 07A

Inoperative, all d-c voltages low: The cause of this condition was traced to a badly burned tone control. This suggested a shorted tone control condenser. However, this was not the case. The condenser checked O.K. Further investigation disclosed defective insulation of the control itself. Replacement was necessary; value 150,000 ohms.

L. Baw

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Zenith 4V31, 4V59 (Chassis 5405)

Intermittent operation: Often caused by a defective low-frequency padding condenser (C2); value 200 to 550 mmfd.

No reception on low frequencies: If battery voltage is O.K. replace the 15 oscillator-first-detector tube.

J. E. Steoger

•

Zenith 666 (Chassis 5616)

Noisy: Noisy reception, evident when the set is in the car but absent when it is removed to the service bench, is often caused by a loose nut that holds the oscillator coil to the can. The nut is located under the tuning condenser gang. It will be necessary to remove the chassis to tighten the nut.

Allan Siepman

TEST EQUIPMENT . . .

Set Tester Circuits

In radio service, or maintenance work, the Service Man is interested in several groups of measurements. The first group involves the fall of potential across any circuit, being measured in volts, or in smaller or larger graduates such as millivolts or kilovolts, the last being very rarely used in present-day service work. The second group depends upon the rate of flow of current through any given circuit, and is measured in amperes or its equivalent larger or smaller graduates, such as microamperes, milliamperes, etc. The product of the fall of potential across the circuit and its flow of current result in the amount of power dissipated by the circuit which is measured in watts, certain other factors being taken into consideration in a-c measurements. Other electrical measurements such as capacity, decibels, tube quality, etc., have circuits peculiarly adapted to their use. Inasmuch as we have no method whereby we can, through human senses, measure these quantities, it is necessary to fall back on external physical bodies actuated by mechanical or electrical forces to do our measuring for us. Thus we have the electrical meter which responds to the effect of electricity upon a given circuit. A meter may be calibrated in standard units of voltage, current, power, etc.

D-C Voltmeter Circuits

When a meter has a full-scale of 1.0 ma, the required series resistance necessary to make the meter read a 1-volt potential at full-scale deflection is 1,000 ohms. This is the "ohms-per-volt" designation and is always equal to the total resistance of the internal meter armature resistance and the external resistor, or R_t, divided by the required maximum voltage for full scale deflection. Stated as a formula:

$$R_{pv} = \frac{R_t}{E_t}$$

As the resistance-per-volt value of the meter is equal to the total external and internal meter circuit resistance divided by the maximum voltage value for full-scale deflection, to compute the total external and internal resistance value for any voltage range, it is only necessary to multiply the "ohms-per-volt" value of the meter times the maximum voltage for full-scale deflection required.

This formula is as follows:

$$R_t = R_{pv} . E_t$$

In other words as a 1-ma meter has an "ohms-per-volt" value of 1,000 if a total deflection scale value of 7 volts is required, it is only necessary to multiply 1,000 times 7 equalling 7,000 or the necessary number of ohms internal and external resistance for a 1-ma meter to be used as a 7-volt full-scale voltmeter.

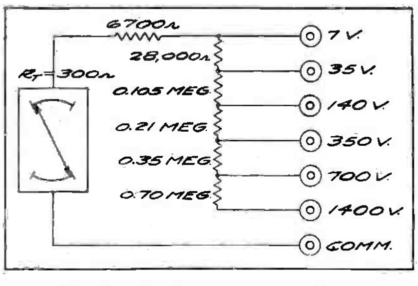

Fig. 1. Voltmeter connections.

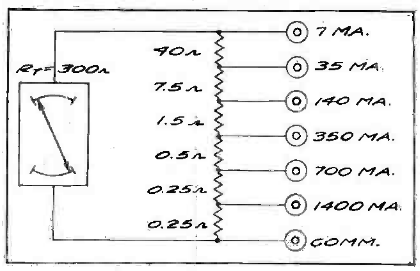

Fig. 2. Milliammeter connections.

As the internal armature resistance of the meter is approximately 90 ohms and, therefore, the external resistor necessary to bring it up to a common 300-ohm value is approximately 210 ohms, the additional resistance necessary to be used in the 7-volt voltmeter circuit would be 6700 ohms.

A typical multi-range voltmeter circuit (as used in most of this year's radio testers) utilizing a 1-ma meter is illustrated in Fig. 1. As can be seen by the diagram, the 35-volt range, inasmuch as the meter has an "ohms-per-volt" value of 1,000 would require a total of 35,000 ohms, this being made up of the internal resistance of the meter (90 ohms approximately), the external compensating resistor (210 ohms approximately), the 6700-ohm resistor for the 7-volt range and the 28,000-ohm additional resistor to make up a total resistance of 35,000 ohms. The 140-volt range would require 140,000 ohms and, inasmuch as we already have a total series resistance of 35,000 ohms it is only necessary to add a 0.105-meg. resistor to make up the correct value. The balance of the ranges are calibrated in exactly the same manner.

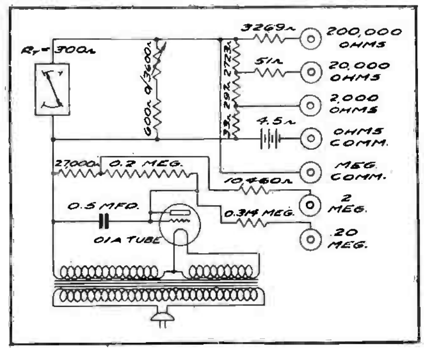

Fig. 3. Ohmmeter connections.

D-C Milliammeter Circuits

When using a meter to measure the current passing through any circuit, it must be borne in mind that the total current passing through the circuit to be measured must also pass through the meter or be by-passed around the meter through the use of a "shunt" resistor. If a circuit to be measured is carrying a current of 7 ma, we may use a 7-ma meter or a 1-ma meter and a shunt resistor which will by-pass the balance of the 6 ma. In servicing work, it is not possible to standardize on any one meter movement which will take the total current to be measured, and also give an indication of the smallest amount of current to be measured, without using some combination of shunt resistors.

In the 1-ma meter circuit designed for current measurements and used with most of the 1937 Supreme line, the total shunt resistor has a value of 50 ohms and is tapped for lower shunt resistor values according to the various higher current ranges desired, as shown in Fig. 2. In this case, if a total current of 7 ma must pass through the meter circuit and only 1 ma maximum may flow through the meter, a resistor which is exactly one-sixth the total external and internal meter resistance must be used to by-pass or "shunt" the other 6 ma of current. As the total meter resistance is 300 ohms, 1/6 of 300 ohms would be 50 ohms.

For the current measuring ranges above the 7.0 ma range the 50-ohm shunt resistor is tapped at several smaller resistor values, thereby forming what is known as a "ring-type" shunt, the total "ring" resistance value is 350 ohms. The sectional resistance values of the 50-ohm shunt resistor are calculated by multiplying the total "ring" resistance (350 ohms) by the full-scale current of the meter (.001 ampere), dividing the result by each range value, in turn, from the common terminal, and subtracting the sum of the preceding values from each newly determined value. So, by mutilplying 350 ohms (the "ring" resistance) by .001 ampere (the full-scale meter current) we have a value of 0.35

Pick-up Facts

This will answer a great many letters on the question of tone-arm mounting:

Any radial play-back mechanism, to be effective, must recognize simple geometry. From the very nature of the circular object called a record and the path inward which is taken by the needle, it is obvious that "tangency" (the angle at which the actual "functioning axis" meets the record) varies as the needle progresses.

Contrary to some erroneous opinions,—the arm should be so mounted as to definitely favor the inner grooves as much as possible. To one versed in the art, the reasons for this are obvious. The fact is that the outside grooves can much better stand a tracking error than the inner ones. For that reason the leading phonograph companies long ago adopted an arm-mounting generously favoring the inner grooves.

It is possible to average up the errors over all the grooves, either by varying the distance of arm-pivot from center of record, or, as has been done back in the Victrola days, in the case of short arms, the reproducer head itself, may be put at an angle to the arm. However, unless properly executed, this only "robs Peter to pay Paul,"—taking it away from the inner grooves and giving it to the outside ones. In no case should this be done unless the error on the outside grooves becomes too great,—as happens when the arm is short.

