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# RADIO & TELEVISION DATA
## for
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# Antenna Considerations

### Bandwidth, Beam Width and Gain Must All Be

● The old saying that there's nothing new under the sun applies to TV antennas as well as anything else. There's hardly a type available which wasn't long ago employed by hams, commercial broadcast stations or the military.

Nevertheless, when a type appears which has hitherto not been used, or not been used much, in TV, we tend to think of it as "new." For instance, when the Yagi array was described it was considered to be an innovation, although it was really older than TV itself. And even then, it did not come into widespread use for probably at least another year.

It seems that dealers in the fringe areas, using typical American ingenuity, will try *anything* to get a few more DB out of the mud (noise to you). Manufacturers are to be complimented for their courage in presenting many elaborate new designs in an effort to satisfy the enthusiasm of the DX crowd.

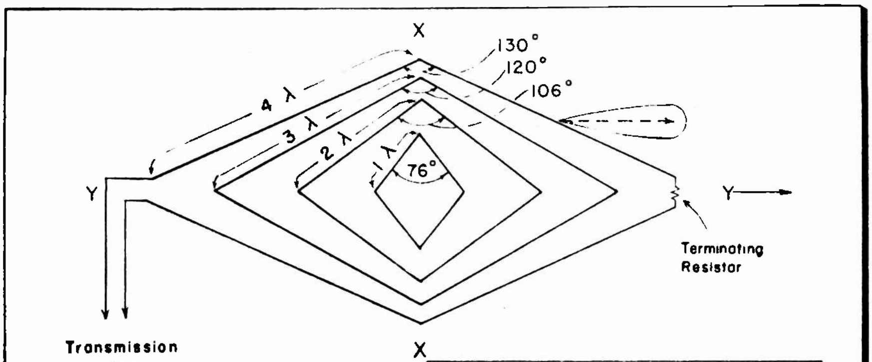
Two relatively recent entries in the DB Derby are the rhombic and the corner reflector antennas. While these have been around for some time, there seems to have been an increase in interest in them last summer, with many technicians trying their hands at construction, and some manufacturers offering new models.

The rhombic is a paradoxical product which has some wonderful advantages which would fire the enthusiasm of any wooer of weak signals, but also some disadvantages which would cause any old time radio man to say that it is totally impractical for TV.

Its advantages are broad bandwidth, excellent directivity, good signal-to-noise ratio and high gain. A well designed rhombic can have a gain of 16 DB over a standard dipole, a frequency bandwidth to the half power point (3 DB down) of as much as ± 50% from the frequency for which it is cut, and a beam width of about 20 degrees—which is narrow enough for sharp orientation and high gain, but not so narrow as to be supercritical. The impedance is about 600 ohms, a good match for the increasingly popular open wire line.

And before you get out the pencil to figure the bandwidth, let's take an example: with a center frequency of 150 MC, plus or minus 50% would take it down to 75 MC and up to 225.

All the above is on the plus side. What about the disadvantages? The rhombic is basically a long wire antenna. In broadcast, communications and amateur work it is often used for extremely long distance transmissions because of its high gain and sharp directivity. In such situations, it would be




| | LEG LENGTH | OVERALL LENGTH: Y AXIS | OVERALL WIDTH: X AXIS |
|---|---|---|---|
| | 1 λ | 1.1 λ | 1.3 λ |
| | 2 λ | 2.9 λ | 2.2 λ |
| | 3 λ | 5.0 λ | 2.7 λ |
| | 4 λ | 7.0 λ | 3.2 λ |
| CHANNEL 13: 2λ LEGS→ | 8'- 10" | 12'-6" | 9'-5" |

**Fig. 2—Typical rhombic designs based on interior angles which complement those shown in fig. 3. When the legs or sides are larger multiples of a wave length at the operating frequency, the antenna gets longer and narrower as does the beam, and the gain goes up. Similarly, when the size remains the same but the frequency goes up: a leg which is 2λ long at 100 MC is 4λ at 200 MC.**

mounted on four high, heavy poles, and could run from 200 to 400 feet in overall length and width, and about 50 to 75 feet high.

You might jump to the conclusion that TV antennas would be much smaller because of the frequency (and you're right), but you'll run into dimensions such as those mentioned above in the 5-30 MC band.

A rhombus is an equilateral parallelogram having its angles oblique. In plain English, that is a four-sided figure whose sides are parallel and equal, and whose angles are *not* right angles (that is, a square is excluded from the definition).

In the form in which it is usually seen, the rhombic antenna resembles a diamond. It is longer than it is wide, and an imaginary line drawn through the long way is called the major axis; through the short way is the minor axis.

The direction of maximum reception is along the major axis; the "front" point is towards the station and the transmission line is connected at the rear point of the diamond. Typical rhombic antenna shapes can be seen in figure 2.

The four sides of the rhombic are called "legs," and *each leg* is a number of wave lengths long at the frequency for which the antenna is designed. The longer the legs, the narrower the beam and the higher the gain.

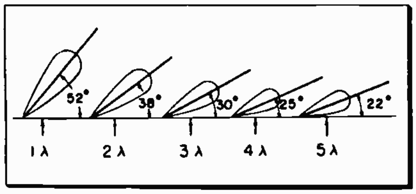
A corollary to this is that as the frequency gets higher, the legs get relatively longer, and the gain goes up.

We said earlier that the rhombic is a "long wire" antenna, and the behavior of such antennas is that the lobes of the radiation pattern form at an angle to the wire. The longer the wire is (in relation to the wave length of the frequency to be received) the smaller the angle is that the lobe makes with it, up to 8 wavelengths (see fig. 3).

What we desire is to have the lobes "point" straight ahead toward the station, and all together (there is one major lobe on each leg). If we consider one leg only, we know that when it is on a line with the station, the lobe is pointing away from the station by a certain angle, as shown in fig. 3, according to the number of wavelengths long it is. If we move it away from "straight ahead" we will arrive at an angle where the lobe is on line with the station.

