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J. E. Smith

Heavy Odds . . . Either Way

A noted teacher was talking to a large group of men—average fellows from many walks of life. He asked, "If you were flat broke, how many of you would be willing to cut my lawn for $1.50?" **500 hands shot into the air.**

"But," explained the teacher, "I have only one lawnmower and a small lawn, so you have one chance in 500 of getting the job —500 to one against you."

"How many of you can mix your own paint and do a first class job of painting

(*Continued on page* 8)

INVERSE FEEDBACK IN AUDIO AMPLIFIERS

by
John G. Dodgson
NRI Consultant

PRACTICALLY every book on electronics contains a chapter devoted to inverse feedback in amplifiers. The information is usually either a circuit analysis explanation for servicemen or in the form of complex mathematical formulae for design engineers. Although both types of information are perfectly adequate and correct for their purposes, neither offers much help to the serviceman or hobbyist who likes to design or modify his own amplifiers. This article then is an attempt to take the middle road—a sort of practical application of inverse feedback.

First of all let's take a quick look at what feedback means and what it does. As the name implies, feedback means feeding back part of the output voltage of an amplifier into its input circuit. The voltage fed back must be out of phase with the input voltage; if it is in phase we have an oscillator instead of an improved amplifier! Proper application of feedback can reduce amplitude and frequency distortion, noise, hum, and can even improve speaker operation.

(*Continued on page* 3)

Christmas? IT'S CLOSER THAN YOU THINK!

Each year, during October, November, and December, we receive many letters from students, graduates—their friends and relatives—who would like to purchase equipment from the NRI Supply Division as Christmas gifts. Regardless of whether you're a full or part-time serviceman, hobbyist, or beginner, there are useful servicing tools, instruments, and accessories to fit every pocketbook.

To help you in making a selection (and in dropping hints), this issue of NRI News and the December-January issue will feature a condensed description of available equipment. See page twenty-two.

A father, mother, wife, may purchase any item for a student or graduate. Also, we will make shipment to any address designated. But as a suggestion—place your Christmas order early. Mail moves slower during this season. You may be sure our Supply Division will cooperate in every way possible to help you have a truly Merry Christmas.

How To Connect Accessories To Receivers

By J. Kelly,
NRI Consultant

Servicemen are frequently called upon to connect an extra speaker to a receiver, add a phono pickup, or perhaps install a set of headphones. These jobs are simple, if you know what can be done from a practical viewpoint and how to do it, and can add appreciably to your income.

In some of these jobs, you will have to mount jacks or switches on chassis and make connections with shielded wire so before we take up the individual jobs, we will give some practical advice on preparing shielded wire, and drilling chassis holes.

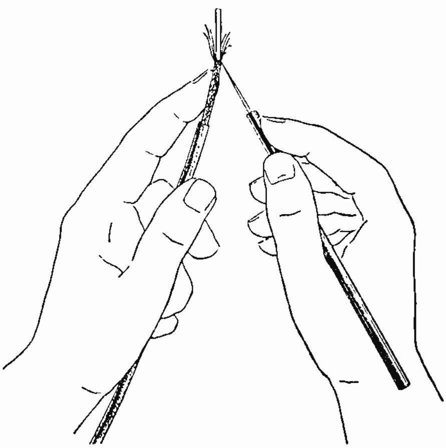

FIG. 1. How to unravel a shield braid with a sharp-pointed tool.

How to Prepare Shielded Wire

To prepare shielded cable for use, proceed in this manner. Remove the plastic insulation carefully from the end, with a sharp knife. You will find beneath the plastic insulation the shield itself. This will be in the form of stranded wire, which may be either woven into a mesh or simply wrapped around the inner wires. If it is woven into a mesh, use a sharp scribe, an awl, or some other pointed instrument, to comb out the wire mesh so that the various strands are no longer woven together, as shown in Fig. 1. Insert the sharp point between the strands and pull it toward the free end. You do not need to work around the cable; proceed in a line down one side of it. This will expose the plastic-covered wire beneath the shield. Twist the various wire strands together into a single pigtail that can be used as a connector for the cable shield. When you solder this pigtail, be careful you do not use too much heat. If you do, you will find the soft plastic insulation beneath the shield will melt and cause a short between the shield and the main wire.

Drilling Chassis Holes

To mount jacks or switches on the chassis, drill a hole in the receiver chassis at the point selected. Make sure the drill does not damage any parts when it goes through the chassis. Shake out all metal particles. If your drill will not make the size hole required (generally ⅜ inch is desired), drill the largest hole you can, and bring it up to size with a reamer or a rat-tail file. A typical drill is shown in Fig. 2.

Adding Headphones

There are two cases where a customer may ask you to add a set of headphones to his receiver. One is to permit program enjoyment by a member of the family who is hard of hearing and normal volume produced by the loudspeaker is not loud enough. The other and most probable is that one or more persons want to listen while the rest of the family enjoys a little quiet. In these cases, two different types of installation are required.

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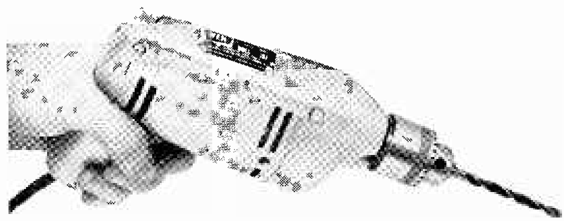

FIG. 2. The Wen ⅜″ drill, which you can purchase from the NRI Supply Division. With this drill you can make a ⅜″ hole, which is the standard size of most radio-TV switches, potentiometers, etc., in one operation.

Inverse Feedback In Audio Amplifiers

(Continued from Page One)

Figure 1 shows a single ended power amplifier which is conventional with the exception of the feedback circuit consisting of R2 and R3. Notice that the grid resistor R1 is not grounded but rather is corrected in series with R2. In addition, one side of the output transformer secondary winding is grounded while the other side is connected through resistor R3 to the junction of resistors R1 and R2. With this arrangement part of the output voltage (E_0) is fed back into the grid circuit. The amount of feedback voltage (E_2) as compared to the input signal E_1 is controlled by the values of resistors R1, R2 and R3.

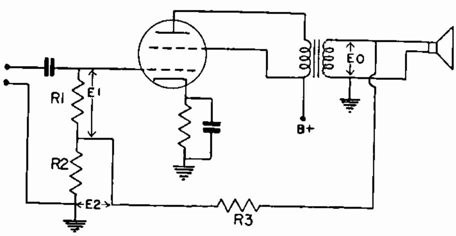

Fig. 1. An R-C coupled amplifier with feedback to the grid circuit.

Now, what happens when an input signal is applied to the circuit? First, the input signal E_1 is applied to the tube and after amplification appears in the output as E_0. For simplicity, let us assume that although E_1 is a pure sinewave input voltage as in Fig. 2A, the output E_0 looks something like the solid curve in Fig. 2B. The "bump" on the output wave may represent noise, distortion, or hum (or all three) generated in the amplifier tube. The bump thus represents something that should be eliminated, because it was not present in the original signal.

Through our feedback circuit a portion, shown by dotted line E_2, of the distorted output E_0 is fed back to the grid in series with E_1. This E_2 voltage is indicated by the dotted curves in Figs. 2B and 2C.

For our purpose, we can assume that all these things occur instantaneously; that is, there is no delay between the time E_1 is applied to the grid, and the instant that E_2 is fed back into the grid circuit. Suppose we have connected the windings of the output transformer so that feedback voltage E_2 arrives exactly 180° out of phase with input voltage E_1 as shown in Fig. 2C. This means we have inverse feedback. Since E_1 and E_2 are of opposite polarity, the resultant input is equal to their difference. This input is illustrated by the curve in Fig. 2D which is obtained by subtracting E_2 from E_1 in Fig. 2C.

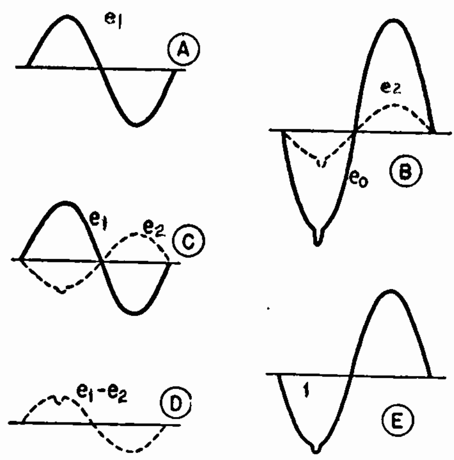

Fig. 2. The effect of feedback voltage on hum, noise, and amplitude distortion.

The final output caused by the new reduced input will be something like that in Fig. 2E. It is apparent that this is a much better reproduction of the original input than that obtained in Fig. 2B.

Through the use of inverse feedback we have taken the amplitude distortion components of the output and put them back into the input in such a direction that they tend to cancel themselves.

It is true that the output is reduced in

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amplitude in the process, because of the reduced effective input voltage (2D is smaller than 2A, so 2E is less than 2B.) but if the input signal voltage (E_1 in Fig. 1) is increased, the output can be brought back to its former level while the distortion components remain substantially reduced.

The amount of reduction of all distortion, hum, and noise by inverse feedback depends upon the amount of output voltage fed back to the grid circuit and upon the gain of the amplifier without feedback. In general, the gain of an amplifier and the distortion in its output caused by the amplifier itself are reduced by an equal per cent. This means that if feedback voltage is increased until the gain has been reduced 50%, distortion will be reduced 50% also. If the input voltage is then doubled, the output will return to its former value, but the distortion in the stage will remain at the reduced value; it will still be only 50% of what it would be without feedback.

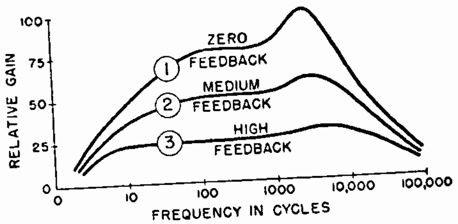


Fig. 3. The effect of feedback on frequency response.

Improvement of Frequency Response

Suppose we have an amplifier that without feedback, has the frequency-gain characteristic curve 1 in Fig. 3. Let us say the poor response below 100 cycles is caused by coupling condensers that are too low in capacity, the peak at 3000 cycles by resonance effects in a transformer, and the loss of frequencies above 10,000 cycles by the shunting effect of tube capacities. Obviously, an amplifier with such a response would not give high-fidelity reproduction.

Now let us see what improvements inverse feedback might make. With a medium amount of output voltage fed back into the input in proper phase, we get response curve 2 in Fig. 3. This is a considerable improvement. Observe that although the over-all gain has been reduced, the response of the intermediate range, and the undesirable peak at 3000 cycles has been cut down so they are more nearly equal to the lower frequency response.

How feedback brings this about may be visualized as follows: Below 100 cycles and above 10,000 cycles, where the amplifier's inherent gain is low, the output voltage also is low. This means the feedback voltage is small in magnitude, so the input is not reduced much. For the peak at 3000 cycles, however, the gain originally is high. The increaased output voltage makes the feedback voltage quite large. When this is fed back, it cancels a large part of the original input and cuts the gain considerably. Therefore, the feedback corrects for frequency distortion as well as for amplitude distortion.

Even greater improvement in frequency response can be obtained if the value of the feedback voltage is increased, as in curve 3 of Fig. 3.

Practical Considerations

It seems then that feedback is a "miracle drug" for amplifiers. It will not only improve the desirable characteristics but will reduce the undesirable. And all we have to do is feed back a portion of the output signal to the input 180 degrees out of phase. Besides the obvious questions of how much feedback and where to feed it back, the last phrase in the preceding statement—180° out of phase—is the real fly in the ointment! As you know a tube provides a strict 180° phase shift from input to output. If we only had tube phase shifts in an amplifier, it would be a "snap" to apply feedback since all we'd have to do is count the stages. Unfortunately, though, we also have R-C networks and transformers in an amplifier and these shift phase other than 180°. Furthermore these reactance devices cause phase shifts that vary with frequency. Thus, although the output voltage may be exactly 180° out of phase at 1000 cycles in relation to the point to which we intend to apply feedback, it cannot be 180° out of phase at any other frequency. Normally the phase shift in an amplifier will be fairly constant at mid-frequencies and shift at the low and high ends of its pass band. If the phase shifts enough the amplifier will oscillate. Even if the phase shifts don't add up to 360° to cause outright oscillation the amplifier will be in an unstable condition. This means that a loud level signal or a steep wave front will cause a burst of oscillation. Thus we can overload stages and cause distortion or saturate the output transformer and cause distortion. Even worse if the oscillation occurs at a high frequency, as it most often does, and gets to the loudspeaker it will be dissipated in the form of heat causing eventual warping

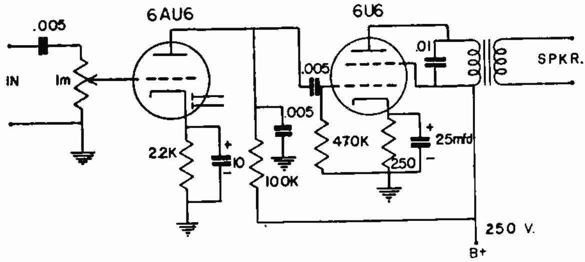


Fig. 4. A simple two tube phonograph amplifier.

of the voice-coil form. Such oscillation and stability problems can never be eliminated but they can easily be minimized as we will see later.