Away back in 1918, while the boys were still in France, I was called away from my laboratory one bright morning for an emergency consultation at the plant of one of the leading phonograph companies. These folks had just made a change in their talking machine mechanism . . . and something was WRONG.

It wasn't long before the trouble was located. In mounting the tone-arm they had been favoring the outer grooves at the expense of the more needy inside ones . . . and the resulting angular pressure on the last part of the record was giving trouble. (Today there still are a good many electric pick-ups having destructively high needle-point impedance but, serious as this is, they are mild as compared with what the reproducers were in those days).

The obvious answer: — A pickup whose needle-point impedance is so low that the average tracking error can have no effect on wear.

Tremendous trifles have their say in the construction of electrical reproducing sound-apparatus. Men and machinery and methods are important . . . but the one intangible MILLION-DOLLAR "if" is EXPERIENCE.

Maximilian Weil

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1

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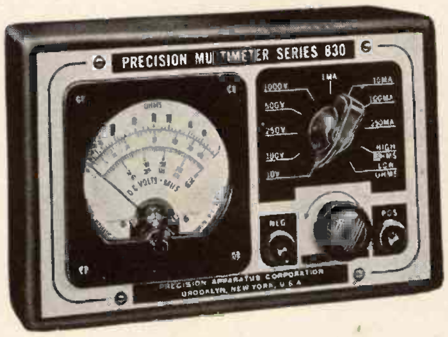

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- Compact size; 4½ x 7 x 2½.
- Leatherette covered case.
- Self-contained battery included.
- Accurate and adequate voltage, current and resistance ranges for point to point set testing.
- Zero adjust compensator for accurate resistance readings.

2

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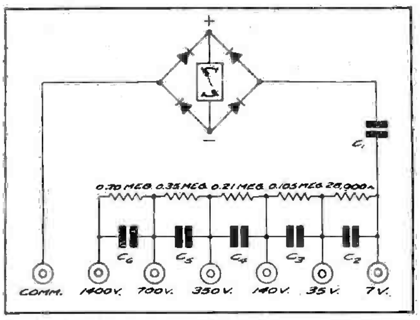


Fig. 4. Voltmeter connections for a-c measurements.

into which each range value is divided, in turn, for determining the required shunt values. Taking the shunt values for the highest range (1400 ma) as our first problem, we divide 1.4 amperes into 0.35 (our total ring "IR" value) and find that a value of 0.25 ohm is correct for this resistor. The 700-ma range shunt value of 0.25 ohms results from dividing 0.7 ampere into our total ring "IR" value of 0.35, or 0.5 ohms, but, since we already have a value of 0.25 ohms for our pervious range, subtracting this value from 0.5 ohms results in a value of 0.25 ohms for the second section of the shunt also. The other values may be computed similarly.

Resistance Measurements

The resistance measuring circuits of the 1937 Supreme instruments use the meter primarily as a voltmeter with the current passing through the meter calibrated on an "ohms" scale instead of a "volts" or "mils." scale. In the multi-range ohmmeter circuits of these instruments shunts are used to enable the different sensitivities required for each range and to this extent the ohmmeter circuit, resembles current-measuring circuits in which shunts are usually required.

In the design of ohmmeter functions, it is necessary to take into consideration the current required by the meter for full-scale deflection; that a small amount of current must be allowed for passage through a variable "zero adjustment" rheostat to compensate for the natural depreciation of a new battery; that another small amount of current must be allowed for passage through the fixed shunt for the highest resistance measuring range; that these three current values, when added together constitute the load for the highest resistance measuring range possible with the available battery potential and that the current loads for the lower ranges must be deci-multiples of the current load for the highest range in order that all ranges fall on the same "ohms" scale.

Consider the circuit shown in Fig. 3. This is a circuit diagram of the ohmmeter used in the Supreme Model 585. A close analysis of the circuit will show that for the lowest, or 2,000-ohm range, the 33-ohm resistor is a shunt resistor while the 297-ohm and the 2723-ohm resistors act as multipliers to the meter with its 600/4200 ohm shunting resistor made up of a fixed 600-ohm resistor and a 3600-ohm rheostat. For the 20,000-ohm range, the 33-ohm and the 297-ohm resistors (330 ohms total) act as a shunt and the 51-ohm and 2723-ohm resistors function as multipliers. For the 200,000-ohm range the 33-ohm, 297-ohm and 2723-ohm resistors (3053 ohms total) act as a shunt and the 3269-ohm resistor acts as a multiplier.

In this particular circuit the current value for the highest range is 0.0012 ampere (0.001 ampere through the meter,

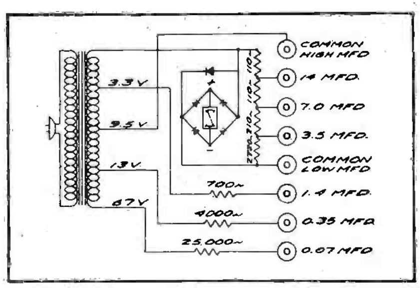


Fig. 5. Condenser leakage test circuit.

0.0001 ampere through the variable "zero adjustment" shunt, and 0.0001 ampere through the fixed shunt made up of the 33, 297 and 2723-ohm resistors). For the next range the current is 0.012 ampere total and for the lowest range the current is 0.120 amperes. The current for the lowest range is about the load limit for a small 4.5 volt battery to carry and still give economical service.

A-C Measuring Circuits

The a-c potential measuring functions of Supreme's 1937 line, differ from the d-c measuring functions in that the meter is connected to the output terminals of a full-wave instrument rectifier; a capacitor is substituted for the first multiplier resistor, and the capacitor is connected in series with the rectifier input circuit; each of the multiplier resistors above the first range are by-passed with a calibration capacitor. A typical a-c potential measuring circuit is shown in Fig. 4.

In the design of the a-c potential circuit under discussion, it was found advantageous to minimize the effect of the instrument rectifier's current density characteristic by using a series capacitor (C_1 in Fig. 4), as a multiplier reactor for the low range, instead of ultilizing a multiplier resistor. This arrangement constitutes an impedance circuit wherein the potential developed across the capacitive reactance is 90 degrees out of phase with the potential developed across the meter and rectifier resistance, so that the impedance elements may be represented by a right-angled triangle in which the resistance of the circuit is represented by a short leg of the triangle and the capacitive reactance by a long leg; the resulting impedance is represented by the hypotenuse of the triangle.

Condenser Leakage Measurement

The circuit shown in Fig. 6 is used in the Supreme Models 500 and 585 to check electrolytic condensers for leakage. The condition of the electrolytic capacitor is indicated on a good-bad scale on the meter. The required d-c is supplied by a self-contained miniature power pack. The d-c is supplied through a resistor R which limits the current to a safe value for good capacitors and protects the meter against a shorted capacitor.

Capacity Measurement

In the capacity measuring functions of the Supreme 1937 instruments, the resistance value of the meter, shunts and multiplier resistance associated with the measuring circuit shown in Fig. 5 constitute one leg of an impedance triangle. The capacitive reactance of a capacitor of unknown value, connected into the circuit for determining its value, constitutes the other leg of the impedance triangle. The resistance value of the meter, shunt and multipliers will be a constant value for any particular range and the vector's capacitive reactance is in every case determined by the capacitive value of the capacitor inserted into the circuit for the purpose of determining its value. The meter current is related di-

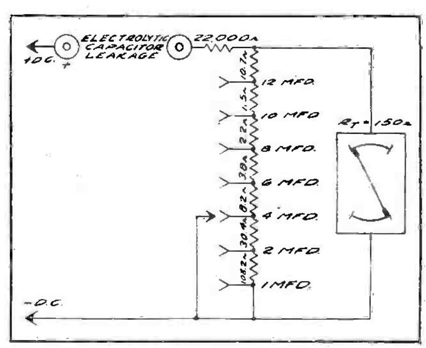


Fig. 6. Measuring electrolytic condenser leakage.

rectly to the hypotenuse length of the impedance triangle and will not have linear relation to the capacitive values. For example, let us assume that we have an impedance triangle in which the full-scale meter current corresponds to a capacitive value of 5.0 mfd; if we remove the 5.0-mfd capacitor and replace it with a 2.5-mfd capacitor, the length of the reactive leg of the triangle will be doubled, but the length of the hypotenuse of the impedance triangle will not be doubled, and therefore, the meter current will not be reduced to one-half its former full-scale value.