So the first step in designing a rhombic is to decide how many wavelengths long a leg will be. In TV receiving antennas, where both space and money are at a premium, the designer would select the shortest leg he could, while still achieving enough gain over other antennas to make the job worth while. Remember that the shorter the legs, the wider the beam and the less the gain. A probable likely minimum would be 2 wavelengths: L (length of leg) = 2λ (wavelengths). A properly terminated

**Fig. 3—Formation of radiation lobes on long wire antennas of different lengths with respect to a wave length at the operating frequency.**



# in Fringe Area Reception

## Taken Into Account to Achieve Optimum Results

2λ rhombic could have a gain of 13 DB; 4λ would give 16 DB.

If the design center frequency were 150 MC, for instance, λ is about 6.24 feet and 2λ would be 12.48 feet. In figure 2 we see that the overall length of such an antenna would be 3.4λ or 21.2 feet, the width would be 2 or 12.48 feet.

These figures will give the reader some idea of the dimensions of a properly designed rhombic. They're rather large, but not impractical. The size of the rhombic really gets cozy when you get up into UHF (and we'll probably see a lot of them later on). At 500 MC, λ would be 1.86 feet, a 2λ antenna would have an overall length of 6.3 feet and width of 3.72 feet. A typical UHF rhombic is shown in fig. 4.

In discussing the size and shape of antennas, and their gain, bandwidth, etc., we refer, of course, to theoretical designs. In actual practice, manufacturers may alter the size, shape, diameter of elements, etc., to improve on the theoretical design and/or to fit commercial requirements.

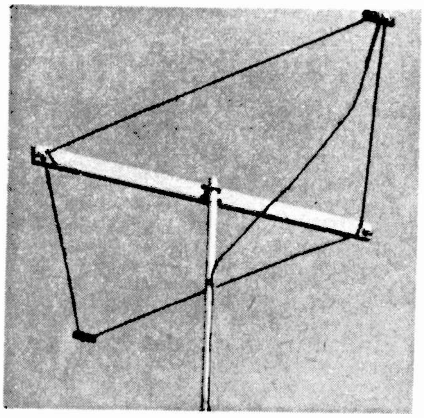


**Fig. 4—A typical UHF rhombic antenna. The antenna is "pointing" in the direction opposite the end to which the lead-in is attached.**

Design of the rhombic calls for "termination" of the antenna across the front "point" with a resistor of specified size. When properly terminated, the antenna is unidirectional, with high front to back ratio. When unterminated, it is bidirectional with a consequent loss of gain in the forward direction. The terminating resistor tends to absorb reflections which would otherwise destroy the unidirectional characteristic of the antenna.

Height of the rhombic, an important factor at lower frequencies, can be ignored at VHF, since getting the antenna higher than one or two wavelengths above the ground is no problem at such frequencies.

Having considered the physical appearance of the rhombic, we might refer again to its characteristics. When constructed properly and installed under optimum conditions, gain can be as great or greater than most antennas and arrays available, and the bandwidth is quite broad—not usually characteristic of directional high gain arrays.

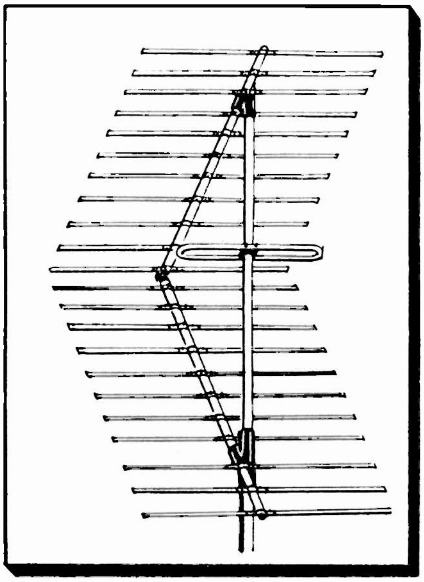


**Fig. 5—A typical Corner Reflector antenna. Although a very effective high gain unit, this antenna is fairly large and heavy, and therefore is most practical on the high-band channels.—*Illustration courtesy Radio Merchandise Sales, Inc.***

In many fringe area installations, optimum conditions might be achieved and considerable advantage attained with a rhombic. As for wide band operation, the writer has not had the opportunity to observe the reactions of the rhombic under such conditions. Most VHF antennas exhibit resonances at certain harmonics of their design frequency, and a change in the lobe formation which changes the direction of maximum gain. It is also true that most VHF antennas work poorly *below* their design center frequency. The rhombic is not supposed to display such characteristics, as some tests have shown.

The corner reflector antenna is another special type, which is a straight or folded dipole (usually folded, for impedance reasons) with a rather large reflector consisting of a number of elements arranged in two planes so that they resemble a book half open. The dipole is placed at the center within the included angle, or in other words, inside the corner. Gain and bandwidth are relatively high on this type of antenna, too. Physical size and weight of the reflector, however, suggest that its use would be confined to high band VHF, or to UHF.

The corner reflector is actually closely related to the parabolic reflector, which will probably be used considerably in UHF (as it is already in radar), when the size of the "dish" becomes practicable. Gain of an antenna with a parabolic reflector is slightly more than the corner reflector, but the bandwidth is only half as wide.

Vertical pickup on the corner reflector antenna is practically nil (not so with the rhombic) and front-to-back ratio is very high.

A typical antenna for approximately Channel 13 would have a reflector consisting of two sheets or planes at right angles to each other. Each sheet would be about four feet long, each made up of 10 reflector elements 31 inches long, ¼ inch in diameter and 5 inches apart. A commercial corner reflector antenna is shown in fig. 5.