How, Where, and How Much?

In a single ended amplifier the favorite and best place to run a feedback loop is from the secondary of the output transformer to the cathode of the stage preceding the power amplifier. There are many valid reasons for this. First of all including the output transformer in the loop will reduce the distortion generated in the transformer. This is especially important in low and medium cost amplifiers since the transformer contributes a high percentage of the total amplitude distortion and particularly frequency distortion. Furthermore, the feedback at the transformer secondary will lower the apparent source impedance of the amplifier and improve speaker damping.

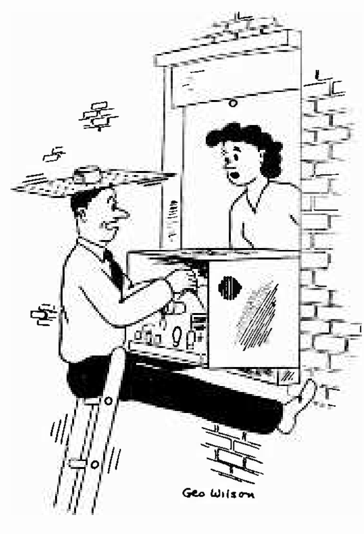
Since the feedback will reduce distortion in all of the stages it includes, it is desirable to include as many as possible. Unfortunately though, each added stage means more phase shift and this in turn means a necessary reduction of feedback voltage to keep the amplifier stable. As you can see, a point of no return would be reached where including anymore stages would necessitate such a reduction of feedback voltage that the improvement would be negligible. Connecting the feedback loop to the cathode of the tube is merely a matter of convenience. Tying into the high impedance grid circuit would increase the possibility of hum pickup. This would also lower the input impedance of the stage and if the crystal (or ceramic) phono pickup was fed into this grid circuit the lower impedance would decrease the loading and directly reduce bass response.

To further illustrate the practical application of a feedback loop let's take the two-tube phono amplifier in Fig. 4 and "improve" it.

The first step in improvement is to increase the size of the coupling capacitors and remove the plate by-pass capacitors. Since we want to eventually connect a feedback loop to the cathode of the first (6AV6) stage, the cathode by-pass capacitor should also be removed at this time.

If the amplifier tends to oscillate at this point it may be necessary to reconnect plate by-pass capacitors. However smaller values should be used to preserve the high frequency response. First connect a .001 mfd to .003 mfd unit from the plate of the 6V6 tube to the screen. If this doesn't stop the oscillation connect the same value capacitors from the plate of the 6AV6 tube to ground.

Before installing the feedback loop, it is necessary to determine which side of the output transformer secondary winding should be connected to ground and which side should be connected to the feedback loop. Connecting the wrong terminal to ground will give positive feedback and cause oscillation. To determine which end of the output transformer secondary should be grounded, connect a speaker to the transformer and feed in a signal—either with an audio signal generator or play a record through it. Temporarily ground one side of the transformer secondary and connect a 100K ohm, ½ watt resistor from the other side of the winding to the cathode of the 6AV6 tube. Correct phasing will be indicated by a reduc-



"You ever think of getting a smaller set for that little apartment?"

tion in volume since the feedback loop reduces the gain of the stages in the loop. Incorrect phase will be indicated by an increase in gain or squealing—in this case remove the ground on the secondary terminal and connect the other secondary lead to ground. If connecting the resistor does not change the sound from the amplifier, try a smaller resistor (about 47K ohms). Once the correct transformer phasing is determined, the transformer winding can be permanently grounded.

The next step is to find the correct value for the feedback resistor which determines the amount of feedback voltage. Since the feedback reduces the gain, the amount of feedback we can apply will directly depend on how much extra gain we have in the amplifier, assuming that the amplifier will not become unstable. We can determine the extra gain either by listening or by measuring. Measuring is by far the preferable method since the ear is not an accurate device. However the measuring method requires an audio signal generator and a VTVM or VOM. For either method it is first necessary to connect a 100K ohm potentiometer, wired as a variable resistor, in place of the feedback resistor. To wire the potentiometer turn it with the control shaft facing you and connect the center terminal to the outside terminal on your right. Check it by connecting ohmmeter leads to the outside terminals. As you rotate the shaft clockwise the ohmmeter reading should decrease and eventually becoming zero ohms. Turning the shaft counterclockwise should cause the reading to increase from zero ohms to within 20% of 100K ohms. After checking the potentiometer connect one outside terminal (either one) to the ungrounded side of the output transformer secondary winding. Connect the other potentiometer outside terminal to the cathode of the 6AV6 tube and turn the control shaft to its maximum counterclockwise position.

To determine the maximum amount of feedback that we can use in the amplifier all we need do is feed a signal into the input and turn the volume control to it maximum (clockwise) position. Since the amplifier has excessive gain the output will be too loud and distorted form overloading in the 6V6 stage. However instead of turning the volume control counterclockwise to reduce the signal, the feedback control is slowly turned clockwise to increase the feedback voltage. This will decrease the gain of the amplifier and eventually a point will be reached where the 6V6 stage overloading will cease and sufficient but not excessive output will be obtained from the amplifier. This indicates the correct amount of feedback and the potentiometer should be removed from the circuit and measured between both outside terminals with an ohmmeter. The next largest size resistor can then be permanently installed. For example, if the ohmmeter reading is 19K ohms, a 22K ohm, ½ watt, 10% resistor should be used.

If an audio generator is available it can be used to provide an input signal and the output can then be measured instead of listened to. The generator output should be set to the same level as the phono cartridge. Most extended range cartridges have an output of .5 volts. The output of the 6V6 tube is rated at 4.5 watts. However, this does not include the transformer which usually has an efficiency between 80% and 90%. Thus we can expect to get between 3.6 watts and 4.05 watts from the amplifier. Actually about 3.5 watts is generally more than enough in this type of system. The output voltage measured across the transformer secondary leads can then be determined by using the figure of 3.5 watts and the speaker impedance which is either 3.2 ohms or 8 ohms. Assuming an 8 ohm speaker we can substitute in the familiar power formula of $P = \frac{E^2}{R}$ to obtain $3.5 = \frac{E^2}{8}$ and then transpose to obtain $E^2 = 3.5 \times 8$ or $E^2 = 28$. Solving for E, we get approximately 5.3 volts.

Instead of connecting the loudspeaker to the transformer secondary winding, an 8 ohm, 5 or 10 watt resistor should be used. An 8 ohm, 10 watt resistor is commercially available and it is perfectly satisfactory. Incidentally if a 3.2 ohm speaker will be used with the amplifier, the load resistor should, of course, be as close to this value as possible. For example, three 10 ohm, 2 watt resistors can be connected in parallel to obtain 3.3 ohms at 6 watts. A power of 3.5 watts is equivalent to approximately 3.3 volts measured across a 3.2 ohm load.

The feedback resistor can then be determined by following the same procedure previously described except that instead of listening, the feedback potentiometer will be adjusted for a reading of 5.3 volts across the load with the amplifier volume control turned full on. Be sure to have the audio generator set for .5 volts output at a frequency of 1000 cps.

Before considering the amplifier improvement as completed it should be checked for stability and the possibility of high frequency oscillation. To check for oscillation turn the volume control to its maximum counter-clockwise position and check for a voltage across the output with a VTVM. A resistor should be substituted for the speaker. The hum output of the amplifier should be measured but should be very low—below .5 volts. If a value above this is obtained, it generally indicates high frequency oscillation assuming that the audible hum with a loudspeaker is unobjectionable. The oscillation, of course, is due to excessive phase shift at a high frequency or a band of high frequencies. The solution is to reduce the gain of the amplifier at that particular frequency. This can be done by either increasing feedback at the high frequency end of the pass

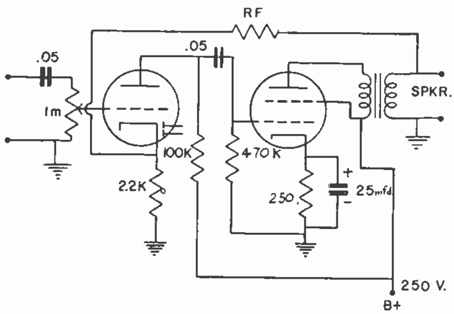


Fig. 5. An improved phonograph amplifier with feedback.

band which will automatically reduce the gain of the amplifier or the gain can be reduced directly. The high frequency feedback can be increased by shunting the feedback resistor with a small capacitor from 10 mmf to 500 mmf in capacity. Direct reduction of gain at high frequencies is accomplished by connecting by-pass capacitors from plate to ground in either the 6AV6 or 6V6 stages. Values from 500 mmf to .002 are generally satisfactory. Sometimes combinations of both methods are necessary. In any case, it is necessary to keep trying different values of capacitors in the circuits until the oscillation ceases. It is important to use as small a capacity as possible to prevent loss of high frequency response below 15,000 cps.

Of course, the method previously described is quite unscientific but is usually quite satisfactory for the type amplifier shown in Figs. 4 and 5. On higher cost push-pull amplifiers it is generally necessary to use an audio sine and square wave generator and oscilloscope. The unique qualities of a square-waves—abrupt start, steep wavefront and abrupt stop—are very similar to musical instruments. Remember that there are no pure sine-wave musical instruments except for the Theremin and that's held in contempt by many musicians. As previously mentioned excessive phase shifts can occur at the extreme low and high ends of the pass band and cause an unstable condition. Since this will not cause outright oscillation it cannot be detected by shorting the amplifier input and measuring the output. In addition, it isn't often possible to detect this unstable condition with sine waves because of the low rise and decay time.

However, since music most often consists of very fast rise and decay periods in addition to quick changes of power level, these unstable circuits can be triggered into bursts of oscillation. This will result in a blurring together of musical sounds taking out the "presence or bite" which is characteristic of true high fidelity sound. Because other defects in a system, such as a worn stylus or loose speaker enclosure panel, will cause this same symptom it's important to stablize the amplifier by using square waves and an oscilloscope. Oscillation caused by instability most often appears on square waves as shown in Fig. 6. The solution, as with sustained oscillation, is to use by-pass capacitors on the feedback resistor and tube plates. It is sometimes also necessary to reduce the feedback.

Feedback, like putty and paint, can be used to cover up a lot of sloppy construction! It shouldn't—it should be used to make a good amplifier sound even better!

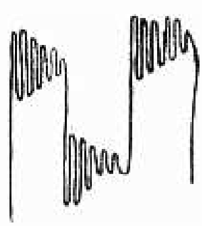


Fig. 6. Square-wave response of an amplifier showing high frequency oscillation.

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Heavy Odds—Either Way

(Continued from Page One)

my house inside and out?" **50 hands were raised.**

"Having only one house, the odds are 50 to one against you," answered the teacher.

"I have a color TV receiver that I want put in first class shape. How many of you can do this job?" **Only one hand was raised.**

"Now," he said, "when you hunt common labor, like cutting grass, the odds are 500 to one against you. The country is full of men and boys who will do that type of work for little pay. If you are able to do work that requires more skill such as painting a house—you have one chance in 50 to get the job. But if you have specialized training—like the one man who raised his hand—the odds are 500 to one you will land a job."

This is the kind of story that hits home—shows more clearly the opportunities

trained men have to get and hold good jobs. This does not apply only to Radio-TV-Electronic technicians and engineers—it means "trained men" in every field. Regardless of what business conditions may be or the employment situation—your job chances are just about 500 to one in your favor if you are trained in a specialized field—or 500 to one against you without the benefit of specialized training.

———*n r i*———

Hi Fi Corner

by John G. Dodgson

NRI Consultant

Hi Fi in a Bottle: The bass response of a speaker is directly related to its resonant frequency. Maximum output occurs at the resonant frequency and the bass output falls off very rapidly below that frequency. The exact point of resonance is determined by the combined characteristics of a number of parts—particularly the cone material, spider compliance, and rim suspension.

Ideally, the speaker cone should be of thick material, to prevent breakup, and should float freely with minimum "drag" of the rim suspension and spider. This can be done by using a thick one piece molded cone that tapers (becomes thinner) at the outer rim and a very light (highly flexible) spider. Since high flux density is necessary in the voice coil gap for optimum sensitivity, power handling ability, smoothness, and minimum distortion, the gap tolerance is very low especially since the light spider is less efficient in centering the voice coil assembly. As might be expected such a speaker could have a low resonant frequency and consequently good bass response. It is evident though that such a speaker would also carry a high price tag.

There have been many attempts, over the years, to lower the cone resonance and improve the bass response without appreciably increasing the price of a speaker. Perhaps the most popular method is to cut slots in the speaker cone near the outer rim. Since at least once a year a magazine article appears describing this "miraculous development," I don't doubt that dozens of speakers go down the drain this way every year. I know because I've tried it! Another favorite method is to paint the outer rim of the speaker with various liquids. These suggested liquids have included olive oil, lubricating oil, grease, gylcerin, etc. I've lost a few speakers that way too!