From the foregoing it is natural to ask how capacitive measurements are made on an evenly divided scale. The answer lies in the variable resistive value introduced by the full-wave copper-oxide rectifier employed. The shunts and multipliers were designed to be of such value as to allow the variable element of the rectifier to counterbalance the variable reactive element of the different capacitors which may be measured.

For the measurement of electrostatic (paper) capacitors a comparatively high a-c potential may be used. Low values of a-c voltage must be used on the high value electrolytic capacitors to protect the electrolytic film of such capacitors the actual potential used for electrolytics is about 9.5 volts.

Samuel C. Milbourne,
Service Engineer,
SUPREME INSTUMENTS CO.

Checking Signal Generators

Much of the latest receiver service data issued by the set manufacturers includes sensitivity ratings in terms of microvolts input necessary to produce 50 milliwatts output. Accurate alignment and correct adjustments and measurements can now be checked against original factory standards provided a suitable signal generator is available—but what are the requirements of a suitable signal generator?

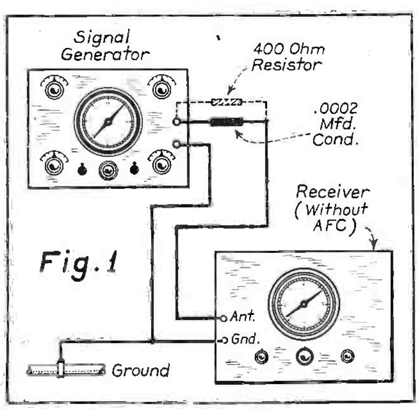


Fig. 1

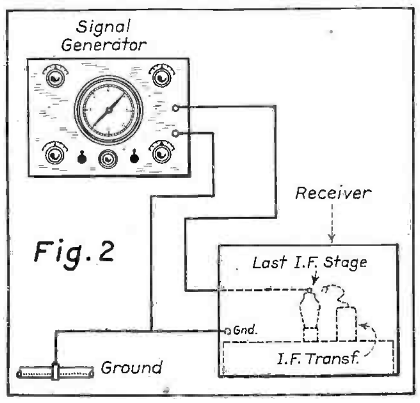


Fig. 2

A modern signal generator is a carefully designed oscillator with a uniform signal output over a range of about 100 to 70,000 kc. It differs from earlier oscillators in that the signal output is steadier and calibrated attenuators control this output. The modulation signal is supplied through a separate audio oscillator and modulates the carrier of the signal generator. A 400-cycle note, the standard audio test frequency recommended by IRE, is usually employed. This frequency is above the resonance point of dynamic speakers and well below the high-frequency cut-off point of audio systems or sharp tuned i-f stages and is therefore quite suitable for testing purposes.

Choice of Generator

In choosing a signal generator several important features should be checked or determined from reliable sources. The accuracy of the frequency calibration; the leakage of signal at zero attenuation (volume control of signal generator at minimum setting) and linearity of attenuator calibration can be checked on any Service Man's bench. The waveform of the modulated r-f carrier and of the 400-cycle audio signal require more complicated equipment for their determination. Any signal generator that passes the first three tests is likely to be a good instrument—if it also passes the other two it is as good as most generators can be.

Frequency Calibration

The first test is for frequency calibration. The equipment required for this is any good receiver, without afc, which covers broadcast and short-wave bands. Tune in some clear channel broadcast station, for example WLW on 700 kc. Couple the signal generator to the antenna of the receiver through a 0.0002-mfd condenser. After a few minutes to warm up, turn the signal generator dial to 175 kc. The forth harmonic of 175 kc should beat with the 700-kc signal of the station. Likewise the second harmonic of 350 kc and the 700-kc signal from the signal generator should beat with the station signal. Then select some one of the major American short-wave relay stations. Replace the 0.0002-mfd condenser with a 400-ohm resistor. Check the signal generator calibration against the frequency of that station by the zero-beat method. One-half that frequency on the signal generator should also produce a strong beat with which to test and one-quarter of the test-station frequency should also provide a test point. The object is to determine if the signal generator provides signals which check accurately with the dial settings when compared to the larger stations using crystal oscillators and known to remain steadily on their assigned frequency. A signal generator which does not read within 2 percent of its dial calibration usually requires a special hand calibrated curve drawn on suitable graph paper to assure accuracy; otherwise it is difficult to make allowances for deviations.

Zero Attenuation

The second test is for zero attenuation. Tune the receiver to some spot on the broadcast band but disconnect the outside aerial. Tune the signal generator to the same frequency with the modulator operating to produce an audible signal in the receiver. Make certain the receiver is grounded and that the ground lead of the signal generator is connected to the same ground at the receiver. In testing the broadcast bands a condenser of 0.0002 mfd should be connected in series with the signal generator and the antenna lead to act as a dummy antenna; on short-wave bands a 400-ohm carbon resistor should be substituted for the series condenser for the same purpose. The dummy antenna prevents the detuning effect on the antenna input coil caused by the shunting effect of the signal generator attenuator when it is set close to zero. After these precautions have been taken increase the receiver volume control and reduce the signal from the generator to zero. If the control is of the proper design and

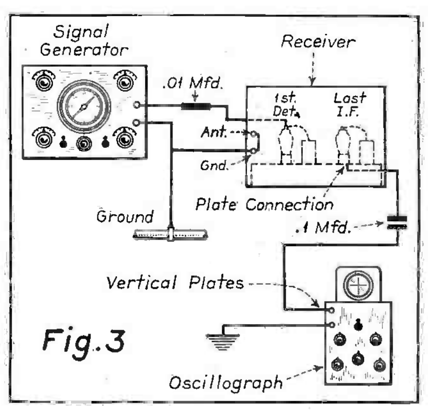


Fig. 3

the leakage is negligible, no trace of the modulated signal can be heard in the output of the radio set. Usually the radio picks up noise of greater intensity than even a slight trace of signal from the generator but a good unit will go down to zero on sets as sensitive as 1 microvolt. Repeat this test on the short-wave bands. Here the attenuation is not always so effective but it should closely approach an inaudible point.

Linearity of Attenuator

The third test is for linearity of the attenuator. This can be made by coupling the generator directly to the grid cap of the i-f tube preceding a diode detector, after removing the normal top grid connection. With the ground lead still on the chassis, this circuit shunts out the avc and permits tests of the attenuator. An output meter or an oscillograph may be used to indicate the intensity of the output signal. Tune the signal generator to the i-f peak of the receiver. Operate the attenuator controls and watch the output indication, if the controls are linear in action, the output will increase directly in proportion to the movement of the controls. An oscillograph will disclose when the signal overloads the amplifier—with an output meter, it is necessary to listen for distortion at the overload point. Accurate attenuator tests cannot be made beyond the overload point of the receiver amplifier.

Waveform

The fourth test is for waveform of the modulated r-f carrier. This test is made by connecting the output of the signal generator to the grid of a mixer or first detector in a superheterodyne receiver and a wire from the plate of the last i-f to the vertical input of an oscillograph. The oscillograph sweep may be set to 50 or 60 cycles and the modulated carrier observed on the screen. The modulation contour should be symmetrical. Increase the sweep frequency to 20,000 cycles and turn off the modulation. This will give the wave pattern of the carrier on the screen. The waveform should be symmetrical.

The character of the unmodulated r-f wave may be further tested by beating the generator signal against an unmodulated station carrier and examining the resultant beat frequency in the audio output of the receiver. A good signal generator will produce a steady pattern on the oscillograph when used in this way; an evidence of frequency stability.

The fifth test may be made by connecting the audio output of the signal generator across the vertical input of the oscillograph and setting the sweep at 100 or 200 cycles. A clean, undistorted, sine wave should appear on the screen if the audio signal is suitable for quality testing of audio amplifiers.

As a final check upon results, repeat as many of the tests as possible on a different receiver to make certain that some of the results observed were not peculiar to the set being used.

J. P. Kennedy
Triumph Mfg. Co.

RCA 150 Test Oscillator

In the January issue of Service[1] the circuit diagram of the RCA model 150 test oscillator was given and some description attempted in conjunction with its use as a companion to the RCA model 151 cathode-ray oscillograph. A more complete description is now available.