Beam width of the corner reflector type antenna is relatively wide (compared to the rhombic, for instance) with a blunt front, which would make it possible to receive several stations slightly different in orientation from the site. Vertical pickup is smaller than almost any other type of antenna which can be selected, and should be advantageous where noise pickup from the ground (as with auto ignition, for instance) is a problem.

The sheet reflector antenna is a dipole with a simulated flat sheet behind it (as

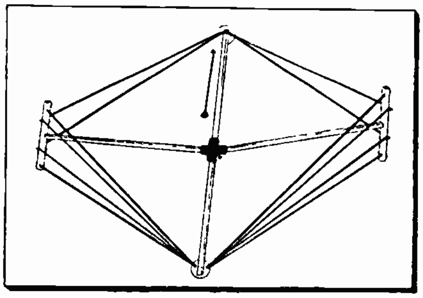


**Fig. 6—An unusual rhombic in which the long axis is broadside to the station. Extra elements on the back are designed to improve pickup on the low band. By increasing the diameter of the elements, it is said to be possible to utilize shorter legs.—*Courtesy Roger Phillips Research Labs.***

opposed to the folded sheet of the corner reflector). The sheet consists of a number of reflector elements in a hayrack formation very similar to certain types of radar antenna we used during the last war; but with the radar antenna, there were also a great number of driven elements, several elements wide as well as high. Gain of the sheet antenna, of which the Gonset Radaray is an example, is not, in theory, as high as either the rhombic or the corner reflector, nor is the bandwidth as wide. But these factors, in actual field performance, would depend on the intricacies of the manufacturer's design. Front to back ratio is very high, and the theoretical antenna would have *no* pickup either from the ground or from the rear. Beam width is quite broad and blunt, even more so than the corner reflector.

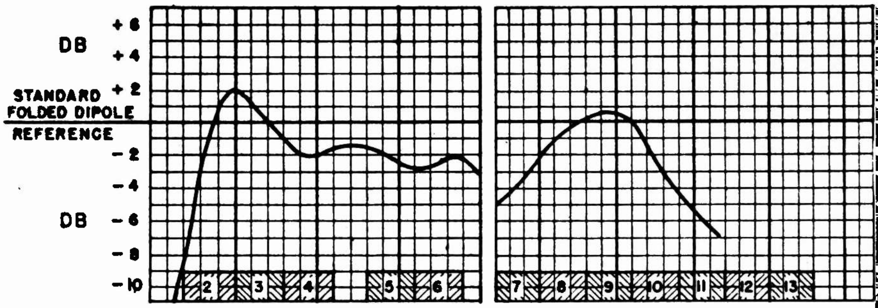



**Fig. 2: Gain of a simple dipole (90" long) and reflector over the 12 channels, compared to "standard" cut for each frequency. Compare this broad-band, low-gain antenna with the narrow-band, high gain Yagi shown in fig. 3. Illustration courtesy American Phenolic Corp.**

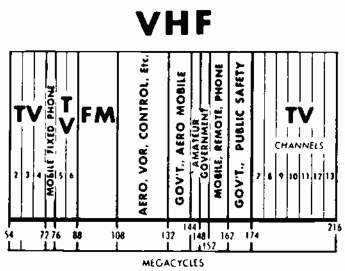
## Part 2:

● The importance of TV antennas in the overall reception chain from transmitter to picture tube can be graphically illustrated by citing the example of a certain TV transmitter: the transmitter delivers 2.68 KW of video power to the antenna, while the effective radiated power is 18.5 KW. The antenna itself thus provides a power gain of 6.9 times (8.4 DB).

Gains of as high as 10 DB are not unattainable with receiving antennas. Since we are more accustomed to consider volts (or rather, microvolts) at this stage of reception, we can interpret this as a voltage gain of 3.16 times.

The importance of antenna gain can be appreciated from a brief analysis of picture reception in the fringe areas. Picture quality can be (and usually is) marred by (1) Lack of contrast, (2) Snow, (3) Interference and (4) Poor sync. All of these troubles can be summed up by the expression "weak signal." Snow and external interference will degrade the contrast by breaking up the solid blacks and whites as if a screen were put over them. Interference can upset sync by injecting relatively high amplitude noise peaks over the weak sync signals.

Therefore it can be seen that snow and external interference can be the seat of most of the troubles. The sources of external interference need not be explained at great length. They are such things as ignition, motors (particularly with arcing brushes), unwanted RF signals, etc., and are familiar to the technician.



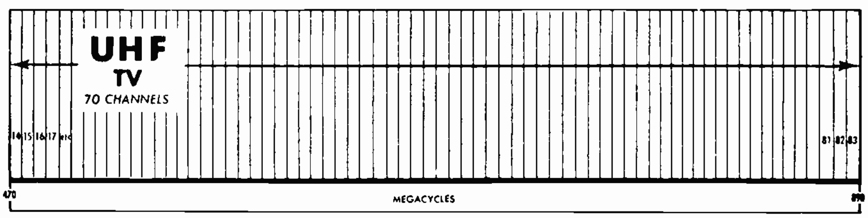




**Fig. 1: UHF TV band is 2-4 times higher in frequency and almost 3 times as wide as VHF.**

Snow is, however, internal. A certain level of noise in tubes and resistors is inherent in the design of electronic equipment. Ordinarily this noise is kept at a minmum and is well over-ridden by the signal. In the presence of a weak signal, however, the receiver is operating "wide open" and the higher the gain of the stage, the greater the tube hiss and noise (which manifests itself as snow). In other words, the signal-to-noise (S/N) ratio is already low with a weak signal, and by running the gain wide open, we increase the noise and lower the ratio still further. This ratio should be at least 10:1 at the output of the tuner, which is one of the principal limiting factors on the sensitivity of a receiver.