Since it isn't practical for the average guy to alter the voice-coil, spider, or cone material, treatment of the cone suspension is a logical step. Unfortunately, at least until now, I don't know of any practical method and I've tried all I have heard about. A new product, **Flexicone,**

(Continued on page 14)

Let's Look At A TV Portable

by J. Schek

NRI Consultant

THIS article discusses the operation and circuitry of a TV portable receiver which was widely sold. A thorough understanding of how the various stages and sections operate will make servicing of this and similar portables much easier. Because portables have been in widespread use for about three years and are now becoming an important part of the service man's daily work this article should prove particularly helpful at this time.

RCA 8-INCH "PERSONAL" SET

The small and compact RCA model 8PT-7030 features an 8½-inch rectangular picture tube and is housed in a case that is only 10½" by 9¼" by 12-⅞" and weighs approximately 22 pounds. Fig. 1 shows the receiver chassis and cabinet.

The receiver circuit has 11 tubes including the 8DP4 picture tube. This tube employs 90 degree deflection with electrostatic focus. Four crystal diodes and two selenium rectifiers are used. The crystals serve as video second detector, sound i-f limiter, and ratio detector and the seleniums as the power supply rectifiers. The receiver incorporates the usual number of stages. However, in the video i-f strip only two pentode stages are used. Fig. 2 is a block diagram of the receiver showing how the tube and diode complement are used in the various stages.

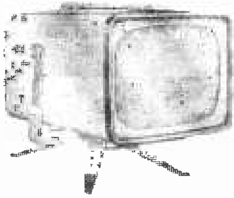
Normal i-f gain is achieved at the expense of the band pass which is somewhat narrower than usual This is allowable since the small picture tube size permits a loss of frequency response (picture detail) that is not noticeable. The receiver is constructed on three separate chassis sub-assemblies. Two of the sub-assemblies are vertically mounted, through which the picture tube is inserted. The third assembly is the rf tuner.

Circuit Analysis

Fig. 3 shows a circuit diagram of the tuner section. This switch type tuner uses two pentode-triodes (6U8) as rf amplifier, converter, rf oscillator and first picture i-f amplifier.

The antenna input circuit includes an antenna matching tranformer, two i-f traps, and an FM trap. The output of the antenna section is coupled to a grounded-grid rf amplifier. The agc bias voltage is applied to the rf grounded grid through a 22,000-ohm decoupling resistor. The grid is put at rf ground through the 680-mmfd capacitor.

The rf amplifier plate voltage is obtained from the cathode of the first i-f amplifier. That is, the cathode of V1B returns to B- through V1A and the voltage drop across the plate and cathode of V1A serves as the operating voltage for this stage. A 1000-ohm resistor decouples the two stages



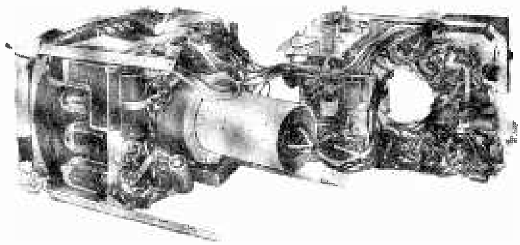


Fig. 1. External and internal views of RCA Portable Model 8PT7030.

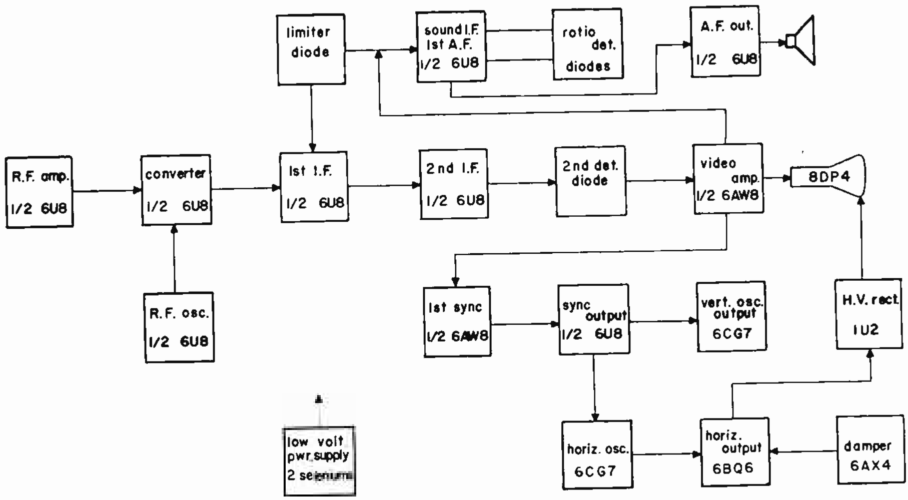


Fig. 2. Block Diagram showing tube complement.

preventing inter-action. The plate of the rf amplifier is tuned on channel 13 by adjusting L8 and on channel 8 by a .5 to 3 mmfd variable capacitor, (C9). The low channels are individually aligned by adjusting the spacing of their coil turns for the proper response.

The output of the rf amplifier is both capacitively and inductively coupled to the grid circuit of the converter stage, (V2B). Grid loading is obtained through the 15K and 150K-ohm resistors. Converter grid tuning is accomplished by means of L23 and a .5 to 3 mmfd variable capacitor (C14) on channel 13 and 8, respectively. As in the case of the rf amplifier, low channel adjustment is secured by varying the coil winding spacing of individual coils. The output of the oscillator is coupled to the converter grid by a 1 mmfd capacitor. The converter obtains its plate to cathode potential by acting as the cathode resistor for the oscillator stage. The i-f output of the converter is coupled to the grid of the first i-f amplifier by means of a tuned circuit consisting of L50 and a 330-mmfd capacitor. These components form a series resonant circuit.

L49 serves as the fixed converter plate load impedance. Effective decoupling between the oscillator and converter is maintained by use of 82 mmfd, 180 mmfd, and .047 capacitors connected between the cathode of the oscillator and ground. The output of the first i-f stage is developed across L47 and is then coupled to the grid of the scond i-f. A parallel resonant trap (L48 and C25) is intended to be used as a 41.25 mc sound boost. In the event that there is no setting of the fine-tuning control at which good sound picture can be obtained, the picture should be tuned in as clearly as possible and the sound boost slug (L48) should be adjusted until the sound improves.

The grid voltage for the first i-f stage is held at a predetermined potenial by means of a 1 meg and 1.5 meg voltage divider, R9 and R10. Since agc voltage is applied to the rf amplifier, agc action is accomplished in the first i-f amplifier because the series arrangement of these tubes causes a change in I-F tube current as the current varies in the RF tube. Fig. 4 shows the circuit diagram of the receiver (Mfgr.'s service manual diagram.)

The output of the first i-f amplifier in the tuner coupled to the grid of the second video i-f amplifier through the 2200-mmfd capacitor. AGC is applied to this grid through a 47,000-ohm resistor, R115. Bias voltage for the crystal diode sound i-f limiter (CR101) is provided by a 12-ohm resistor (R117) in the cathode of the 2nd PIX i-f stage. This diode acts as a low resistance path to ground when the amplitude of the am interfering signals is enough to overcome the bias voltage. The third video i-f tranformer drives the crystal (CR104) second detector. The agc voltage is obtained by filtering the rectified i-f signal across diode load R121; the filter consists of an 820,000-ohm resistor and a .33 mfd capacitor (R120 and C117). This agc bias voltage is applied to the rf amplifier and to the second picture i-f amplifier.

The band width of the i-f under normal signal conditions is approximately 2.1

megacycles. However, as the strength of the incoming signal decreases agc bias is reduced proportionately and the band width decreases. This is due to the Miller effect and provides greater i-f gain for weak picture signals. The Miller effect raises the "Q" of the input tuned circuit as the bias decreases.

A single pentode type (V103A) is used as a video amplifier. Its output drives the cathode of the picture tube. The 4.5 mc. sound i-f carrier is capacitively coupled to the grid of the sound i-f amplifier V101A from this stage.

The 4.5 megacycle sound i-f carrier is coupled to the sound take-off transformer (T101) by a 5-mmfd capacitor (C101). The sound i-f amplifier V101A serves, in a reflex circuit, both as sound i-f and first audio amplifier. The ratio detector stage consists of two crystal diodes, CR102 and CR103. The detected audio signal is coupled through a .01 mfd capacitor (C110) to the grid of the pentode section (V101A) of the 6U8 tube. This part of the 6U8 tube is used in the reflex circuit that functions as a combined sound i-f and first audio amplifier stage.

The audio signal in the plate circuit of V101A is developed across a 33,000 ohm resistor (R104) and is coupled through a .01 mfd capacitor (C110) to the grid of the sound i-f and first a-f amplifier. An audio deemphasis network consisting of the 1000 mmfd (C105) the 220-mmfd (C134) capacitors reduces the excess high frequency response and feeds the now normal audio signal to the volume control circuit.

The triode section of the 6U8 tube (V101B) is used as the audio output stage. The entire sound section, therefore, consists of only one tube and three crystals—surely an achievement in modern circuit design.

The sync and sweep circuits are conventional in many respects. One unusual feature, however, is that the plate of the horizontal output tube is connected directly to the plate of the high-voltage rectifier. The 8-inch picture tube requires a second anode voltage of less than 6000 volts and this potential can be obtained by rectification of the voltage pulses which occur at the plate of the output tube. No step-up winding is necessary on the horizontal output transformer.

The horizontal output tube has a dual type number (6BQ6GTB/6CU6) which means that the tube is the same size as the 6BQ6GT but that it has higher electrical ratings similar to those of the 6CU6. An exact replacement is required if this tube fails. An ordinary 6BQ6GT is not

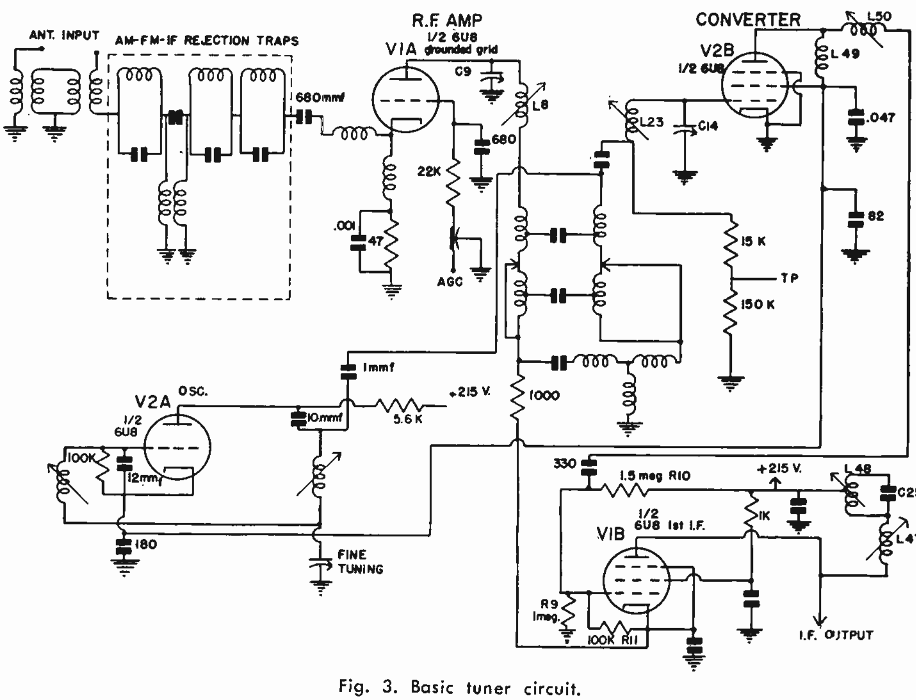


Fig. 3. Basic tuner circuit.