The model 150 test oscillator consists of two radio-frequency oscillators (one fixed and one variable) whose outputs are combined in a mixer tube to provide the desired r-f signal. Either amplitude modulation (400 cycles) or frequency modulation (of plus or minus 20 kc maximum) of the output frequency may be obtained, depending on which type of modulation is employed on the fixed oscillator. Referring to the circuit diagram in last month's issue, the following action takes place:

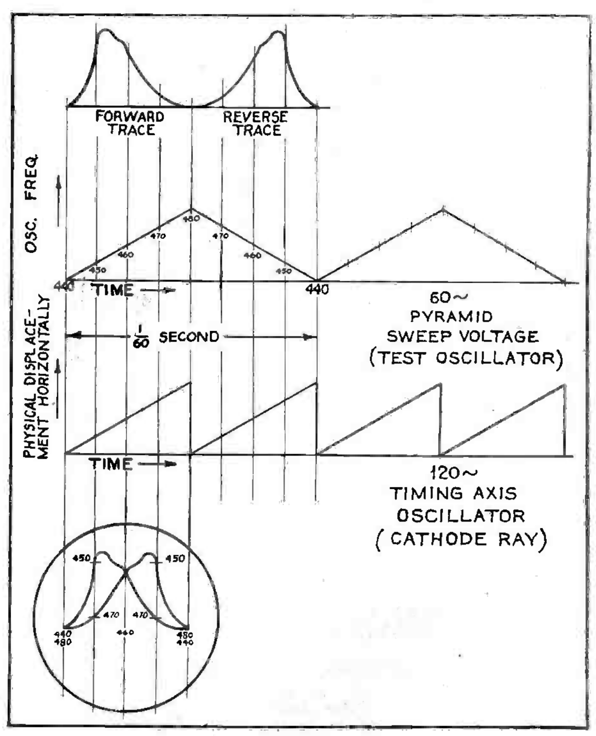
A fixed r-f oscillator, consisting of the pentode section of the 6F7 tube and its associated inductance and capacity oscillates at a frequency of 800 kc. A pickup coil coupled to this tank circuit feeds energy from this oscillator into the No. 4 grid of the 6A7 combination oscillator-mixer tube. The triode section of this tube, together with its associated inductances and capacities make up the variable oscillator which is tuned by the variable capacitor, C7. Because of the coupling in the electron stream there will appear in the output plate circuit of the 6A7 frequencies corresponding to the sum and difference of the frequencies of the two oscillators. The tuning dial is calibrated directly in kc corresponding to the difference of the two oscillator frequencies up to 7 megacycles. Above 7 megacycles the sum frequency is used. The foregoing description applies for the condition of no modulation on the fixed oscillator.

When amplitude modulation is employed the same action holds true except that the triode section of the fixed oscillator tube oscillates at 400 cycles and is coupled externally to the r-f oscillator section so as to impress the audio voltage in series with the plate supply of the oscillator section. The resultant output voltage from the 6A7 tube is amplitude modulated an amount equivalent to the modulation impressed on the fixed oscillator.

When frequency modulation is employed the above action of the variable oscillator and mixer tubes still holds true, but the signal from the fixed oscil-

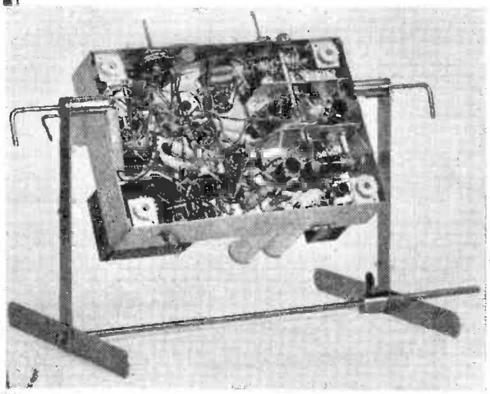
(*Continued on page* 119)

[1] "A Cathode-Ray Oscillograph for the Service Man". Service, page 13, January 1937.



Resultant curves on cathode-ray screen.

ACRO CHASSIS CRADLE



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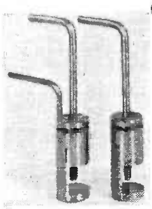

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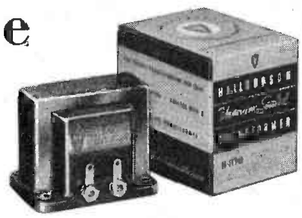

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ASSOCIATION NEWS . . .

INSTITUTE OF RADIO SERVICE MEN

Cleveland Chapter

At the January 4, 1937, meeting, the time was well filled with election of officers; a chicken dinner (with all the trimmings); a burlesque entertainment and last, but not least, "Soharsm."

Robert L. Kline was elected chairman; P. R. Kendall, vice chairman; George H. Roberts, secretary; James E. Hausser, treasurer, and L. Vangunten, official observer.

A number of members made a New Year's resolution to make 1937 a better year for all. It is the general opinion of the membership that a better job can be done if everyone in the radio industry pulls together.

The new officers were installed at the meeting held January 20. At the same meeting, "Ask Alex, He Knows" Plakadis, an old-timer, conducted a publication review and service discussion as only Alex can. P. R. (Red) Kendall and Al Theriault opened the ball for the coming examinations conducted by the NRSQP.

L. Vangunten, Official Observer

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Sheboygan Chapter

Some time back the officers of the Sheboygan Chapter, noting the comparative success of various noon luncheon clubs, decided to try a get-together dinner.

The first of these, an informal dinner scheduled for 6:30 p.m., proved to be a successful method of bringing the boys to the meeting. Others were equally popular. In a private dining room the members that have been out on the job until 6:20 p.m. can come directly, without the necessity of returning home to change clothes.

Over a good dinner it is rather a simple matter to set up a spirit of camaraderie so necessary in an organization of competitive business such as radio service.

Harold R. Nitze, Secretary

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ASSN. OF RADIO SERVICE MEN

The first meeting this year of the Association of Radio Service Men of Rochester, New York, held January 11, proved interesting and eventful.

Reports of the publicity and membership committees opened the proceedings and reflected an optimistic attitude towards the coming year.

William Bellor, the program committee for the evening, inaugurated a new idea locally by presenting a technical contest.

The first section consisted of attempting to identify and state the use of two unlabelled circuits on the board, namely, a high-frequency magnetron super-regenerative circuit and a simple oscillator designed for diathermy application. Secretary Frank Burgo rated 100 per cent on this test, while two others tied for second place.

The second part required drawing the schematics for each of thirteen tubes, type numbers being given on the board. The less said about the results, the better, but two members tied for first place with somewhat less than 100 per cent.

Chairman Bert Lewis read a letter from the Federal Communications Commission asking the opinion of the association regarding the suggested increase in broadcast station blanket area limit signal strength.

George Driscoll, who has been actively connected with broadcasting, gave a talk on the factors to be considered on this subject, which was highly enlightening.

The group agreed unanimously, after discussion, that such increase might benefit the Service Man, and authorized Mr. Lewis to transmit this decision to the FCC.

Mr. Woodworth, of *Radio Today,* who is an associate member, addressed the organization briefly, and received suggestions regarding his publication.

The meeting was adjourned, after which it degenerated into private controversies which continued, as usual, far, far into the night.

Frank W. Bloom, Press Agent.

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RADIO ASSOCIATION OF CALIFORNIA

The January 18 meeting ended all too soon to suit the members. Frank Kester, marine editor of the Oakland Tribune, spun several yarns about ships and sailors and things, and time sprouted wings and flew on by. . . . The members tendered Chairman of the Board Knox permission to go ahead with necessary work on the clubroom ceiling and then throw a blowout to cover the deficit. . . . A roll call was conducted expressly for our old friend Frank, whom startled members hadn't seen since Hector was very small, indeed. . . . And commodore-of-the-commissary Fink reported the loss of the old broken bucket with which we were wont to build our coffee of a meeting night.

Ralph Moore will give a review and practical uses of avc at the February 15 meeting.

Another speaker to watch and wait for is Harold Lindsay of the Shell Development Company.

H. R. Anderson, Secretary

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RADIO TECHNICIANS ASSN. OF UTAH

Two years ago the Service Men of Ogden, Utah, organized. Today the association boasts a membership of about 27. At the meetings case histories are discussed as well as local service problems.

The organization has been successful in establishing price levels for service work and has used its influence in having a radio interference ordinance passed by the city government.