The acceptance of both external and internal noise is increased as the bandwidth increases. This makes sense if we consider random noise as occupying a broad band of frequencies. The wider the bandwidth of the receiver, the more of the noise spectrum it will accept. This is why a TV receiver with a 6 MC bandwidth is so much more susceptible to noise than, for instance, a high sensitivity AM set.

Improvement of the signal to noise ratio must take place prior to the grid of the first IF amplifier, or in other words, in the front end or at the antenna. Or to put it another way, this is the most critical spot for S/N, since the signal level is low and the gain is relatively low. Any noise passed on by the tuner will be tremendously amplified by the IF amplifier and, if the level is high enough, will appear in the picture.

Assuming for the moment that we do not intend to make any changes in the receiver, then it is obvious that the only way to increase the S/N ratio at the output of the tuner is to increase the signal input to it. This could be done with a better antenna or with a booster. Considered purely as an amplifier, however, a booster would contribute noise of its own, and in addition would amplify any noise present at the antenna. A booster has certain advantages, however, which will be taken up later. But for improving the S/N ratio, the antenna is the likeliest place.

Let us assume some hypothetical values for the sake of clarification. Suppose we have a tuner with a gain of 10 from input to converter plate, and internal noise at the output of 50 microvolts. A signal input (pure, without external noise) of 50 microvolts would produce an output of 500 microvolts, and this would give us our desired S/N of 10:1.

But now let us suppose that the input signal were not clean, but instead that there was a 10 microvolt noise signal present (actually a very small amount). The signal to noise ratio in the input would then be 50:10 or 5:1. After 10 times amplification by the tuner, we would have 500 microvolts of signal plus 100 microvolts of noise. This added to the 50 microvolts of internal noise would give a total of 150 microvolts of noise. The noise ratio at the output of the tuner would now be 500:150 or about 3.3 to 1, a very unsatisfactory ratio.

To overcome a situation such as this would require a signal of 150 microvolts. With the same 10 microvolts of external noise and a tuner gain of 10, we would have an output signal of 1500 microvolts and a noise signal of 100. This latter, added to the internal noise (50) would give 150 microvolts of noise. 1500 to 150, then, would give the desired 10:1 ratio.

To achieve this result, namely to increase the input signal from 50 to 150 microvolts, would require an antenna voltage gain of 3, or about 9.5 DB. A Yagi could do it, or a corner reflector, or several other types of antennas previously mentioned in these pages.

Thus it can be seen that an improvement in the signal to noise ratio must be achieved early in the game in order to effect a really worthwhile improvement in the picture. Although increases in amplification may produce more black and white, if the snow and interference are not reduced, detail will not be improved and annoyance and eyestrain will be the only results.

Antennas may increase gain by cutting down in beamwidth and bandwidth, or both, for they can "reach out" farther. They can also cut down on noise pickup with narrow beamwidth, low front-to-back ratio and low vertical pickup, since they tend to eliminate the possible areas of noise origination. Reduced bandwidth also helps to cut down noise pickup, since as we mentioned earlier, it tends to discriminate against some of the noise frequencies.

A typical Yagi response is shown in figure 3. It can be seen that the useful bandwidth of this antenna is hardly wider than the channel it is intended to cover. The antenna is cut for the low side of the channel, which emphasizes the picture carrier, a desirable feature in the fringe. The gain of the antenna, of course, is high.

Compare the above with the response curve shown in figure 2, for a simple dipole and reflector. While not nearly so high in gain, this type of antenna is usable over a great deal of the VHF-TV spectrum.

### *Beamwidth vs Gain*

The polar response patterns (horizontal plane) in figure 4 show the relationship of beam width between a 6-element Yagi (left) and a simple dipole and reflector (right).

These two comparisons, of bandwidth and beam width, tell the general story for high gain antennas, with a few exceptions. The rhombic has a narrow beam (narrower than the Yagi) but a broad bandwidth (in addition to high gain). The corner reflector antenna, also discussed last month, has both a broad beam *and* a broad bandwidth, while still a high gain antenna. These two antennas, probably too cumbersome for general use in VHF-TV (especially the low band) will no doubt be more widely used come UHF, along with a number of other specialized types not used at all in VHF.

UHF will make many exacting demands on the antenna installer, when it arrives. In the first place, the spectrum (470-890 MC) is 420 MC wide, 2½ times the size of the present VHF band from channel 2-13. UHF will furnish 70 channels, from 14 to 83. In the second place, signal powers attained at the transmitter are as yet relatively low compared with VHF. At the same time, attenuation of the signal is greater, so that signal strengths are low comparatively, and 20 miles will probably be a "fringe" area. In addition, reflections and shadows are more of a problem, and attenuation due to rain, leaves, etc. is much greater. Consequently, antennas will need to be very high gain and very directional, but due to the frequency, need not be large. A half wave length at 500 MC is less than a foot. Attenuation in flat twin-lead due to weathering has been quite serious, but tubular twin-lead seems to stand up better, and it is likely that the latter will be used extensively in UHF. Attenuation in coax is rather high, but it weathers well, and it is also recommended. Impedance matching will be critical at UHF, and even special lightning arresters are recommended, so that losses and unbalance will not result.

Getting back to our fringe reception problems, it is of course, axiomatic that gain is inversely proportional to bandwidth in amplifiers. It is also true that noise is inversely proportional to bandwidth. Therefore it can be seen that by cutting down the bandwidth (that is, by tuning more sharply, or peaking the response), we can not only increase the gain but also cut down on the noise so that we make a two-fold improvement in S/N ratio. In TV, naturally, this means cutting down on picture definition. But if by sacrificing some definition we can improve contrast, cut down on snow and interference and make the sync more stable, it may often be worth it. This is actually done by many TV set owners in setting the fine tuning control for the brightest picture, usually at the expense of the sound as well as picture definition. It is also done, more skillfully of course, by some fringe area servicers, who peak-align the sets for higher gain. There are also some receivers which incorporate a circuit which automatically reduces the bandwidth when the signal strength is down.