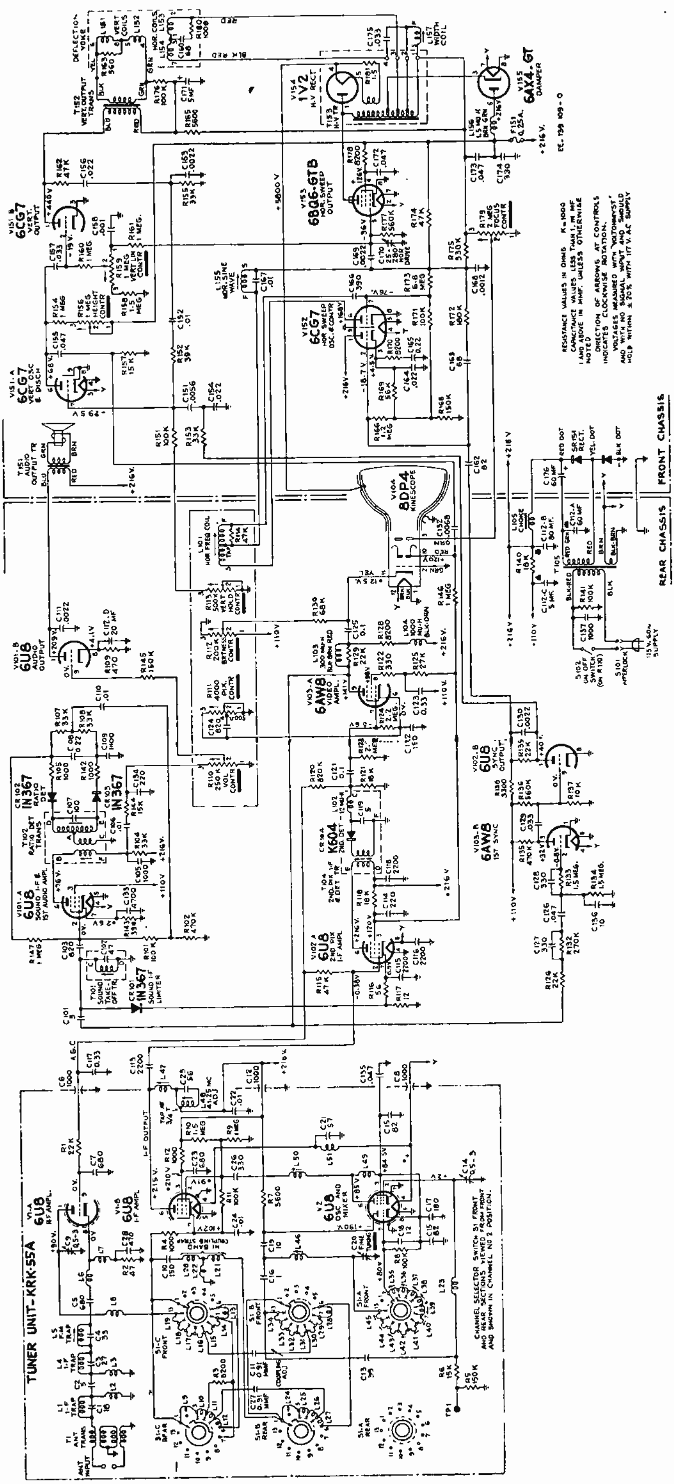


Fig. 4. Schematic diagram of the RCA Model 8PT7030 TV Portable.

adequate for use in the 90-degree deflection system of this receiver and a full size 6CU6 is too large for the available space.

Two selenium rectifiers are used in the half-wave voltage doubler circuit, and its output is a B+ voltage of 216 volts. The power supply also includes a transformer having two secondary windings. One winding supplies power to the voltage doubler circuit and the other is a filament winding which furnishes 6.3 volts to all tube filaments wired in parallel. Since the power tranformer serves as an isolation transformer also, the chassis is electrically "cold"—a highly desirable feature. The rated consumption of the receiver is 90 wattts.

Many of the components in this receiver are of familiar design, but there are some exceptions. For example, the potentiometers and the terminal strips are smaller than those in standard Television receivers.

Chassis Disassembly and Service Adjustments

You can see in Fig. 1 that many components are tightly packed into a small space. All circuits are mounted on two vertical chassis which fit around the neck of the picture tube in such a way that the wiring side of one chassis faces the wiring side of the other. Conventional rather than printed wiring is used throughout the receiver. The two chassis are fastened to each other and to the picture tube by metal rails that extend straight back from the corners of the picture tube mask. The top edges of these chassis are also joined together by a broad, perforated bar of metal. The mounting rail, the two chassis, the picture tube, and the front panel of the receiver form a rigid assembly that can be pulled out of the cabinet as a unit.

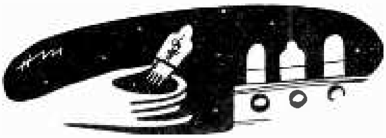
Before the chassis can be taken from the cabinet, the following items must be removed: The carrying handle, one screw at the center of the bottom edge of the picture mask and the control knob together with the control panel at the top of the cabinet. The control panel and its hinged cover form a box-like assembly that can be lifted out of the cabinet after the control knob and three screws have been removed. The power and antenna connections are made through interlocks located on the rear panel of the cabinet and these connections are automatically broken when the receiver is disassembled.

The width, height, vertical linearity, focus, and horizontal drive adjustments are located on the bottom of the front chassis. Special holes in the cabinet are provided so that these adjustments can be made without disassembling the receiver. The deflection circuit and the selenium rectifiers are also mounted on the front chassis, and the speaker is held in place by a bracket that is attached to this chassis. The video, sound and sync circuits, the operating controls, the tuner, and the power transformer are located on the rear chassis.

The two chassis do not have to be separated when replacing tubes. All tubes on the rear chasis, except those in the tuner, are accessible as soon as the receiver is taken out of its cabinet. Before removing the tuner tubes, loosen the set screw which holds the speaker in its bracket. Then the speaker can be lifted out of the way of the tube.

Whenever the picture tube, a sweep oscillator or output tube, or the high voltage rectifier is to be replaced, the picture tube must be detached from the rest of the chassis assembly. This requires the removal of four screws that join the mounting rails to the picture tube mask. The socket, the anode lead, and the ion trap must then be removed from the picture tube before the latter can be freed from the chassis assembly. The technician can gain access to nearly all components by separating the rear chassis from the rest of the receiver. This can be done when the screws which fasten the rear chassis to the mounting rail are removed. The inter-connecting leads between the two chassis are long enough that the rear chassis may be moved some distance away from the normal position.

Fig. 1 shows the rear chassis separated from the rest of the receiver. The receiver may be operated while it is in this position and voltage and waveform checks can be made. The front part of the receiver is shown placed on its side so that the service controls on the bottom edge of the front chassis can be reached easily. The rear chassis is upright so that the main operating controls on the top of the chassis are accessible. Examining Fig. 1 further notice the metal hood that surrounds the neck of the picture tube. It is attached to the front chassis. The hood acts as a receptacle for the yoke and also shields the neck of the tube from the magnetic field of the power transformer.



The ion trap magnet is on a paper sleeve that extends slightly beyond the yoke hood. To adjust the ion trap magnet, move it backward and forward, at the same time rotating it slightly around the neck of the picture tube. This procedure is, of course, standard with all ion trap adjustments. To facilitate this adjustment grasp the paper sleeve with long nose pliers. Movement of the sleeve automatically rotates the ion trap magnet. Continue this adjustment until maximum raster brilliance is obtained. Yoke adjustment for raster tilt can be made by loosening the tension screw mounted behind the yoke and shifting the assembly. Tighten the screw after adjustment has been made.

Two disc-type centering magnets are mounted directly behind the deflection yoke and can move independently. Proper raster centering is accomplished by rotating the discs alternately, then rotating the entire magnet assembly around the neck of the picture tube. A small screwdriver placed in the teeth of these discs helps the adjustment.

The horizontal width and drive adjustments are similar to other receivers. The width control is adjusted so that the raster overshoots the sides about one quarter inch. The drive trimmer is adjusted clockwise until an overdrive line appears in the picture. Then the adjustment is backed off until this line just disappears. Making width and drive adjustments this way results in the brighest picture and best focus. The height, vertical linearity, and focus controls are adjusted last.

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Hi Fi Corner

(*Continued from page* 8)

shown in the photograph consists of three different liquids that are used to paint the outer rim of the speaker cone. The object, of course, is to loosen the rim suspension and thereby improve the bass response by lowering the cone resonance.

After much bad experience with previous similar methods, I was quite skeptical, to say the least, when I first heard of Flexicone. However, I measured the cone resonance of three different speakers, applied Flexicone and then re-checked the resonance. The results speak for themselves. The first speaker, a 12″ RCA, resonated at 90 cps before treatment and 40 cps after treatment. The next speaker tried was an Oxford 8″ P.A. unit that

originally resonated at 110 cps. This was dropped to 55 cps. Fnally an excellent 8″ Stromberg-Carlson was treated reducing the resonance from 69 cps to 45 cps. The exact reduction in resonant frequency depends on the cone material and spider flexibility and will vary with different speakers.

After being treated with Flexicone, the edge of the cone becomes unbelievably soft permitting the cone travel to increase quite a bit. A hidden advantage of the treatment is that loosening the edge of the cone permits the spider to more fully take over its job of positioning the voice coil. This reduces the possibility of voice-coil rubbing.

Listening tests of the treated speakers clearly showed the improvement. Not only was more output obtained at lower frequencies but it was cleaner and truer. Surprisingly the mid and high frequencies were also cleaner and less harsh.

Of course, it still isn't possible to make a silk purse out of a sow's ear! A $3 replacement speaker cannot be made to sound like a $30 Hi Fi speaker. But—the $3 speaker could end up sounding like a $10 or $15 speaker.

No doubt the greatest use of Flexicone will be in improving PA and low-cost Hi Fi speakers. Since each three bottle kit will treat two or three eight inch speakers (depending on the cone thickness) and costs only $3, it certainly is an excellent buy. Incidentally it is available at many local jobbers or can be ordered directly from the manufacturer: Howard Hi Fi Line, 824 Kennedy St., N.W., Washington 11, D. C.

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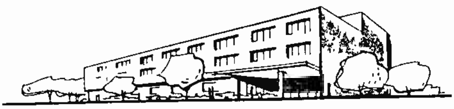
CONVENIENT

New model cars will soon have everything—beds, TV, phonographs, refrigerators—giving the driver a place to live while looking for a place to park.

Tribune, Lynden, Wash.

NRI ALUMNI NEWS



John Babcock And Thomas Hull Are Nominees For Presidency Of NRIAA

In our primary elections for National Officers of the NRI Alumni Association, John Babcock of Minneapolis and Thomas Hull of New York City have emerged as nominees for the 1959 Presidency.

Babcock received a very large majority of the nominating votes for the Presidency. The next highest number went to Thomas Hull. Jules Cohen of Philadelphia came in third in the nominations, but he received many more votes for a Vice-Presidency. So our candidates for President for 1959 are John Babcock and Thomas Hull.

This is not the first time Babcock has run for national office. He was a successful candidate for Vice-President in 1956 and served in that capacity in 1957. Babcock operates his own part-time Radio-TV service business in Minneapolis, was chiefly responsible for organizing the Minneapolis-St. Paul (Twin City) Chapter, was chosen as its first Chairman and later Secretary. He has proved himself as an able and industrious leader, is a strong supporter of the NRI Alumni Association and a mainstay of the Twin City Chapter.

No less can be said for Thomas Hull. He is a former Vice President (1954) and President (1955). He is a strong and very active leader of the New York City Chapter, has served both the NRI Alumni Association and his Chapter well and faithfully.

Either John Babcock or Thomas Hull would be an excellent choice as President of the NRI Alumni Association for 1959.

Nomination votes for Vice-President were more evenly distributed. Joseph Stocker of Los Angeles, an incumbent Vice-President, received enough votes to qualify as a candidate again, but he has informed National Headquarters that he does not wish to serve as a National Officer for the coming year.

Our other current Vice-Presidents have been nominated to run again for the office: F. Earl Oliver of the Detroit Chapter, who continues to set a record for re-election to the office; William Fox of the New York City Chapter, who is beginning to give Oliver competition for that record; and Jules Cohen, the energetic and hard-working Secretary of the Philadelphia-Camden Chapter. The other candidates for a Vice-Presidency are Joseph Dolivka, Chairman of the Baltimore Chapter; Howard Smith former Chairman and now Secretary of the Springfield (Mass.) Chapter and our President for the current year; Elmer Buck, former Secretary of the Minneapolis-St. Paul Chapter; Frank Skolnik, Chairman of the Pittsburgh Chapter; and Edwin Kemp, former Chairman and now Secretary of the Hagerstown Chapter.

Vote for **one** candidate for President and **four** candidates for Vice-President. The polls will close at midnight, October 25, 1958. Results will be announced in the December-January issue of the NRI News.

To vote, fill in the ballot on the next page and mail it in time to reach Washington by October 25.

All members of the NRI Alumni Association are eligible to vote and are earnestly requested to do so. It is the duty and privilege of every member to help choose the officers of his Alumni Association.

Election Ballot

All NRI Alumni members are urged to fill in this ballot carefully. Mail your ballot to National Headquarters immediately.

FOR PRESIDENT (Vote for one man)

- ☐ John Babcock, Minneapolis, Minn.
- ☐ Thomas Hull, New York, N. Y.

FOR VICE PRESIDENT (Vote for four men)

- ☐ F. Earl Oliver, Detroit, Mich.
- ☐ Jules Cohen, Philadelphia, Pa.
- ☐ Edwin Kemp, Hagerstown, Md.
- ☐ Joseph Dolivka, Baltimore, Md.
- ☐ Frank Skolnik, Pittsburgh, Pa.
- ☐ Howard Smith, Springfield, Mass.
- ☐ William Fox, New York, N. Y.
- ☐ Elmer Buck, Minneapolis, Minn.

SIGN HERE:

Your Name ....

Your Address ....

City ....State ....

Polls close October 25, 1958. Mail your complete Ballot to:

T. E. ROSE, Executive Secretary

NRI ALUMNI ASSOCIATION

3939 Wisconsin Ave.

WASHINGTON 16, D. C.

NRI ALUMNI NEWS

Chapter Chatter

MILWAUKEE CHAPTER'S final meeting of the previous season undertook a discussion of transistors, their application, voltage and polarity in TV circuits and Radio receivers. All the members present took part in this discussion, as it is a subject of vital interest to all Radio-TV service men.