Through the medium of simple advertising the association claims to have established fair practices and capable workmanship in the service industry in Ogden.

G. E. Arnold, Sec'y.

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RADIO SERVICE ASSOCIATION

Harold L. Olsen, of the Weston Electrical Instrument Corporation, Newark, New Jersey, lectured on the subject "Radio Service and Testing" at the meeting of the Phoenix Chapter of the Radio Service Association of Arizona held January 14 at the Phoenix Junior College. Mr. Olsen is assistant general sales manager of the Weston Corporation and has been associated with the Jewell Instrument Company and with the Marconi Company. His lecture was of great interest, and was appreciated by the attending members.

Ken Sloan, Editor,
The Output.

NRIAA

The following officers have been elected for 1937: P. J. Dunn, president; Earl Bennett, C. Stokes, R. H. Rood and F. E. Oliver, vice-presidents; Earl Merryman, secretary; and R. B. Murray, executive secretary.

Although Mr. Murray was reelected executive secretary he has resigned from the position and L. L. Menne will take his place.

The officers are to serve until January 1938.

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PRSMA

Beginning this autumn the Board of Education of Philadelphia contemplates the introduction of a radio course in the vocational schools which are now in the process of construction.

Although no definite plan has yet been announced, it is believed the course will include different phases of radio and radio service.

The Philadelphia Board of Education, eager to do a complete job, are conducting an intensive research in the needs of the radio industry, and in the types and content of the radio courses necessary to satisfy these needs.

The Philadelphia Radio Service Men's Association (PRSMA) has been honored by a request from the Philadelphia Board of Education to cooperate in supplying information pertinent to accepted standards of workmanship, tools, test equipment, supplies, etc., in the service field.

To date, one conference has been held by the PRSMA Committee on Education and members of the Philadelphia Board of Education and rapid progress is being made. Many more conferences will no doubt be required before the research is concluded. PRSMA is happy to render this service, which eventually may make for better conditions in the service industry in Philadelphia.

Paul G. Freed, Chairman, Committee on Education.

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A SUCCESSFUL ASSOCIATION

The following suggestions were received from the Associated Radio Technicians of British Columbia with the title "How to Make an Association Successful":

Don't come to the meeting. But if you do come, come late. If the weather doesn't suit you, don't even think of coming.

If asked by the chairman to give your opinion regarding some important matter, tell him you have nothing to say. After the meeting tell everyone how things ought to be done.

Do nothing more than is absolutely necessary; but when other members roll up their sleeves and willingly, unselfishly, use their ability to help matters along, howl that the association is run by a clique.

Hold back your dues as long as possible, or don't pay at all. Don't bother about getting new members. Let the secretary do that.

Don't tell the association how it can help you, but if it doesn't help you, resign. If you receive benefits without joining, don't think of joining.

Agree to do everything said at the meeting and disagree with it outside.

REDUCING HUM IN RECEIVERS AND AMPLIFIERS

(*Continued from page 77*)

a more elaborate filter than the converse. Minute periodical variations in the plate current of the detector due to inefficient filtering will result in hum, the intensity depending on the gain of the a-f unit.

With low a-f gain a small amount of ripple can be tolerated since the succeeding amplification is not as great. This effect does not occur in the diode detector, since it is independent of the filter. However, some voltage may be induced to the wiring from neighboring apparatus on the chassis, resulting in hum. Adequate shielding is the remedy. As a rule, most hum originates in the detector and its immediate circuits.

A resistance connected across the secondary of the interstage audio transformer often helps to reduce hum, but at the expense of gain and quality. The value of the resistance will be dependent upon the amount of gain that can be sacrificed. A 100,000-ohm resistance across the secondary sometimes reduces the hum materially, but does not weaken the signal to a great extent. This method is not recommended for general practice since it affects the quality of the signal, but as a temporary expedient, or where quality is not of paramount importance it will suffice.

In resistance-coupled detectors and first a-f stages a resistance-capacity filter (RC shown in Fig. 3) is usually employed. Some reduction in hum may be obtained by increasing the size of the condenser (C) or the resistance (R). Increasing the resistance, however, will reduce the gain of the stage and is recommended in extreme cases only.

MODULATION HUM

Another form of hum, particularly annoying, makes its presence known only when a station is tuned in. Between stations it remains in hiding, figuratively speaking, and when a station is tuned in the hum superimposes itself on the carrier and no amount of dial and volume control manipulation will stop it. It is a form of modulation originating within the receiver and can usually be eliminated with a condenser or two placed at strategical points in the circuits. Fig. 4 will show the position of the condensers, one or more of which may be used, depending on the severity of the hum. The condenser connected on the high-voltage side of the transformer should have a working voltage of at least 1000 volts to provide adequate insurance against breakdown. For the alternating-current line condenser, a working voltage of 400 volts will provide a sufficient factor of safety.

HAMMARLUND CATALOG

The Hammarlund Mfg. Co., Inc., 424 West 33rd St., New York City, have published a catalog designed to afford a maximum amount of information about each of their products.

The Hammarlund Mfg. Co. will forward a copy of this catalog to anyone interested in their line of telegraph and radio apparatus.

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ARCTURUS OFFERS COOPERATION

Arcturus Radio Tube Co., Newark, N. J., has notified all of its distributors and many dealers in the flood areas that tubes and cartons damaged by the flood will be reconditioned and reboxed, free of charge.

•

NEW SERVICE MEN'S STORE

Tom Waite and George De Buc have opened a Service Men's and experimenters "bargain" place at 89 Cortlandt St., New York City, under the name of Douglas Radio.

The boys, known to the Cortlandt Street trade for 15 years, expect to carry a full line of replacement parts, kits, etc., and an abundance of circuit diagrams.

•

GHIRARDI RETURNS FROM TOUR

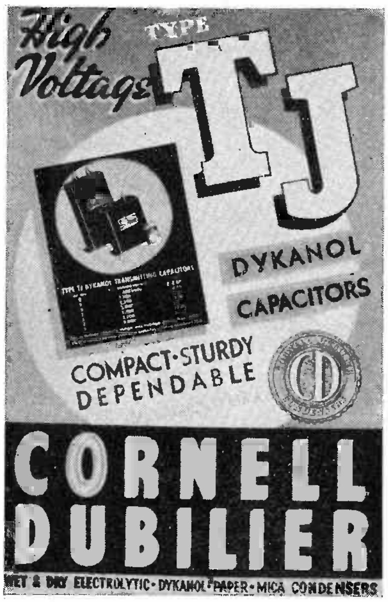
Alfred A. Ghirardi, writer on radio topics, has returned to New York from a nation-wide trip, devoted to personal investigation of new developments and trends in the radio set and servicing business in different parts of the country. Traveling 3,400 miles by car and 6,200 miles by air, Mr. Ghirardi also had the opportunity to make a study of aircraft radio equipment and reception, radio beams, and other problems connected with aviation radio. He remarked upon the absence of radios for the entertainment of air passengers in transport planes.

Asked to summarize his observations, Mr. Ghirardi stated that he found three trends in the radio business today that were particularly noticeable on his tour. First, he said, was the new interest in progressive merchandising and business promotion methods by even small radio dealers. "In my opinion," he said, "during the next 12 months we will see a great change in the sales promotional methods and activity among all radio dealers and Service Men who are alive to changing conditions and new opportunities."

•

TUNG-SOL FACTORY

The new Tung-Sol factory at 370 Orange St., Newark, N. J., is now in full operation. Adding the capacity of this plant to the former plant, Tung-Sol expects to keep pace with production even during peak seasons.



CORNELL-DUBILIER DISPLAY CARD

JOBBER HELPS BY C-D

Continuing its policy of merchandising and advertising its products, the Cornell-Dubilier Corp. has released the fifth of its series of 4-color counter displays. Distributors who have received this "point of sale" promotion agreed that they have materially helped promote the sale of condensers. Additional placards are available to either distributors or dealers. Address all requests to the Cornell-Dubilier Corp., South Plainfield, N. J.

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NATIONAL TRADE SHOW

The industry can get a quick mental picture of the size of the National Trade Show to be held at the Stevens Hotel, Chicago, June 10 to 13, when they know that this, the first show managed by Radio Parts Manufacturers National Trade Show, Inc., is already a third larger than the one conducted by the IRSM in Chicago last spring. With four months still to go, it is anticipated that the 1937 Exhibition will be nearly twice as large as the 1936 Trade Show.