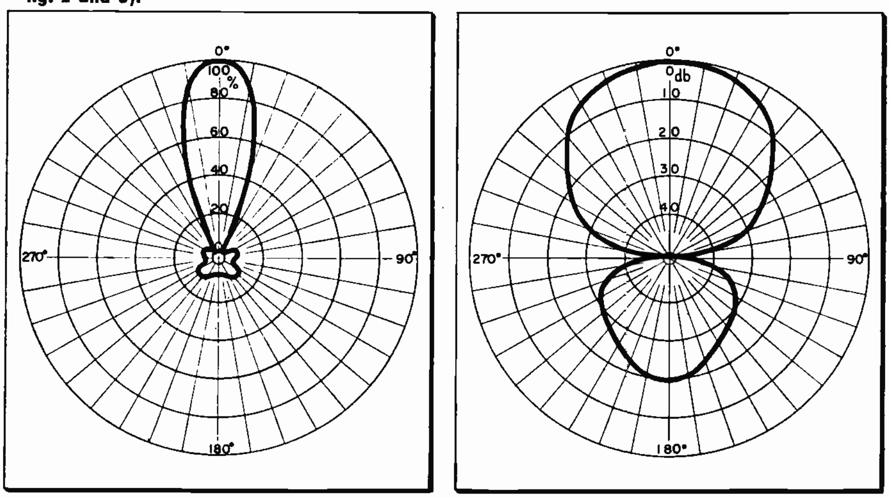



Fig. 4: Comparison of a narrow beam (left—a 6-element Yagi, from Tele-Tech) and a broad-beam antenna (right, a simple dipole and reflector, from TV and Other Receiving Antennas by Arnold B. Bailey). These patterns do not indicate the difference in gain between the two (see fig. 2 and 3).

This is the point to which we were referring when we said that amplification is not the only function of boosters. Many tunable boosters not only permit the user to peak-tune the input for higher gain and narrower bandwidth, but are actually built to provide a narrower bandwidth signal. Adding a preselector ahead of the front end of the receiver also tends to cut out some interference signals.

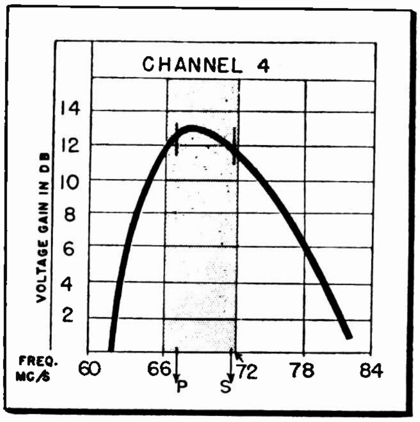



Fig. 3: Response of Telrex Y5X1-4, a 5-element Yagi cut for channel 4. "P" and "S" are pix and sound carriers. This high gain antenna shows less than 1 DB variation over the channel.

Before aligning the receiver, however, the installer would do well to do all he can with the antenna installation. This, of course, includes picking the highest gain array which will suit the local situation (as to number of channels, frequency of channels, etc.); trying additional height; using low-loss lead-in well matched at both ends; keeping lead-in away from roofs and walls (with long standoffs) where they might be subject to excessive moisture; experimenting with tilt of the antenna, both in the horizontal and vertical planes, etc.

Regardless of what is used after the antenna—whatever make set, booster, etc.—best results will be obtained with the optimum antenna installation. Attention lavished on this detail will pay off in better picture quality, more satisfied customers, and more dollar profits in the end.

## SHOP HINT

### *Scope Requirement for TV Alignment*

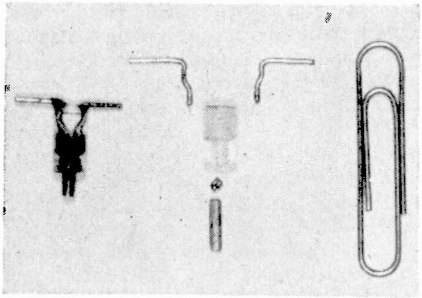
"While a wide-band response is essential for the observation of sync and blanking pulse shapes, it is well to point out that a scope having a response of plus or minus 10% to 40KC is ample for all sweep alignment work on TV and FM. The sweep curve observed is not RF but is derived from the frequency-modulated RF or IF signal by detection, and so it is actually well within the audio range.

# Latest Transistor Units

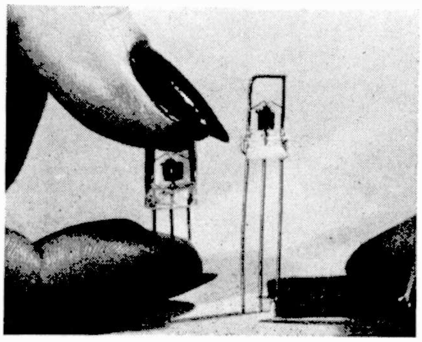
***Preview of point-contact germanium types now in developmental and pilot production stages by five manufacturers***

WHILE poring through the daily newspaper one may be highly impressed with the imminence of wrist watch radios and pocket-size TV receivers, devices made possible by the advent of the transistor. As one non-engineering enthusiast put it, "The vacuum tube is a cooked goose!" However, the transistor is presently in a developmental phase, and the state of the art does *not* warrant the zealous acclamations of an immediately forthcoming technological revolution. No one is more impressed with the imposing potentialities of the transistor than the scientists actively engaged in its study, but their sober evaluations tell us that although the future holds a key role in store for the crystal triode, much more must be learned before its marvelous abilities become commonplace in our daily lives.