After having suspended meetings for the summer months, the Chapter is now going ahead with its program for the new season. Regular meetings are being held once again on the third Monday of each month at the Radio-TV Store and Shop of S. J. Petrich, 5901 West Vliet St., Milwaukee. All NRI students and graduates in the Milwaukee area are cordially invited to the meetings. Get in touch with Secretary Erwin Kapheim, 3525 N. Fourth Street, Milwaukee.

CHICAGO CHAPTER'S Frank A. Dominski, who only recently became a member of the Chapter, has been elected to the office of Treasurer, replacing the former Treasurer, Gordon Hull. Congratulations, Frank!

There followed an interesting lecture by Chairman Nicely, accompanied by blackboard illustration, of the most widely used and consequently most often serviced radio receiver, the AC-DC superheterodyne. The lecture was both fascinating and educational for all present. Many questions were asked both by Chairman Nicely and by those in the audience. This session emphasized the need for frequent review and study of the fundamentals applying to all and even the simpler electronic circuits.

All students and graduates in the Chicago area are welcome at the meetings and should avail themselves of this opportunity to supplement their training and experience. Telephone or write Secretary Charles Mead, 666 Lakeshore Dr., Room 228. Meetings are held at 8 P.M. on the second and fourth Wednesdays of each month at the American Furniture Mart Building (West Door), 666 Lakeshore Dr., Chicago.

MINNEAPOLIS-ST. PAUL (TWIN CITY) CHAPTER'S meetings during the summer were taken up almost entirely by dog TV and radio receivers brought in by members for working over. The members seemed to like to tackle these problem sets, and new members learn by watching the more experienced trouble-shoot the sets. The spare time the members had left over from this project was devoted to converting TV sets for sound only, the converted sets to be donated to the blind.

Kermit Olson won a door prize of $20 to be applied to the purchase of test equipment.

The chapter has plans under way for a free member-and-wife banquet tentatively set for November 1. Mr. and Mrs. John Babcock were appointed to investigate suitable locations for the banquet.

The chapter extends a cordial invitation to all NRI students and graduates to come to its meetings. For more information get in touch with Chairman John Berka, 2833 42nd Ave., S., Minneapolis. Meetings are held at 8 P.M. on the second Thursday of each month at Walt Berbee's Radio-TV Shop, 915 St. Clair, St. Paul.

SOUTHEASTERN MASSACHUSETTS CHAPTER has admitted three new members to membership in the Chapter. They are Antone Medeiros and Frank Sarro, both of Fall River, and Richard Pacheco of North Fairhaven. A cordial welcome to these new members.

As mentioned in the August-September issue the Chapter is following the practice of holding some meetings at members' homes for trouble-shooting sessions, with the necessary test equipment at hand ready for use. Another such meeting was held at the home of one of the Chapter's newest members, Edward Cacilhas, Mattapoisett. At this meeting Ed showed the assembled members how a Wintronix Dynamic Sweep Circuit Analyzer works on a Television receiver. An auto Radio receiver was then worked over, and finally a battery portable receiver. Coffee and doughnuts were served to top off the evening.

Students and graduates in the southeastern section of Massachusetts should take advantage of this opportunity to increase their practical knowledge of Radio-TV servicing. Whether you are a member of the Chapter or not, you will be welcome at the meetings.

The Chapter holds its regular meetings on the last Wednesday of each month, 8:00 P.M. at the DAV Hall, 120 Third St., Fall River, Mass. The Chairman is Michael Lesiak, 20 Cooper St., Taunton; the Secretary is Ernest McKay, 16 Austin Court, New Bedford.

FLINT (SAGINAW VALLEY) CHAPTER discontinued meetings for the summer months but has now resumed its regular meetings for the new fall season.

The Chapter meets at 7:30 P.M. on the second Saturday of each month at Vice-Chairman Aaron Triplett's Repair Shop 2538 Walcott St., Flint. All NRI students and graduates will be warmly welcomed to the meetings. Get in touch either with Vice-Chairman Aaron Triplett or Secretary George L. Hinman, 603½ State St., Bay City.

LOS ANGELES CHAPTER is enjoying a sizable increase in its membership, having recently admitted seven new members. They are: Dock Hill, Rexall Salisbury, Earl Dycus, and Donald Woodard, all of Los Angeles; John Ricklin of El Monte; Mike Raftis of Hermosa Beach; and Kenneth Williams of Santa Monica. Congratulations to these new members!

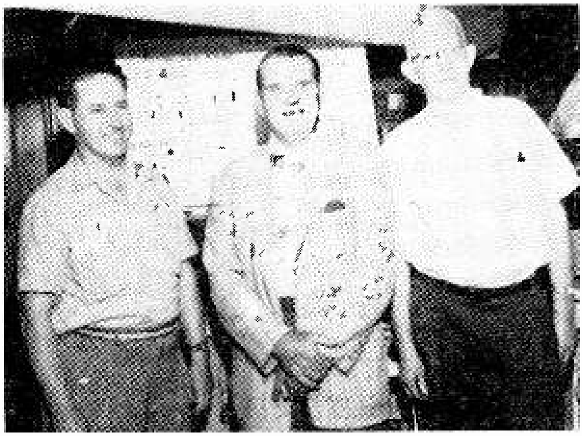
Members were pleased to welcome Mr. M. N. Leventhal, manufacturer's representative for Doss Electronic Instruments, as a guest speaker at one of its meetings. Mr. Leventhal spoke on advanced techniques of TV troubleshooting and demonstrated his talk with Doss Electronic Instruments. The members felt that this was a very worthwhile talk and demonstration indeed and that they got a great deal of practical help from it.

Our apologies to the new Secretary of the Chapter for getting his name wrong in the last issue of the NRI News. We stand corrected.

All NRI students and graduates in the Los Angeles area will be warmly welcomed to the meetings of the Los Angeles Chapter. Those interested should get in touch with Chairman Thomas McMulllen, 1002 W. 187th Place, Gardena, or Secretary Earle B. Allen, Jr., 11523 S. Broadway St., Los Angeles. The meetings are held at 8:00 P.M. on the second Friday of each month at St. Joseph's Catholic School Hall, 1220 S. Los Angeles St., Los Angeles.

BALTIMORE CHAPTER Member Edwin V. Kapp recently visited NRI, made a tour of our new building, and enjoyed a chat with President J. M. Smith.

Mr. Kapp is also a senior member of the American Society of Tool Engineers. As General Sessions Chairman at the Society's National Tool Show in Philadelphia this year he was presented with their Achievement Award for a substantial contribution to the Society. Our congratulations to you, Mr. Kapp. The Society will hold a "Work Shop in Tape Controlled Equipment for the Small Shop" in Balti- on October 23-25, in which a large number of outstanding machine tool maufacturers will take part. Anyone interested in attending the work shop, should get in touch with Mr. Kapp at his home, 2523



Thomas McMullen, center, Chairman of the Los Angeles, visiting the Detroit Chapter. Flanking him are Earl Oliver, left, and Charles Mills of the Detroit Chapter.

Canterbury Road, Baltimore.

The Baltimore Chapter will be glad to welcome all NRI students and graduates in the area as guests or as prospective members. If you have never attended a meeting get in touch with Chairman Joseph Dolika, 717 N. Montford Ave., or Secretary John Woolschleger, 1106 S. Lakewood Ave., Baltimore. The Chapter meets at 8 P.M. on the second Tuesday of each month at 100 N. Paca St., Baltimore.

DETROIT CHAPTER section of Chapter Chatter in the last issue of the NRI News mentioned that the Chapter was visited by Mr. Thomas McMullen, Chairman of the Los Angeles Chapter. A photograph taken of Mr. McMullen during this visit reached us too late to be included in the August-September issue. We are pleased to include it in this issue.

As we go to press the Chapter was busy with plans for its Twenty-Fifth Anniversary Celebration. It will consist of refreshments and a banquet to be followed by dancing and a general get-together to be held on October 11, 7:30 P.M., at St. Andrews Hall Auditorium, 431 E. Congress. This should be a gala affair and we hope to have a report on it in the next issue of the NRI News.

The Chapter has a standing invitation to all NRI students and graduates to come to its meetings either as guests or prospective members. The meetings are held at 8 P.M. on the second and fourth Fridays of each month at St. Andrews Hall, 431 E. Congress St., Detroit. The Chairman is John Nagy, 1406 Euclid St., Lincoln Park; the Secretary is Ellsworth Umbreit, 12523 Racine Ave., Detroit.

HAGERSTOWN (CUMBERLAND VALLEY) CHAPTER, after suspending meetings in July and August, has resumed regular meetings at 8 P.M. at the Northend Hagerstown Senior High School, Hagerstown, on the second Wednesday of each month.

NRI students and graduates in the area are eligible to join the chapter and will be welcomed at the meetings. For further information contact Secretary Edwin M. Kemp, 618 Sunset Ave., Hagerstown.

PHILADELPHIA - CAMDEN CHAPTER, rather than discontinuing its meetings altogether during July and August, held one meeting in each of those months. Much of the time at these summer meetings was devoted to work on the Chapter's TV Dynamic Board and the Chapter members have made good progress with this project. The Board is expected to be completed shortly.

The Chapter is beginning to lay plans for its Twenty-Fifth Anniversary Party to be held in May, 1959. If this party turns out to be anything like similar ones that the Chapter has given in the past, it will really be a big shindig.

The Chapter is now going full force with its regular meetings, to which all NRI students and graduates in the area are cordially invited. Those interested should communicate with Secretary Jules Cohen, 7124 Souder St., Philadelphia. The meetings are held on the second and fourth Monday of each month at the Knights of Colombus Hall, Tulip and Tyson Streets, Philadelphia.

NEW YORK CITY CHAPTER, after suspending meetings during the summer months, held the first meeting of the new season on September 4.

The Chapter is now in full swing again, planning programs to make its meetings as interesting as possible. With the excellent cooperation of its members who, upon request, unhesitatingly get up and deliver lectures and give demonstrations on all

(Continued on page 26)

How To Connect Accessories To Receivers

(*Continued from Page Two*)

For the hard of hearing, the speaker and phones should work at the same time. In the other case, the phone should work while the loudspeaker is silent, and vice versa.

The first case is simple and easily solved by using the circuit shown in Fig. 3. Here on an ac set, you connect terminal 1 to the chassis and terminal 2 to the plate of the output tube (either plate if push-pull operation is used). On an ac-dc set, in which the chassis is not an electrical part of the circuit, connect terminal 1 to B—. The 100,000-ohm audio-type volume control permits the loudness level of the headphones to be adjusted without changing the volume at the speaker.

If it is desirable to use phones without the speaker, the circuit in Fig. 3 is again used. The speaker can be silenced by using a single-pole, double-throw switch, as shown in Fig. 4, to substitute a resistor in place of the speaker voice coil. The resistance should be approximately equal to the voice-coil impedance. If the voice-coil impedance is unknown, which is usually the case, a 5-ohm resistor will probably be satisfactory. The resistor must dissipate fairly large amounts of power. For the average small set, a 5-watt, 5-ohm resistor should be used. With larger sets use a 10-watt, 5-ohm resistor.

To operate more than one set of headphones, three or four regular 100,000-ohm volume controls wired in parallel through C1 and C2 can be used to operate an equal number of headphones—good in large families where the adults want to read while the small fry watch TV. Install the capacitors in the receiver chassis, and the volume controls in individual boxes, wood or metal. Do not make any electrical connections to the metal of the boxes. Twisted lamp cord can be used to connect the potentiometers to the capacitors. If you use metal boxes, bring the headphone and lamp cord wires through rubber grommets. The arrangements in Fig. 1 and 2 work equally well on ac-dc, ac, or FM radios, and TV sets.

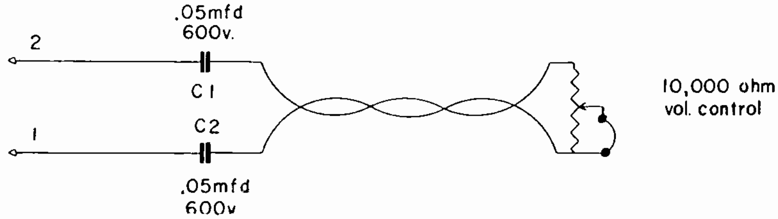


FIG. 3. Headphones set up to be connected in plate circuit of power amplifier.

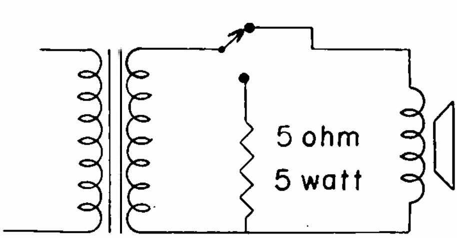


FIG. 4. Method of switching out speaker.

Adding Extension Loudspeakers

Another device the serviceman is often asked to install is an extension loudspeaker. Again either of two different types of installations may be required, as follows: 1. Both speakers work at the same time. 2. Extension speaker works while the set speaker is silent. In either case, it may be desirable to control the volume of the extension speaker at its location. Fig. 5 shows how the job can be done. Since the connections are made at the secondary side of the output transformer, it makes no difference whether the output is push-pull or is single-ended.