The goal of 100 booths has already been attained.

•

BOOK REVIEWS

THE MALLORY YAXLEY RADIO SERVICE ENCYCLOPEDIA, compiled by P. R. Mallory & Co., Inc., Indianapolis, Inc., 216 pages, 8½ by 11 inches, hard covers. Price, $2.50.

P. R. Mallory & Co., Inc., desiring to aid the Service Man in his daily work and save him valuable time have prepared the "Radio Service Encyclopedia." Three years were spent in gathering the material necessary to complete the volume.

The encyclopedia is divided into 14 sections in which technical information and circuits are given. The initial section of 4 pages is spent in describing exactly how to use the volume. Sections 2, 3, and 4 are devoted to a 99-page table of receiver listings which gives technical information on volume controls, tone controls, condensers, vibrators, types of tubes, i-f peaks and transformer connections. These receiver listings are said to be more complete than any other similar listing or compilation.

The 25 pages of Section 5 are devoted to a discussion of controls, determination of tapers, volume and tone control circuits and applications, tapped control circuits, etc. Five pages of typical control circuits are given.

Section 6 of the encyclopedia discusses condensers, with suitable circuit diagrams.

Vibrators, alignment and automatic frequency control are discussed in the 12 pages of Section 7.

Section 8 covers receiving tubes. Numerous charts, socket layouts, formulae and voltage data can be found in the 20 pages of this section.

Transformers, resistors and antennas are treated in Sections 9, 10, and 11 respectively.

A compilation of useful charts and tables can be found in Section 12. Simple formulae, indispensable to the Service Man, are presented in Section 13 together with information concerning their use. This section also includes data on measurements and constructional details for a vacuum-tube voltmeter and a practical bridge.

The final section is devoted to radio definitions.

A complete index makes the information contained in the volume easy to find.

The standard circuits covered in the encyclopedia are said to be complete and cover every hookup in common use. Technical information is given on the circuit action of each hookup, explaining how-and-why in every-day shop English.

•

THE "RADIO" ANTENNA HANDBOOK, prepared by the engineering staff of "Radio" under the direction of J. N. A. Hawkins, edited by Frank C. Jones and W. W. Smith, published by Radio, Ltd., 7460 Beverly Boulevard, Los Angeles, California, 80 pages, price 50c.

The editors of "Radio," feeling that antenna data has been incompletely presented in most common texts and that a need existed for a more complete presentation of the subject, have prepared *The "Radio" Antenna Handbook.* Their aim has been to present a comprehensive and practical outline of the whole antenna problem for the Service Man and amateur.

As is usual in books of this nature, the first chapter has been devoted to fundamentals and discusses ground and sky wave, fading, antenna radiation, antenna length, radiation resistance and antenna impedance, non-resonant lines, etc. This is followed by a general discussion of the advantages and disadvantages of various antenna systems.

Considerable space has been devoted to the methods of feeding antennas as well as to coupling the antenna to transmitters, harmonic operation, directive and receiving antennas. Data are also given on special antennas and methods of support. A number of miscellaneous tables have also been included.

The book has been written from a practical standpoint, and for the most part the various discussions are non-mathematical.

lator delivered to the No. 4 mixer grid is varied at a low-frequency rate (frequency modulation), consequently the output frequency from the mixer tube will vary in like manner. Frequency modulation of the fixed oscillator is brought about in the following manner:

The plate of the 6F7 tube builds up an out-of-phase r-f voltage across capacitor C-22, which is coupled to the grid of the 6C6 frequency control tube. The plate of this 6C6 is connected directly across the grid tank circuit of the fixed oscillator. With voltage of the proper phase angle on the grid of the 6C6 (corrected by the network C-21, R-18) the output of this tube appears to the oscillator tank circuit as a shunt inductance.[2] This inductance, and, hence, the oscillator frequency may be varied up or down, within limits, by raising or lowering the bias on the frequency control tube and so varying its gain. This is accomplished by varying the bias on this tube around a fixed point with a linear 60-cycle pyramid waveform generated by the second 6C6 tube. The pyramid waveform is employed to obtain the double image response or the folding back of the forward and reverse resonance traces of a circuit. A brief explanation of double image response follows:

Refer to Fig. 1 and assume that the oscillator timing axis is set for 120 cycles, exactly twice the frequency of the pyramid sweep voltage, and that the horizontal deflection progresses from left to right on the screen of the cathode-ray tube. In 1/120 second the r-f oscillator frequency progresses from 440 to 480 kc, tracing the response curve on the screen from left to right and controlled horizontally by the timing axis oscillator. At the end of the 1/120-second, the oscillator frequency starts decreasing and during the next 1/120 second changes from 480 to 440 kc. At the reversal point (peak of the pyramid voltage) the saw-tooth oscillator has caused a maximum horizontal deflection on the oscillograph screen, drops to zero and returns the beam to the left side of the screen. It then builds up again, tracing the reverse resonance curve (480 to 440 kc) of the second half of the sweep cycle, thus giving the two superimposed curves, i. e., being the reverse of each other with respect to frequency except at the point corresponding to the alignment frequency. It will be noted that in the trace shown the transformer is purposely misaligned so that both traces will be fully visible.

[2] "Automatic Frequency Control", SERVICE, page 471, October 1936.

THE MANUFACTURERS . . .

WEBSTER CALL SYSTEM

Webster-Chicago, manufacturers of sound systems and accessories, have announced a line of factory call equipment with the trade name "Amplicall".

The systems use permanent-magnet dynamic speakers and require only two wires to be run for each position of a call system.

More complete description of the systems can be obtained directly from the manufacturer.

•

AUDAK PICKUPS

Two "Micromatic" pickups, models AA-74 and AA-76, for twelve in. and transcription records (18 in.) respectively, have been announced by the Audak Co., 500 Fifth Ave., New York City. These units are designed to give wide range response and to have a smooth and rising characteristic at low frequencies—starting at 300 cycles and gradually increasing to 10 db at 70 cycles. This is to compensate for the attenuation in recording at these frequencies. Above 300 cycles the response is said to be substantially flat.

The manufacturer will supply complete literature on these and other Audax units upon request.

•

INSTRUMENT SWITCHES

The Shallcross Mfg. Co., Collingdale, Pa., are manufacturing small-sized rotary switches with ceramic switch plates in either single or double deck with brass or silver contact points.

A descriptive bulletin, 530-C2, may be obtained directly from the manufacturer.

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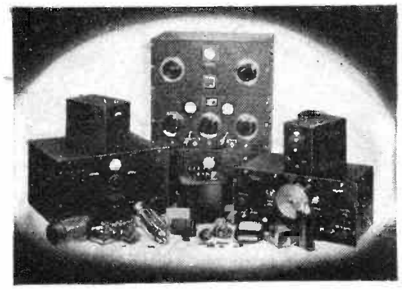
RADIO EQUIPMENT

The Wholesale Radio Service Co., extends an invitation, to amateurs and enthusiasts, to see, hear and operate the latest radio apparatus. A display of modern "Ham" equipment and a demonstration of



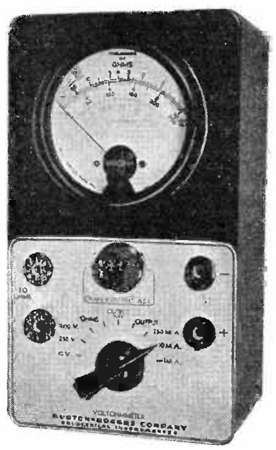
p-a systems has been arranged for those interested. The more recent tube developments are also on display.

The Wholesale Radio Service Co. is located at 100 Sixth Ave., New York City, with branch offices at 901 W. Jackson Blvd., Chicago, and 430 W. Peachtree St,. N.W., Atlanta, Ga.

•

BURTON-ROGERS VOLT-OHMMETER

This compact volt-ohmmeter, milliammeter and output meter should find use in the hands of Service Men. Fitting into the pocket, this instrument may be used for receiver chassis measurements right on the job.