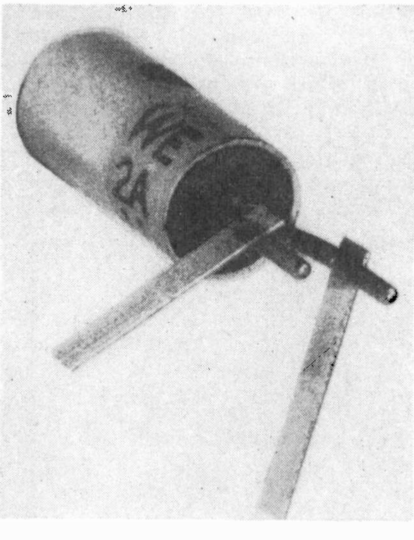
So without sensational fanfare, here are several point-contact germanium transistors fabricated by different manufacturers. Generally speaking, these units are in a developmental or pilot production stage and not commercially available in the mass production meaning of the word. Junction-type transistors have undergone less development to date, and may be considered as being in an even earlier prenatal state so far as well controlled mass production for civilian use is concerned.



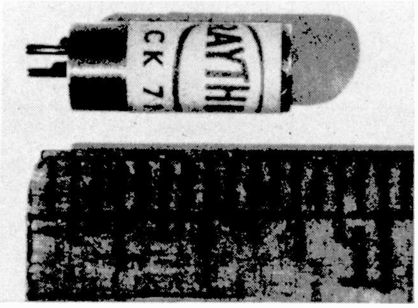
**PHILCO'S** potted transistor for video and r-f carrier amplification is enclosed in an impregnating plastic. The above picture shows the emitter and collector leads, base pin, germanium block from which the crystal wafer is cut, and the plastic case. Whisker crimp provides predetermined contact pressure on the crystal. Electrical characteristics are comparable to preliminary specifications for similar types.



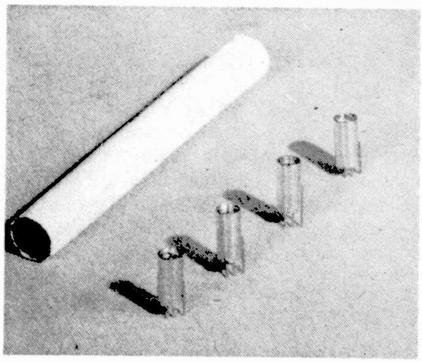
**RCA** transistors are imbedded in a thermo-setting resin to maintain power gains within a 2 db variation over extreme conditions of moisture, shock and temperature. Unit measures 0.6 x 0.3 x 0.2 in. and is shown at the right in an advanced stage of construction before being encased in plastic. Operating characteristics of two representative transistors at 25°C are as follows: emitter volts 0.42 and 0.5; emitter current 1.1 and 0.55 ma; collector volts 20 and 17.5; collector current 4.6 and 3.6 ma; power gain 17.9 and 26.5 db.




**WESTERN ELECTRIC'S** Type 2A transistor functions as an amplifier in the "card transistor" used with the new 4A toll crossbar system for automatic selection of routes in long distance telephone dialing. These units are used in conjunction with Type 3A phototransistors which are activated by light passing through a series of punched cards. The cartridge Type 2A has its base contact connected to the metal shell.



**RAYTHEON'S** Type CK716 transistor is housed in a brass case, 0.65 in. long and 0.255 in. diameter, which acts as the base. The nickel pins are 0.078 in. apart. The maximum electrical ratings are: collector current — 4 ma; emitter current 10 ma; collector voltage — 40 v.; collector dissipation 100 mw. Operating characteristics with grounded base are: collector current 2.5 ma; emitter current 1.0 ma; collector voltage — 15 v.; emitter voltage 0.5 v.; minimum current amplification 1.2; minimum frequency response 100 KC; maximum noise figure at 1 KC, 65 db. Considered as a three-terminal network, the maximum to minimum range of direct input resistance is 150-450 ohms; transfer input resistance 25-140 ohms; direct output resistance 10,000-40,000 ohms; transfer output resistance 15,000-70,000 ohms.



**GENERAL ELECTRIC'S** Types G11 (amplifier and oscillator) and G11A (counter) transistors have the following physical specifications: brass case maximum size, 0.35 in. high, 0.16 in. diameter; impregnated with moisture resistant wax; silver plated phosphor bronze pins; connections, base soldered to case, emitter center pin, collector opposite base pin. Electrical characteristics are collector dissipation 100 mw, collector voltage ($V_c$) 30 v., collector current 7 ma, emitter current ($I_e$) 3 ma, emitter peak-inverse voltage 50 v., ambient temperature 40°C. Operating characteristics for the G11 with grounded base and $V_c$=25, $I_e$=0.5 at 25°C, are as follows: base resistance 200 ohms; collector resistance 22,000 ohms; input resistance 475 ohms; current gain 2.2; power gain 17 db; cut-off frequency 2 MC; noise figure 57 db; minimum dc resistance in emitter circuit 500 ohms. For the G11A the characteristics are: base resistance 450 ohms; collector resistance 30,000 ohms; input resistance 900 ohms; current gain 2.2; turn-off time less than 2 μ sec.