In Fig. 5 both speakers can work at the same time or the output of the extension speaker can be cut to zero by adjusting potentiometer R. This potentiometer should be a 30-ohm wire-wound unit rated at 10 watts or more—one with a lower rating will burn out. The potentiometer should be mounted on the extension speaker enclosure and may be connected to the output transformer secondary with twisted lamp cord or 300-ohm TV lead-in cable. No appreciable loss at the extension speaker will be noticed at distances up to 50 feet.

A simple way to silence the set speaker is to install a single-pole single-throw switch in series with one lead to the receiver voice coil. It is not necessary to connect a resistor in place of the voice coil as it was

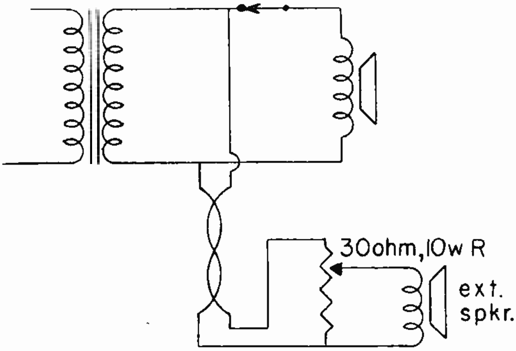


FIG. 5. Use of an extension speaker.

in using headphones, because the extension speaker will furnish an adequate load for the output transformer.

When using an external speaker, you should, of course, use a PM type. Don't use a very expensive speaker, this is not a HI-FI hookup, and spending too much for the extension speaker would be a waste of money.

A somewhat more elaborate arrangement is shown in Fig. 6. Here a jack switch is used so that when the line for the extension speaker is plugged into the set, the receiver speaker is automatically discon-

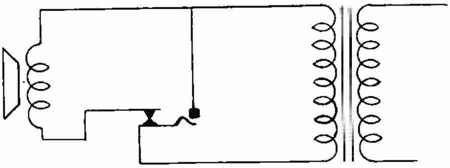


FIG. 6. Contacts in jack switch open and cut off speaker when external speaker is plugged in.

nected. The plug switch may be mounted on the side or rear of the receiver cabinet. The plug switch is the type normally closed. When the extension speaker plug is inserted, one side of the receiver voice coil is opened while the extension is connected across the secondary.

Connecting a Silencing Switch to a Receiver

Sometimes it is desirable to be able to silence a speaker from a distance. For example, from a switch placed near the telephone, or from a chair across the room. The switch shown in Fig. 4 can be used in this way. Because this is a low-impedance circuit, there is no danger of hum pickup, so leads may be run from the receiver to a control box housing the switch. A lever switch with a spring to return the switch to the normal listening position when the hand is removed, is ideal. However, a rotary type switch can also be used. The resistor may be mounted in the receiver cabinet. TV twin lead or twisted lamp cord may be used to feed the switch. A shorting-type switch (which makes contact to one pole before the other connection is broken) should be used, so there will always be a load on the output transformer secondary.

Improving TV Sound

Turn down requests to feed TV audio to a Hi-Fi system, explaining to your customer that in network transmissions the audio is generally cut off above 6000 cycles. Because of this, such changeovers will be disappointing and will not add to your reputation. However, TV sound can frequently be improved by adding inverse feedback in the TV audio amplifier or by substituting a better and in most cases larger speaker if space permits. It is impossible to give detailed general instructions, because what can be done to improve the audio system depends too much on the design of the particular receiver.

Installing a Recorder Output

A tape recorder output jack can be added to most receivers with little trouble, so that radio or TV programs can be recorded. A standard phono jack connected through a .05-mfd 600-volt capacitor to the high side of the volume control as shown in Fig. 7 gives satisfactory results. A switch to silence the loudspeaker as shown in Fig. 4 should also be installed. The shielded lead going from the jack to the recorder input should be as short as possible—not over two or three feet long. A long lead results in hum pickup. If the receiver is the ac-dc type, the recorder must not be on a grounded object and should be far away from such objects so the operator cannot touch ground and the recorder at the same time.

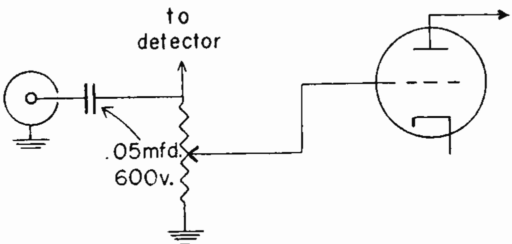


FIG. 7. Jack used to take off sound signal for use in other equipment.

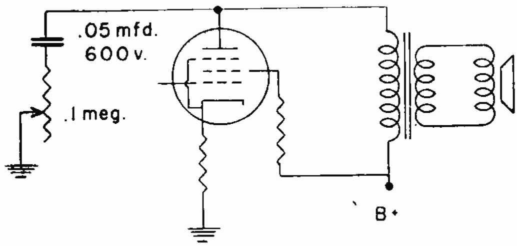


FIG. 8. Tone-control circuit connected to plate of output stage.

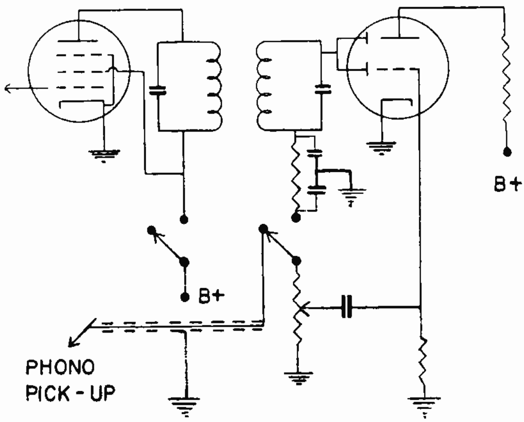


FIG. 9. Phonograph pickup when receiver volume control is to be used.

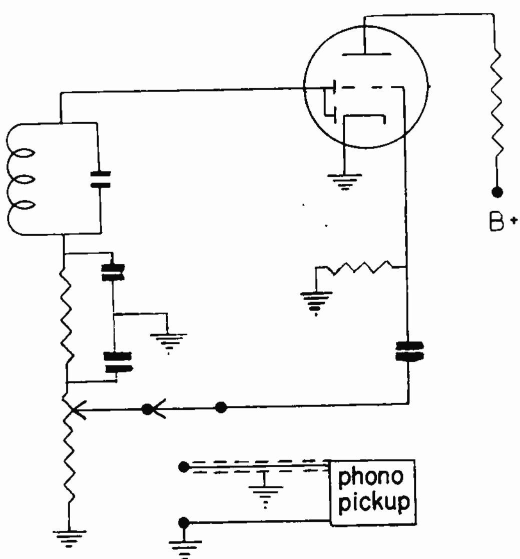


FIG. 10. Connections when phono-pickup has its own volume control.

Installing a Simple Tone Control

There are many different types of tone controls found in commercially manufactured receivers. However, in most cases it would be impractical to try to add an elaborate tone-control circuit. Fig. 8 shows a simple tone-control that can be added to a receiver. This tone control consists of a .05-mfd capacitor and a .1-meg audio-type potentiometer. The tone control works by bypassing the high-frequency signal and thereby giving an apparent increase in the bass response.

If the output is push-pull instead of single-ended as shown in Fig. 8, connect the capacitor to one plate just as in Fig. 8, but instead of grounding the arm of the potentiometer, connect it to the other push-pull plate.

Connecting a Phono Pickup

There is not as much demand for installing phono pickups in radios today as there was a few years ago, because today a record player with a built-in amplifier and loudspeaker costs little more than the record player alone. However, requests will come in and you should be prepared to handle them.

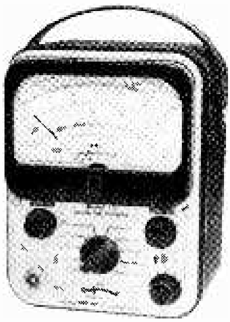
There will be a number of different situations as follows: 1. The record player will have its own volume control. 2. The record player will not have a volume control. 3. The record player will have a crystal cartridge. 4. The record player will have a low-impedance pickup.

Each situation will require different treatment. First we will consider the crystal with and without its own volume control. Fig. 9 shows the i-f amplifier, detector, and first af amplifier in a standard AM receiver. There are, of course, slight variations but the phono installation is the same. In Fig. 9 we want to kill the radio for phono operation and feed the phono signal into the receiver volume control, since the pickup does not have its own control. This is easily accomplished by using a double-pole, double-throw toggle switch as shown. In the position shown, voltage is removed from the screen and plate of the i-f amplifier, effectively killing radio reception,

(Continued on page 24)

Christmas Suggestions

Use order coupon on page 23. Monthly terms can be arranged on all instruments.



Model 12 Vacuum Tube Voltmeter

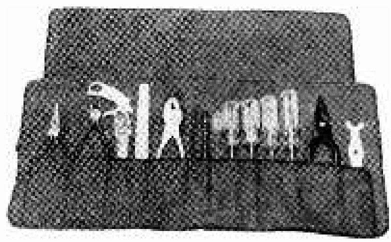
$45.00

Top performance—ease of operation—professional appearance—at a low price. Five ranges, 0-1200 volts AC-DC. Ohmmeter measurements to 1000 megohms in five ranges. Peak-to-peak AC volts. Metal black ripple case with aluminum panel. Size: 7¾″ x 5⅞″ x 3½″. Actual weight 5¼ lbs.; shipping weight 7 lbs. 50-60 cycle, 110-120 volts AC. Shipped Express Collect; test leads and complete instructions included.

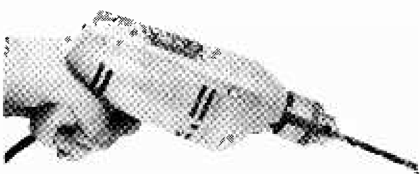
Optional Accessories: 30,000 volt High-Voltage TV Probe—$6.50. Crystal Detector High-Frequency Probe—$9.50.

Professional Tool Kit—$10.95

A real money-saving value. Fourteen carefully selected, top quality tools—not inexpensive store counter specials. If purchased separately, the same tools would run $14.00 or more at dealer's net prices. Recommended for NRI experiments; all Radio-TV service work. Yours thru the NRI Supply Division for only $10.95.—we pay the postage.



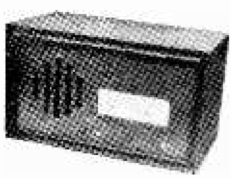
WEN ⅜" Electric Drill—$18.50



Save over $8.00 on this exceptional ⅜″ drill. (Retails for $26.95) Has the power, low speed, and ideal size for Radio-TV work. Takes bits from 1/16″ to a full ⅜″. Shipped complete with rubber covered handle that attaches to either side of drill for safe, two-hand operation. Genuine geared chuck with key. Weight 3 lbs. Length 9″; height 6″. Price includes postage.

Cabinet for your NRI Radio

$4.95



Designed especially for the NRI Radio receiver. Modern appearance; greatly improved tone. Front is well-seasoned Philippine Mahogany plywood; White Gum sides, top, and bottom. Sanded smooth. Shipped knocked-down. Easy—fun to assemble and add your own finish to match room decor. Just $4.95, postpaid.

Cabinet for your NRI VTVM

$4.00

Sturdy aluminum; gray baked-on wrinkle finish; brushed finish chrome handle. Protect your VTVM and improve appearance. Quick installation; exact fit. All necessary screws included. $4.00 postpaid.

and the volume control is switched to the phono pickup and away from the radio circuits. Removing the i-f screen and plate voltage is usually necessary, otherwise, if the set is tuned to a powerful station, signals may come through and mix with the phono signal.

If the record player has its own volume control, use the circuit shown in Fig. 10. Here the controlled output of the pickup is fed to the first af coupling capacitor, and the receiver volume control will have no effect on phono operation.

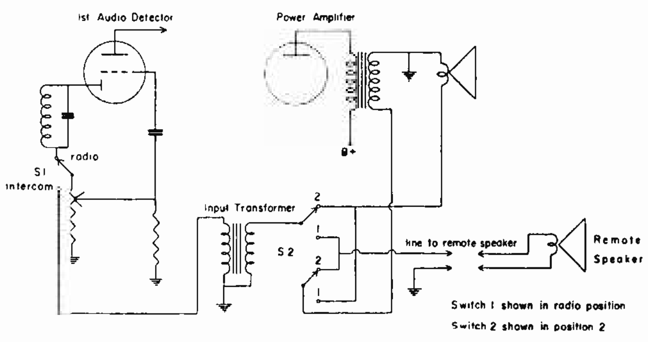


FIG. 12. A standard receiver used in an inter-com. system. Additional remote speakers can be used with a selector to switch from one to another.

In Fig. 10 the ground symbols may or may not indicate the receiver chassis. To be safe, "ground" connections are to be made to the end of the receiver volume control that is at the lowest audio potential (shown in the diagrams as being grounded).

Most record players you buy today come equipped with a shielded insulated lead terminating in a phono plug. All you have to do is mount a phono jack on the receiver chassis and connect it to the switch and volume control. If hum pickup is encountered, a shielded wire should be used between the jack and the switch. Ground the shielding at the low end of the volume control and at the jack.