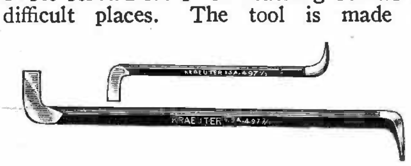


It has a 3-inch meter with 2-color scale, a D'Arsonval movement, knife-edge pointer and zero adjuster. The d-c milliampere scale reads 0-1, 0-10 and 0-250. Two output scales are provided, one for the voice coil circuit, the other with a blocking condenser. The 2-ohm scales are direct reading; lo-ohms from ½ to 500, hi-ohms from 200 to 500,000.

•

KRAEUTER OFFSET SCREWDRIVERS

Kraeuter & Co., 569 Eighteenth Ave., Newark, N. J., have announced a line of offset screwdrivers for reaching screws in difficult places. The tool is made of



chrome-molybdenum and is available in 4½-, 6- and 8-inch sizes.

•

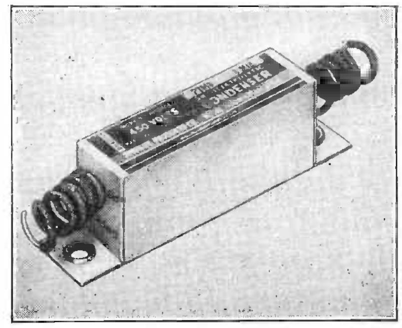
SPRAGUE PINHEAD ELECTROLYTICS

"Pinhead Tiny-Mikes" is the name for the Sprague cardboard dry electrolytic condensers introduced by the Sprague Products Co., North Adams, Mass.

The 8-mfd unit is 2½ in. long by 11-16 in. wide and 1 1-16 in. high. Four-mfd and an 8-8 mfd units are also available.

"Pinhead Tiny-Mikes" are rated at 525 volts. These PTM condensers have the Sprague humidity proof sealing which eliminates one of the causes of failure in units of this type.

A 1937 catalog listing these and other



Sprague condenser developments can be obtained directly from the manufacturers.

•

ARCTURUS 25Z5

A 25Z5 rectifier tube with new features of design has been announced by Arcturus Radio Tube Co., Newark, N. J.

It is said that the troubles such as flash-overs, open cathode tabs, slow heating, shorts and filament burnouts have been reduced to a minimum.

Overload tests, on sample tubes, show a long life for the new tube with freedom from the ordinary 25Z5 troubles, it is said.

•

NEW AMERTRAN PRODUCT

A voltage regulator for alternating-current circuits which offers the same smooth control as obtained from a rheostat plus the high efficiency, good regulation and great flexibility of a transformer has just been announced by American Transformer Company, of Newark, N. J. This new device is known as the Type TH Transtat and is available in various standard sizes for controlling voltage to loads up to 2.5 kva on either 115- or 230-volt lines.

•

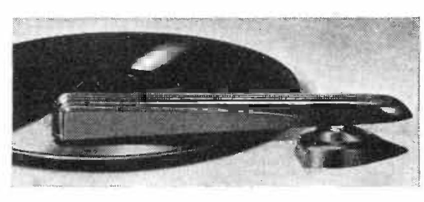
SHURE "ZEPHYR" PICKUP

The Shure "Zephyr", first of a series of crystal phonograph record reproducers, has been announced by Shure Bros., 225 W. Huron St., Chicago.

The tonearm and base of the "Zephyr" are streamlined in molded black bakelite. A built-in needle tilt method is used to reduce tracking error.

The "Zephyr" is said to have a frequency range to 10,000 cycles and sufficient output to operate from the audio system of the average radio receiver.

The needle tilt principle is said to improve reproduction and increase record life by maintaining the projection of the needle very closely tangent to the record groove at all points on the record. A hinge arrangement allows the head to be lifted high above the turntable for needle changing.



THREE RAYTHEON BEAM-POWER TUBES

E. S. Riedel, general sales manager of the Raytheon Production Corp., has announced three new beam type output, power amplifier tubes. Two of the new beam amplifiers, types 25B6G and 25L6, were designed for operation at plate and screen potentials of approximately 100 volts in a-c, d-c receiver service. The third beam type, 6V6G, is a new tube for the output stage of automobile receivers.

Type 25B6G is an octal based glass tube having overall dimensions equivalent to the type 43 tube. Type 25B6G has control and screen-grid alignment features which are found in type 6L6 and in addition has a suppressor grid which is connected internally to the cathode. The power output of type 25B6G is 1.75 watts at 95 volts on the plate and screen.

The grid signal voltage necessary for full power from type 25B6G is more approximately 8 (rms) volts. This new beam amplifier requires no more signal driving power than type 43, and will deliver twice the output power. The heater operates at 25 volts and 0.3 ampere.

Type 25L6 is a new metal tube in a shell which corresponds in size to the shell used for the 6F6. The 25L6 has characteristics approximately the same as for type 25B6G with the exception that a slightly lower signal input voltage is required. Type 25L6 has aligned control and screen grids, which produce beam action. This tube does not have a suppressor grid. The heater operates at 25.0 volts and 0.3 ampere.

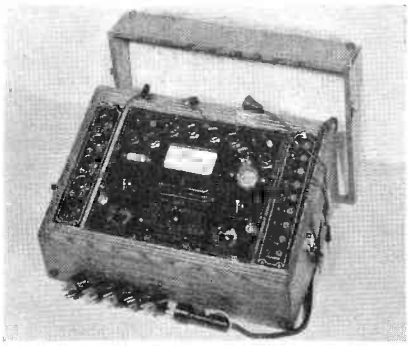
The type 6V6G is designed for use in automobile receivers. This octal based glass tube, corresponding in size to the type 42, will deliver 4.25 watts of audio power at a plate and screen potential of 250 volts. This output is obtained with approximately 8 (rms) volts of signal input.

Beam action is produced by the alignment of the control and screen grids. The 6V6G has no suppressor grid. The heater operates at 6.3 volts and 0.45 ampere.

•

"MULTIPURPOSE" TESTER

The Triplett "Multipurpose" tester, model 1504, combines in one instrument the equivalent of 11 separate units. Checks



any type tube, with additional Neon short test; separate diode test; metered paper condenser test; electrolytic condenser leakage test; d-c voltmeter; d-c milliammeter; a-c voltmeter; ohmmeter; decibel meter and free point tester.

Tube testing is by the power output emission method, providing tests for any type tube.

Furnished in a quartered oak case with sloping silver and black panel. For portable and counter use.

•

JENSEN ADUSTABLE SPEAKERS

The Jensen Radio Manufacturing Co. has announced a complete line of speakers with adjustable impedance transformers. These transformers have marked terminal boards and impedance adjustment is made with flexible lead and pinjack. No soldering is required.

Two types are available, one to match conventional plate impedance values, the other to match conventional line impedance values.

Jensen is also manufacturing and selling adjustable impedance transformers only, and speakers may be purchased less input transformers.

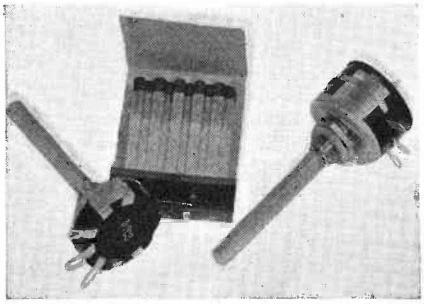
Every jobber and Service Man who would like complete data on this development can obtain a descriptive catalog free on request to Jensen Radio Manufacturing Co., 6601 S. Laramie Ave., Chicago, Ill.

(*Continued on page* 122)

MANUFACTURERS—continued

CENTRALAB MIDGET RADIOHM

From Centralab, 900 E. Keefe Ave., Milwaukee, Wis., comes news of a midget



radiohm in single, twin and triple units with or without switches.

The units have a case diameter of 1 3-64 in., with a depth, for the single switch unit, of 23-32 in.

The midget radiohm is available to Service Men for replacement purposes. Replacement controls are supplied with long, soft aluminum shafts that can be cut to the length desired.

The illustration shows the control alongside a standard pocket match folder to demonstrate its small size.

•

BRUSH MODEL AR-4S3P

The Brush Development Co., 1882 E. 40th St., Cleveland, Ohio, has placed on the market the model AR-4S3P, a 3-in. spherical, crystal sound cell microphone. The output level is—60 db.

This sensitivity is said to make the microphone useful for public address or broadcast applications where longer leads are required with a minimum loss of output.