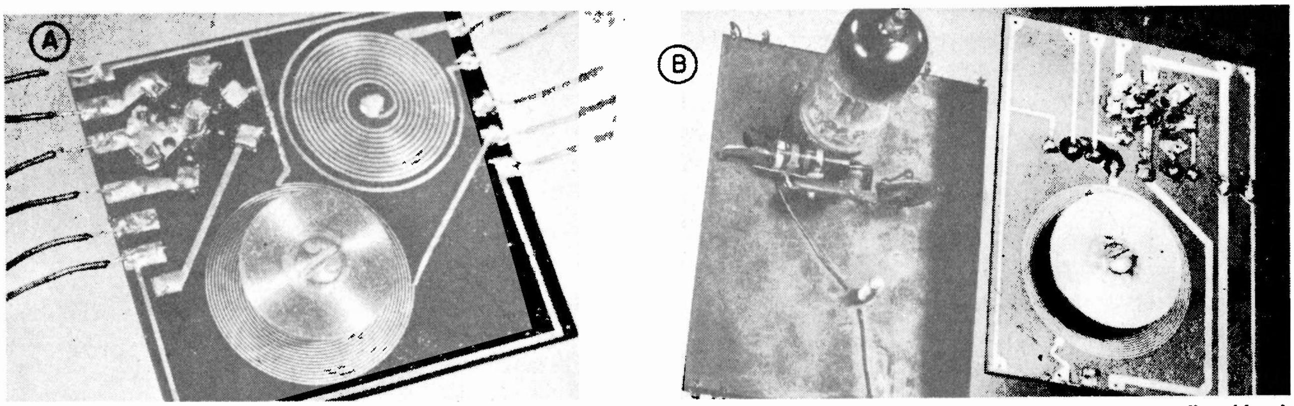


Fig. 1a, b: Two developmental printed i-f stages for 25 MC. Connectors and inductors are photo-etched; resistors and capacitors are dip-soldered

# Printed Unit Assemblies for TV

***Etching and silk screening techniques reduce costs and conserve critical materials in receiver manufacturing. Performance of printed stages compares favorably with standard circuits***

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***Bayside, N. Y.***

RESEARCH in new construction for TV equipment faces strong conflict with existing methods which have established themselves in practice through gradual evolution. Materials, design practice, and methodology are so intertwined that significant changes introduced into chassis structure must necessarily be done with exacting consideration for the assembly line, purchased materials, and above all the net effect upon costs. Nevertheless, circumstances are pressing for the development of circuit printing methods suitable for TV. The impetus to improve manufacture comes not only from cost competition but also from shortages of metals and sporadically from components.

The application of unitizing to equipment design has generally followed two approaches, (1) the functional subchassis and (2) assemblies built around a single tube stage. The functional type designed as a plug-in containing several tubes, such as i-f amplifier, power supply, etc., has received some usage in TV construction. However, its primary contributions to convenience of repair and replacement are of greater importance where a great number of identical equipments are presented to closely knit service organizations, as in military or telephone central office operations. Single stage unit assemblies are primarily a means to improve assembly.

Two notable attempts to introduce a more logical uniformity in the assembly of radio and TV circuits may be seen in the single stage modules patented by Evans (Pat. 1,973,248) in 1934, and more recently by Mitchell (Pat. 2,472,021). Both of these are pre-assembled groups of conventional resistors and capacitors related in purpose to the performance of a tube and incorporated in the tube socket. A more familiar type of unit assembly is the "printed" interstage coupling unit built of silk screened resistors and capacitors on a high-dielectric ceramic base. This form has become well known through the Bureau of Standards—Centralab work and is now present in many sets as the integrator circuit. The silk screened unit in its commercial form is, of course, attached to tube sockets by wire leads.

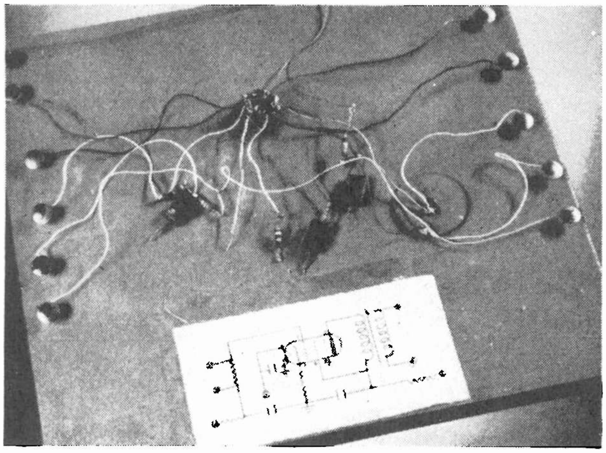
### *Adapting Technique to Circuit*

Each of the silk screening or etching techniques, as we now see them, is best adapted to particular circuit elements. The screening of resistors and capacitors of commercial tolerances on high dielectric plates has become commonplace. However, inductors for 40 MC and less occupy too much area to be screened on ceramic and are of doubtful use on plates of high dielectric. On the other hand, selective etching of metal-clad laminates and die-stamping processes are producing inductors and interconnecting wiring competitive to wire wound elements. The ease of soldering to etched circuits is also attractive but it is not generally feasible to etch bypass and coupling capacitors from clad-laminates. The cure of resistors screened on etching stock is also limited by the thermal stability of the plastic base.

By utilizing the intrinsic process and material advantages of the silk screen and selective etching methods in the development of a unit assembly, *completely printed* TV circuits are possible.

In Fig. 1 are shown two developmental models of a printed 25 MC video i-f stage. The connectors and inductors, both single spiral and bifilars, are photo-etched in an essentially planar, cascade design and the clips from a wafer type tube socket are incorporated directly into the plastic base. The above-deck placement of resistors and capacitors permits assembly to be accomplished by a dip-soldering operation, during which the coils are protected with a high-temperature tape mask. Both models have bifilar transformers under the brass tuning slug and one has also an r-f choke in the heater line.