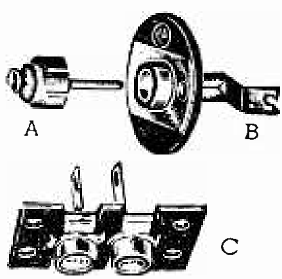


FIG. 11. (A) Single-prong shielded phono plug. (B) Single phono jack—mounts directly on receiver chassis. (C) Double phono pack.

If the chassis is not an electrical part of the receiver, the jack mounting hole in the chassis should be large enough so that the metal part of the jack (to which the shield of the lead connects) does not short to the chassis. Typical jacks are shown in Fig. 11.

Installing a Low-Impedance Pickup

When a low-impedance pickup such as the General Electric variable reluctance unit is used, it is necessary to use a preamplifier. Suitable preamplifiers, complete with instructions for their installation, are available at attractive prices from radio supply houses. It is not worthwhile to construct an amplifier for this purpose.

Adding Phono Pickups to TV Sets. If the question arises of connecting a phono pickup to a TV receiver, it is best to discourage such an installation. Point out to the customer that the TV portion of the receiver cannot be cut off and the sweep circuits must be kept operating. However, you could break into the audio system as shown in Figures 9 or 10. Although the detector systems are different in TV receivers, beyond the volume control the circuits are identical. There is an exception; in some of the recent TV sets, the detector feeds the power output tube without any intervening audio amplifier. However, one of the high-output low-fidelity pickups will drive a power output tube. It should be connected to the volume control as shown in Fig. 9, using a single-pole, double-throw switch instead of a double-pole unit in Fig. 10.

Converting a Radio Receiver Into a Part-Time Inter-Com

Another extra job you can do is to convert a radio receiver into a part-time inter-com system. There are many uses for an inter-com system. For example, you could have an inter-com system connected between the kitchen and the front door. This would save the housewife the inconvenience of interrupting her work in the kitchen to answer the door. It could also provide a simple means of getting rid of persistent salesmen. Another use would be to connect the inter-com between the kitchen and the children's room. This would allow the housewife to hear what the children were doing without interrupting her work.

An inter-com system is nothing more than an audio amplifier with a microphone feeding a signal through the amplifier and then to a loudspeaker. You do not need to have an actual microphone. A dynamic loudspeaker will work quite well as a microphone. Also, you do not need an amplifier at each end of the line. Only one is necessary. A switching system can be used so the connections can be reversed. For example if a kitchen front-door inter-com is being used, when the switch is in one position, the loudspeaker at the front door acts as a microphone and the loudspeaker in the kitchen like a loudspeaker. When the switch is turned, just the opposite is true. Then you can speak into the loudspeaker in the kitchen and it will be heard at the front door.

In Fig. 12 we have shown a circuit that will operate as an inter-com when used with a standard receiver. Notice that the only additional parts are an extra loudspeaker, one single-pole—double-throw switch S1, one double pole throw switch S2, and an input transformer. A conventional replacement type output transformer is used as the input transformer. The low-impedance winding of the transformer is to be connected to the voice coil.

When switch S1 is in the radio position, the system will work simply as a radio. With switch S2 in position 1, the loudspeaker will operate just as usual. The remote loudspeaker will be shut off. With switch S2 in the second position, the radio will then play through the remote speaker and the speaker at the radio will be cut off.

When switch S1 is turned to the inter-com position, the system will work as an inter-com. With the switch S2 in position 1, the person at the radio can speak into the radio's loudspeaker, and he will be heard at the remote loudspeaker. With switch S2 in the opposite position, a person speaking into the remote speaker will be heard at the loudspeaker in the receiver.

300-ohm "twin lead" makes a good conductor to the remote speaker. This is the type of wire used to connect a TV antenna.

These are some of the "extra" jobs you may be called on to do in radio-TV servicing. Doing them well will not only add to your income, but increase your reputation.

———*n r i*———

———*n r i*———

Closed-Circuit TV Keeps Eye On Production In Pennsylvania Steel Mill

Television cameras focused through portholes into the reheating ovens of the Jones & Laughlin steel plant in Aliquippa, Pa., are making it possible for furnace chargers to observe operations and to control the movement of white-hot steel slabs by watching television screens from a safe and comfortable "pulpit" 100 feet distant from the furnaces.

Robert J. Grim, assistant general foreman of the mill says: "The television equipment paid for itself in the first month of use. We have a much more efficient operation as a result, with fewer delays and improved production."

The cameras and associated receivers, operating over a closed circuit, were developed by RCA.

Two RCA ITV-6 cameras scan the scene inside the 2,400-degree ovens and transmit the pictures to the control room where they appear on monitors placed on either side of the operator. The operator, or furnace charger, is responsible for keeping a supply of hot slabs moving through the mill for further processing. Not only must the furnaces be kept fully supplied with the glowing slabs to prevent a jam-up but the charger must see that the slabs are sent on their way with split-second precision to prevent cooling-out before they arrive at the rolling section.

Working with levers and with the aid of the television pictures, the charger is, in effect, close to the scene without having to face the searing heat given off by the ovens.

The cameras are built to stand up under rugged usage and each one is encased in a special heat-proof housing for protection against the high temperatures in which they must operate continually.

"Money and time are the heaviest burdens of life, and the unhappiest of all mortals are those who have more of either than they know how to use."

—Samuel Johnson

types of electronic devices, the Chapter does not find it a problem to arrange always interesting and instructive sessions.

Students and graduates in the area are always welcome at the meetings, are treated cordially and made to feel at home. If you have never visited the chapter, contact Chairman Edward McAdams, 3430 Irwin Ave., New York City, or Secretary David Spitzer, 2052 81st St., Brooklyn. The meetings are held on the third Tuesday of each month, 8:30 P.M., at the St. Marks Community Center, 12 St. Marks Place, New York City.

SPRINGFIELD (MASS.) CHAPTER was blessed with reasonably good weather for its annual picnic. Although the sky was overcast there was no rain. Some forty men, women and children attended. It was obvious that they all enjoyed the day.

As usual, the picnic table was the most popular spot with its abundance of pepper steaks, hot dogs, soda pop, watermelon, etc. The Committee had planned games and races, but everyone seemed to take care of his own entertainment.

The grove where the picnic was held is a day camp for retarded children. This grove has all the accessories for children's entertainment, though of course the children were not interested in games and races. The leftover food was given to the day camp for the children to have the next day.

In the past, the Chapter has been holding its meetings on the first and third Fridays of each month at the U. S. Army Headquarters Building, 50 East St., Springfield. The Chapter will continue to hold its meeting on the first Friday of each month at that address. But the second meeting of each month will be held on the Saturday following the third Friday of each month at a member's shop. This plan will be tried until the first of the year so that at least one monthly meeting will be available to those unable to attend on Fridays.

Due to increased costs, monthly notices will be sent prior to the first meeting of each month to those members who have indicated their desire to remain on the active mailing list. All others will receive special notices periodically. Any member not receiving the monthly notices and desiring to do so, should drop a card to the Secretary.

The most popular spot at the Springfield Chapter's annual picnic—the picnic table.

All NRI students and graduates in the area will be welcome at the meetings. Contact either Chairman Rupert McLellan, 233 Grove St., Chicopee Falls, or Secretary Howard Smith, 53 Bangor St., Springfield, Mass.

PITTSBURGH CHAPTER'S Tom Schnader has completed the initial wiring of the Chapter's dynamic radio demonstrator. The mounting board will now be modified to permit removal of components for practical demonstration of radio defects.

Post-cards have been sent to all members to determine their preference of which day is best to visit a local television station. When the reply cards are received and tabulated, the members' tour of this station will be scheduled. October has been selected for this tour.

The chapter extends a warm invitation to all NRI students and graduates in the Pittsburgh area to attend its meetings either as guests or as prospective members. Those interested should get in touch with Chairman Frank Skolnik, 932 Spring Garden St., or Secretary Kenneth Shipley, 1009 St. Martin, Pittsburgh.

CHOOSING THE RIGHT CAPACITOR

by Dale Stafford

NRI Consultant

CAPACITORS are absolutely essential in the construction of electronic circuits but sometimes it seems as if they were invented by some misguided individual whose sole purpose in life is to make things miserable for the serviceman. Anyone who has ever replaced a defective capacitor only to have the replacement unaccountably fail within a short time or who has been forced to postpone a rush job while he made a trip to the wholesaler for an odd-value capacitor knows what I mean.

To compound the confusion, replacement units come in all shapes, sizes, and prices. Perhaps a discussion of capacitors from the viewpoint of the technician will be helpful.

First, let us look at the electrolytic since, to the serviceman, this is the biggest "villain." Electrolytics open, change capacitance, develop leakage or high power factor or short completely.If the moisture dries out, there will be a decrease in capacitance. Defective seals, excessive operating temperature, and age contribute to this effect. A good capacitor lasts about five years more or less. If an electrolytic is close to five years old, it is fairly safe to assume that it is nearing the end of its useful life.

In power supply filters, an open or decrease in capacity in the input filter capacitor will cause a low hum but the most noticeable effect will be a sharp reduction in output voltage. Leakage allows the hum to increase while the output voltage goes down. The rectifier will be ruined if the leakage is excessive. A high power factor results in an increase in hum and a sharp reduction in output voltage.

Leakage in the output filter capacitor will reduce the output voltage and increase the hum. The filter resistor (or choke) may burn out if too much current is drawn. An open, decrease in capacitance or high power factor in the output filter capacitor will have little effect on the output voltage. However, the hum will rise to a high level. In addition, if the capacitor is also used as an rf-if bypass (as it is in many sets) oscillation will occur.

A good general rule is to stick to exact replacement values whenever possible. However, this may not always be possible or even desirable. For example, wet-type electrolytics have a high leakage and must be mounted upright, so it may be desirable to replace a wet capacitor with a dry type. If so, make sure that the surge voltage rating of the replacement is high enough. Due to the self-healing qualities of the wet-type electrolytics, some manufacturers may operate them closer to the break-down point than comparable dry types. Of course, the working voltage rating of the replacement must be at least as high as that of the original unit.

As a rule, the same capacitance value should be used when replacing filter capacitors. A lower value should never be used as an increase in hum is almost certain

FROM THE WHITE HOUSE

On the occasion of the 32nd Anniversary Conference of the National Home Study Council, the following telegram was received:

"PLEASE GIVE MY GREETINGS TO ALL ATTENDING THE 32ND ANNIVERSARY CONFERENCE OF THE NATIONAL HOME STUDY COUNCIL.

COURSES BY CORRESPONDENCE REPRESENT AN IMPORTANT METHOD IN PROVIDING DIVERSIFIED EDUCATIONAL TRAINING. IN THE DEVELOPMENT OF WAYS TO MAKE THESE OPPORTUNITIES AVAILABLE TO A GREATER NUMBER OF PEOPLE, YOUR ORGANIZATION PROVIDES A SPLENDID SERVICE TO THE NATIONAL COMMUNITY."

DWIGHT D. EISENHOWER

NOTE: NRI and its courses are fully accredited by the National Home Study Council.

to result. Ordinarily, a moderate increase in the value of an output filter capacitor will do no harm. However, care should be exercised in increasing the capacity of the input capacitor, as the rectifier may be damaged by the higher charging current. If this change is necessary, a small surge resistor should be installed between the rectifier and capacitor to limit the current through the rectifier as the capacitor charges.

In AC-DC receivers, the values do not seem to be too critical and a 50-30 mfd dual

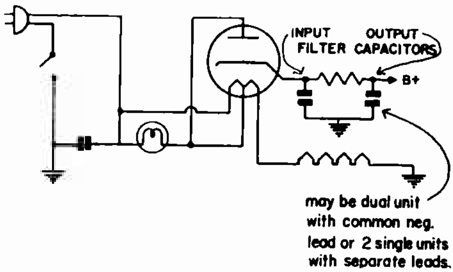


Fig. 1. Typical AC-DC power supply.

capacitor can be used in most of these sets, using the 30-mfd section as the input capacitor and the 50-mfd section as the output. A typical AC-DC power supply is shown in Fig. 1.

A can-type capacitor can be replaced with a tubular capacitor (mounting it under the chassis) if there is sufficient room. However, discretion must be exercised here as the customer may feel that the change impairs the appearance of his set.

When the correct capacitor value is not available, quite often it may be possible to parallel two or more capacitors to obtain the correct value. For example, 20 and 30 mfd capacitors may be paralleled to make up a 50-mfd capacitor. The governing factor in these cases is the space available for mounting the capacitors.

Electrolytic capacitors are available in values ranging from 1 mfd to about 6000 mfd. Working voltage ratings range from 6 to 600 volts but only the more commonly needed voltage ratings are available for each capacitive value. Single, dual, triple, and quadruple units are available in many values.

You may find dual-section electrolytics with three different lead arrangements as shown in Fig. 2A. There may be two separate sections in one container with a positive and a negative lead for each section. Other units may have separate positive leads for each section with a common negative lead while still others may have a common positive lead with separate negative leads for each section.

In Fig. 2B, a dual-section capacitor with a common negative is used while Fig. 2C uses a dual-section capacitor with a common positive lead.