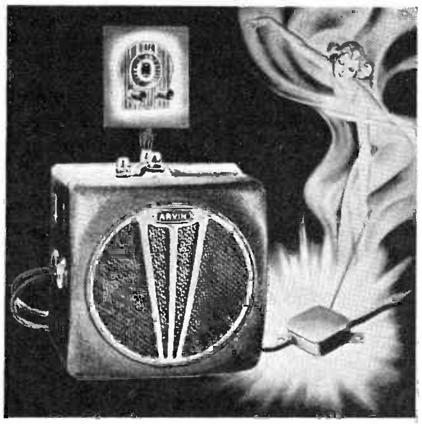
A companion microphone, the model AR-2S6P, has a slightly lower output. This microphone can be supplied with a transformer for operation into low-impedance equipment (50 and 200 ohms).

•

ARVIN AUTO RADIOS

The 1937 line of Arvin car radios features the "Phantom Filter", "Automatic Eliminoise" and "Permatune" i-f transformers.

The Arvin Master model 29, illustrated,



is a 6-tube superheterodyne with a choice of either a 6- or 8-in. speaker in the set. Arvin also supplies a choice of matching panels to fit any make automobile.

WEBSTER "TELETALK" INTERCOMMUNICATORS

The Webster Electric Co., Racine, Wis., announce an enlarged line to their "Teletalk" intercommunicating systems which include fully selective type systems, master station models, paging systems and confidential models which afford privacy in conversation. The distance between stations is not limited and installation is simple.

Features include separate volume control at each station and a circuit arrangement which gives longer life to vital parts and reduces line current drain whereby the tube filaments are kept hot and heavy current is used only when talking.

•

WRIGHT-DE COSTER MODEL 1984

The latest addition to the Wright-DeCoster "Nokoil" line is the model 1984 12-in. reproducer. This speaker is useful for p-a installations and is designed to operate in either indoor or outdoor installations.

The power handling ability of the 1984 is 15 watts. The voice-call form is made of bakelite.

The brass cup which covers the magnet also covers the transformer and protects

it against the weather. The cone is waterproof and the solid center spider protects the air gap from dirt, dust or filings. Wright-DeCoster will send literature regarding this unit upon request. Their address is 2253 University Ave., St. Paul, Minn.

•

G.E. AUTO RADIOS

Three metal-tube auto receivers, one of which incorporates automatic frequency control in its design, have been announced by General Electric Co., Bridgeport, Conn.

Heading the line is Model FA-80, the afc-equipped auto radio. Its case has a gray finish with a chromium plated grille and face plate. Its features include 8 metal tubes, tuning range from 540 to 1,600 kc, afc Class B amplification, 3-point tone control, avc, antenna circuit-matching system, 6½ in. electrodynamic speaker, 7 watts output, adaptable control head, and worm-drive and slip-clutch control.

Model FA-61 is a 6-tube set enclosed in the same case as model FA-80. Its features include 6 metal tubes, tuning range from 540 to 1600 kc, 2-point tone control, avc, antenna circuit-matching system, 6½ in. electrodynamic speaker, 4 watt output, adaptable control head, and worm-drive and slip-clutch control.

Model FA-60 incorporates the features of model FA-61, except the 2-point tone control.

AUTO RADIO—continued

signal is just readable on the meter. Adjust trimmers No. 2 and No. 3 (see Fig. 2) until the maximum output reading is obtained.

Repeat the r-f adjustments to assure accurate alignment.

After the receiver is installed in a car tune in a weak station between 1150 and 1400 kc and readjust the trimmer No. 3 for loudest response in the speaker.

PUBLIC ADDRESS—continued

ments are taken. Here again, if the total distortion is largely due to a non-linear plate characteristic beneficial results will obtain, but if a poor output network is employed, the use of cathode degeneration may result in the introduction of more serious frequency discrimination, by virtue of increased effective plate resistance.

In addition if distortion measurements are taken at a low-output level, at which the output transformer has good characteristics, an apparently large reduction in distortion seems possible. However, if the input signal is increased to the point where the distortion is largely due to the output transformer or load characteristic, negligible improvement will result.

Thus, although the introduction of cathode degeneration might reduce 2-percent distortion to 1 percent in a typical single-tube output stage, it might only reduce 10 percent distortion (in the same amplifier operated at maximum power output) to 8 or 9 percent because the 10-percent distortion is largely due to output transformer saturation, poor load characteristic, etc. When one considers that to accomplish this result appreciable output power must be wasted in the cathode resistor, and frequently discrimination due to variations in load impedance will be increased, the value of cathode degeneration in this connection is highly questionable.

•

Direct-Coupled Amplifier Correction

In the January issue of SERVICE, on page 47, the circuit diagram of a direct-coupled beam-power amplifier is given. A few corrections are necessary.

The suppressor grid of the 6J7 input tube should be connected to its cathode. The screen should be connected directly to the 18-volt tap on the voltage divider instead of the 115-volt tap as shown.

The voltage on the plates of the input 6J7 and 6C5 tubes (and also on the grid of the 6C5 signal divider) is 65 volts. The drop of 150 volts in the 250,000-ohm plate load resistor is caused by the plate current for both tubes. This may be checked from the characteristics of these tubes.

INDEX TO ADVERTISERS

New RCA Test Equipment

at prices every service engineer can afford

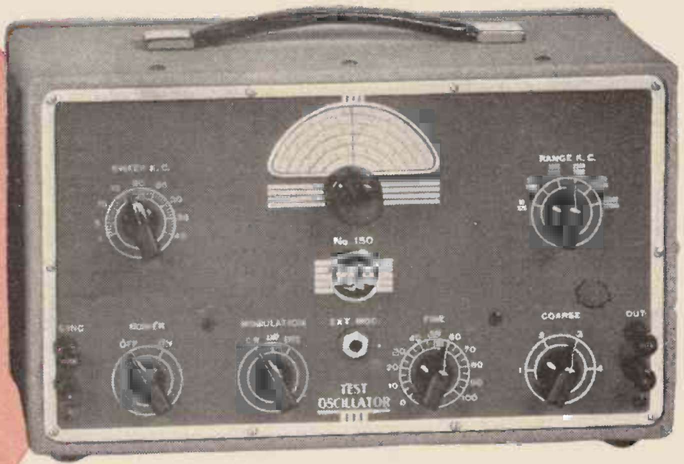
FEATURES:

1. COMPLETE oscillograph using new RCA-913 Cathode Ray Tube—ready for *every* service application.
2. High Sensitivity—1.75 volts (RMS) for full-scale deflection.
3. Both vertical and horizontal amplifiers—Individual gain controls—Flat 30—10,000 cycles.
4. Linear Timing Axis—Range 30—10,000 cycles.
5. Small spot diameter, sharp focus—Individual centering controls on front panel.
6. Removable light shield—Excludes room light and gives intense image. Calibration screen provided.
7. A-C operated—Input power, 50 watts.
8. Ruggedly built—Snap-out leather handle—Symmetrical appearance for use with new Test Oscillator. New two-tone gray, wrinkle finish with highly polished nickel silver etched panel.

RCA CATHODE RAY OSCILLOGRAPH

Stock No. 151 — Net price $47.50

RCA's new Test Equipment offers many new features. It makes your job simpler, faster and more precisely efficient. It's ideal for visual alignment, vibrator testing, checking modulation, distortion and all other general oscillographic applications. Check the features! Then get it and put it to work!



FEATURES:

1. Variable electronic sweep (no moving parts) 1 to 40 kcs.—at any R-F or I-F frequency—Sweep rate, 120 times per second—eliminates screen flicker—air trimmers for all bands.
2. No amplitude modulation with frequency modulation. Horizontal sweep frequency linear across screen.
3. Wide frequency range—90 kcs. to 32,000 kcs.—fundamental frequencies—400 cycle internal modulation—JACK FOR EXTERNAL MODULATION.
4. Large direct reading dial—4 inches diameter—indirect illumination—projected zero indicator lines eliminate parallax—two vernier ratios, 2:1 and 5:1.
5. High r-f output—0.25 volts at all frequencies—negligible leakage—three-step attenuator plus continuously variable control.

RCA ELECTRONIC SWEEP TEST OSCILLATOR

Stock No. 150 — Net Price $64.50

RCA *Parts* FOR PROFIT

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