As you can see by inspecting the diagrams, it would be a simple matter to replace either of these units with two single-section capacitors. A dual-section capacitor with a positive and a negative lead for each section could be used in Fig. 2B by connecting the negative leads together and in Fig. 2C by connecting the positive leads together. Had two single section capacitors been used in either circuit originally, it could have been rewired as shown in Figs. 2B or 2C.

However, in studying Figs. 2B and 2C, you will see that the common negative and common positive units are not interchangeable. In the diagrams, the filter resistor is connected between the two sections of the filter capacitor, providing an input and an output filter capacitor. If a common positive capacitor is used to replace the unit in Fig. 2B, both sections of the capacitor would be connected to the rectifier end or to the load end of the filter resistor. The only way the resistor can be connected between the two sections of the capacitor is to rewire the circuit as in Fig. 2C. It might be done by connecting the capacitor with reverse polarity but this would of course, result in destruction of the capacitor. As you can see, it would be equally impossible to replace the unit in Fig. 2C with one having a common negative lead.

When replacing electrolytics in TV sets or in other applications where they are

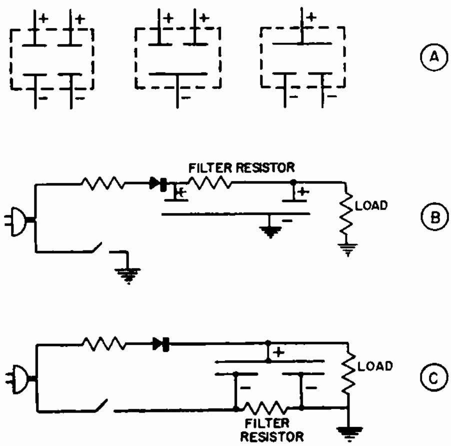


Fig. 2. Dual-section electrolytic capacitors.

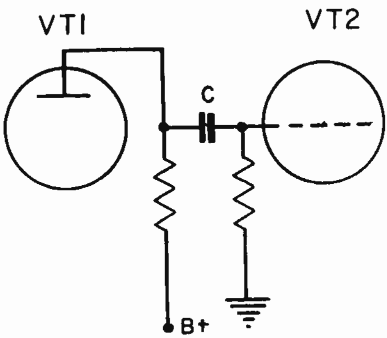


Fig. 3. RC Coupling circuit.

subjected to considerable heat, make sure the replacements are rated for operation up to 85°C.

Sizes of standard single-section replacement units vary from 1" x 2" to 1-3/8" x 4-1/8" for the can type and 13/16" x 1-7/8" x 1-7/16" x 2-7/16" in the tubular type. Miniature tantalum electrolytics as small as 9/16" long by 3/16" in diameter are made for transistor circuits and other uses for requiring compact physical size.

Choosing the correct capacitor for some particular installation is simply a case of matching the characteristics of the capacitor to the requirements. Electrolytics are used where high capacity values are needed. They provide the most capacity per unit of volume and per dollar of cost but stability and accuracy are very low. Capacity changes with frequency are rather severe.

Paper capacitors are commonly available in values from .005 mfd to 1 or 2 mfd at voltage ratings of 100 to 600 volts. Some special units can be obtained with voltage ratings up to 10,000 to 12,000 volts. The cost and size per mfd is lower than for mica capacitors but the accuracy and stability with age and temperature is poorer. Plastic-impregnated capacitors have a higher leakage resistance than the wax-impregnated type so they are more suitable for coupling capacitors. Moulded capacitors are more resistant to moisture or high temperatures than the wax-impregnated cardboard type.

Inspection of the RC-Coupling circuit shown in Fig. 3 will make it easy to see why a coupling capacitor must have a very high leakage resistance. Capacitor C couples the signal voltage from the plate of an amplifier to the grid of the following tube. However, it has another (and equally important) function. It blocks the high positive plate voltage of tube VT1 from the grid of VT2.

Even a very small amount of leakage in the capacitor will allow a positive voltage to be fed to the grid of VT2, cancelling or partially cancelling the normal negative grid bias and causing distortion.

For this reason, only high quality capacitors with very high leakage resistance should be used to replace coupling capacitors.

Mica capacitors provide high initial accuracy, high stability with time, and very little capacity change over a wide range of frequencies. Silver mica capacitors are used where high precision is required. In these units, a change in the applied frequency from a very low frequency up to about 2 mc. results in a capacity change of less than 1%. Capacity change with temperature of as little as 20 parts per million per degree C can be secured. Mica capacitors are available with tolerances as low as 1%—most standard units are 5%.

Ceramic capacitors are available in both disc and tubular forms. The disc type is not suitable for use where the capacity must be held close to an exact value as it is difficult to hold these capacitors to a close tolerance value during manufacture. However, these capacitors compare very favorably with paper units in physical size and in cost. Tubular ceramics are made in values from 1 mmfd up to about 1500 mmfd. The tolerance rating of standard replacement units is usually 5%. Stability with age, temperature, and frequency changes is excellent, comparing favorably with mica. They are smaller and cheaper than mica capacitors of the same capacity.

Tiny ceramic capacitors, .90" to .310" in diameter and .310" to .750" in length, are made in values from .001 mfd to .1 mfd at 100 WVDC for compact circuits. Prices of these miniature capacitors are rather high (40 cents to $5.25 each).

Ordinarily, temperature coefficients are not too important to the serviceman. The only time he is likely to need this information is when replacing a critical component in an oscillator circuit or in one of the tuned circuits in the front end of a communications receiver. Color codes using five bands or dots are shown in Fig. 4 and a six-dot system is illustrated in Fig. 5. In the five-color system, the first band or dot indicates the temperature coefficient. In Fig. 5, the lower left-hand dot shows the characteristics, including the temperature coefficient. In either case, the temperature coefficient is found by locating the matching color in Table I.

An important factor in choosing a bypass capacitor is the operating frequency of the

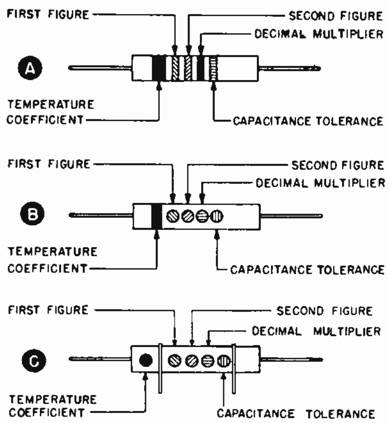


Fig. 4. Color Codes using five bands or dots.

circuit in which it is used. At a certain frequency, the series inductive reactance of the capacitor and the capacitive reactance are equal and opposite and the capacitor is, in itself, series resonant at this frequency. Above this frequency the effectiveness of the capacitor as a bypass falls rapidly.

Paper capacitors have a fairly high internal inductance which ordinarily limits their usefulness to frequencies below 2 mc although some types are satisfactory up to about 5 mc.

Mica capacitors are much better in this respect than paper capacitors and, thus, can be used in circuits where the operating frequencies are very high. Some types of button-mica capacitors have a self-resonant frequency as high as 600 mc.

In common replacement types, ceramic capacitors usually have the smallest amount of series inductance per unit of capacitance. The inexpensive disc ceramic is useful as a bypass up to over 100 mc.

The value of a by-pass capacitor is determined by the frequency to be by-passed and the resistance of the circuit. The capacitive reactance should be 1/10 or less of the value of the circuit resistance. RF or I-F bypass capacitors range from .01 to .1 mfd, with .1-mfd perhaps the most common. Output tube plate bypass capacitors vary from .001 mfd to .01 mfd, with .005 mfd to .006 mfd the usual values. Cathode by-pass capacitors for audio output tubes range from 5 to 50 mfd, 25 or 50 WVDC. Bypass capacitor values are not too critical so some leeway in selecting a replacement is allowable.

Filters are used in electronic equipment for a multitude of purposes. They may be used to filter out an AC ripple, to set the time constant of a circuit, to shape a pulse, to select a single frequency or to pass a band of frequencies. A few examples of simple filters are the grid-leak capacitor and resistor of an amplifier, the R-C combination in a tone circuit, the filter section of a DC power supply, and a tuned antenna coil. These are only a few; there are many others.

The important considerations in choosing capacitors for use in these circuits are the frequency at which the circuit is to work, the time constant necessary for proper operation, and the value of R in the RC combination.

While it is often possible to make moderate changes in a power supply filter, extreme care should be exercised in making any changes in other filter circuits. If the value of the pulse-shaping capacitor in a sawtooth generator is changed, the time constant is changed and the wave-form will be distorted. Improper substitution in the differentiating or integrating networks of a TV receiver may result in incomplete separation of the horizontal and vertical sync pulses or improper forming of the vertical pulse. The wrong value capacitor in a selector or rejector circuit may result in response at undesired frequencies or poor response at the desired frequency.

If the capacitor in a tone control is changed, the tone will also be changed.

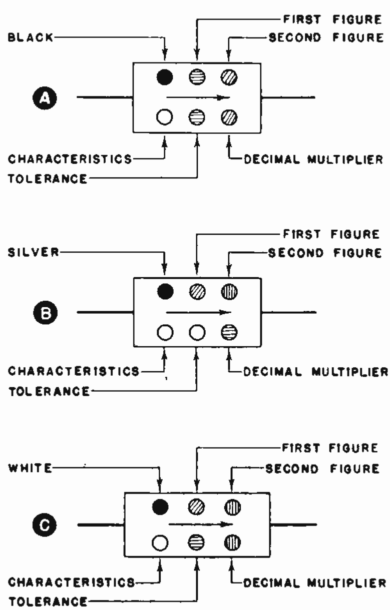


Fig. 5. Six-dot Color Codes.

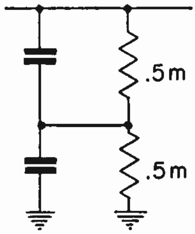


Fig. 6. Voltage-equalizing resistors connected across series-connected capacitors.

While the change may sound pleasing to you, the customer may be dissatisfied.

The same consideration applies to an audio coupling capacitor or output tube plate bypass capacitor.

Care must be exercised not to upset the time constant of the AVC circuit by using the wrong replacement.

Buffer capacitors in auto radios should always be replaced with units having exactly the same value of capacitance. The value depends on the time the vibrator contacts remain open and closed, the flux density of the transformer iron, and the characteristics of the vibrator used and is carefully chosen by the manufacturer for proper operation in that particular circuit. Valucs may range from .001 mfd to .05 mfd (.004 to .008 are probably most common). Although a few vibrator power supplies use capacitors rated at 1000 volts, the usual rating is 1600 volts.

When replacing capacitors, be sure that the replacement unit has a voltage rating at least as high as the original. Do not be misled if the DC voltage drop across the capacitor is low; make sure it is not in a circuit where the AC voltage peaks may be many times the DC values. An example of this is a capacitor connected across the primary of an output transformer. Although the DC voltage across the capacitor may be only 5 or 6 volts, the AC voltage is very high.

Although receiver manufacturers use many capacitors rated at 200 or 400 volts, most servicemen use 600-volt replacements. They find that the increased dependability and the reduction in callbacks are well worth the slight increase in cost.

If necessary, two capacitors may be connected in series to obtain a higher voltage rating. For example, two 500-volt capacitors may be connected in series to make a 1000-volt capacitor.

Since the leakage resistance of paper capacitors may vary widely, even in units of the same voltage and capacity ratings made by the same manufacturer, it is best to connect two matching .5M resistors in series across the series-connected capacitors to equalize the voltage drops as shown in Fig. 6. The exact value of the resistors is not important but they should be matched. With electrolytics, resistors of much lower value should be used. The value is not too critical but should be lower than the leakage resistance of the capacitors.

It is inadvisable to connect two capacitors of unequal capacitance values in series as any AC component in the voltage across the capacitors will divide between the two in inverse proportion to the capacitances. The only safe rule is to use capacitors of the same voltage and capacitance ratings and, preferably, made by the same manufacturer. Of course, when series connected, the two capacitors will have only one-half (or less) the capacity of a single unit.

Complete coverage of this subject is impossible in an article of this length (whole books have been written on the subject) but perhaps some of the points stressed will be helpful to the practical technician.

COLOR	SIGNIFICANT FIGURE	DECIMAL MULTIPLIER	TOLERANCE A	TOLERANCE B	TOLERANCE C	TEMPERATURE COEFFICIENT PARTS/MILLION/°C	CHARACTERISTICS	VOLTAGE RATING
BLACK	0	1	—	± 20 %	± 2 MMF	0	A	—
BROWN	1	10	—	± 1 %	± 1 MMF	−30	B	100
RED	2	100	—	± 2 %	—	−80	C	200
ORANGE	3	1000	—	± 3 %	—	−150	D	300
YELLOW	4	10000	—	—	—	−220	E	400
GREEN	5	—	—	± 5 %	± .5 MMF	−330	F	500
BLUE	6	—	—	—	—	−470	G	600
VIOLET	7	—	—	—	—	−750	—	700
GRAY	8	—	—	—	± 0.25 MMF	+30	—	800
WHITE	9	—	—	± 10 %	± 1.0 MMF	± 500	—	900
GOLD	—	.1	± 5 %	—	—	—	—	1000
SILVER	—	.01	± 10 %	—	—	—	—	2000
NO COLOR	—	—	± 20 %	—	—	—	—	500

"Table I. Data for capacitor color codes."

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