The choice of flat etching stock as a base for the unit was not an arbitrary one. Eighteen three-dimen-



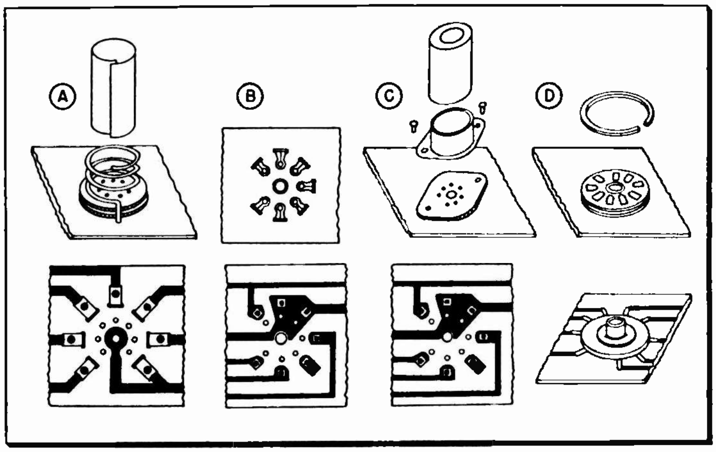



Fig. 2: (L) Pasteboard models for visual study of various shapes. Fig. 3: (R) Design sketches of dip-soldered assemblies incorporating tube sockets

sional pasteboard models of various shapes were constructed for examination, four of which are shown in Fig. 2. Flat stock was selected because of its ready availability, because of the facility of dip-soldering and riveting additional components thereto, and the convenience of a flat master negative. A doubt might arise as to the actual saving of critical material achieved through the use of sheet copper but the photo-etching process provides opportunity for accurate design of each conductor and inductor dimensions to the actual current carrying loads, which usually results in a slight saving in copper when compared with the universal use of one or two sizes of hookup wire. While design standards have not yet been established, the current carrying capacity of etched conductors is remarkably high when compared with a wire of corresponding cross-sectional area.

***Temperature Check Results***

In Table I are shown the results of temperature check made on a 2 μh spiral, which indicates that it could be operated with a current density in excess of 52,000 amp/sq. in. of conductor cross-section without excessive temperature rise.

**TABLE I: CURRENT CAPACITY OF AN ETCHED COIL**

Coil data:

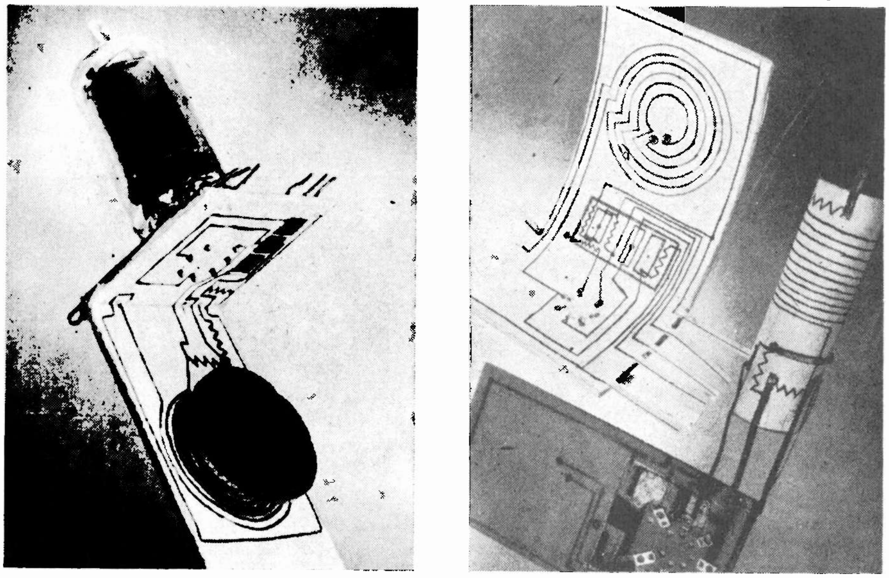
| | |
|---|---|
| Material | Copper on 1/16 in. XXXP laminate |
| Coil Diam. | 1 in. |
| Line width | .024 in. |
| Line depth | .0012 in. |
| Space between lines | .009 in. |
| Inductance | 2.0 μh |
| Conductor cross-section | $29 \times 10^{-6}$ in. |
| Nearest comparable wire size | #35 AWG |

| Current, Amps. AC | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 |
|---|---|---|---|---|---|
| Duration of test | 2 hours | 2 hours | 2 hours | 5 min. | 5 sec. |
| Remarks | Coil cool to touch | Slightly warm | Copper became dis- | Plastic backing smoking | Coil did not open or buckle |

Current density at 1.5 amps = 52,000 amps/sq. in. of conductor cross-section.

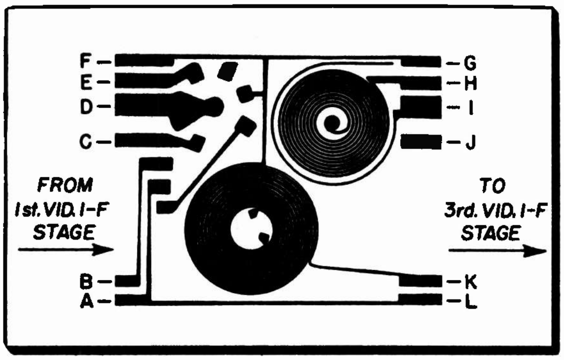
The problem of designing masters for fine, etched bifilar coils has no doubt been one of the factors retarding a more general acceptance of etched circuits. A draftsman has to spend considerable time with compass and straightedge to draw a spiral, and at best accuracy of design is poor. To eliminate this handicap, a turntable apparatus resembling a transcription machine has been fitted with two pens to enable the drawing of master spirals, either single or bifilar, to be made in a matter of minutes. A wide selection of diameters, line width, space width and turns ratio makes possible a rapid improvement in design.

Fig. 4: Puzzleboards consisting of a harness made up of all elements speed circuit design



Master drawings are reduced photographically to a negative transparency of exact dimensions and this transparency is used to photoetch the coils by the now well known process. Table II gives specifications and test data for several etched coils designed for video i-f use. Tuning is accomplished by a brass screw with an oversize head. Although the presence of the disc tends to lower Q, the reduction is fairly constant over the tuning range necessary to stagger-tuned circuits.

Of general interest to engineers concerned with printed circuits, four methods of incorporating tube



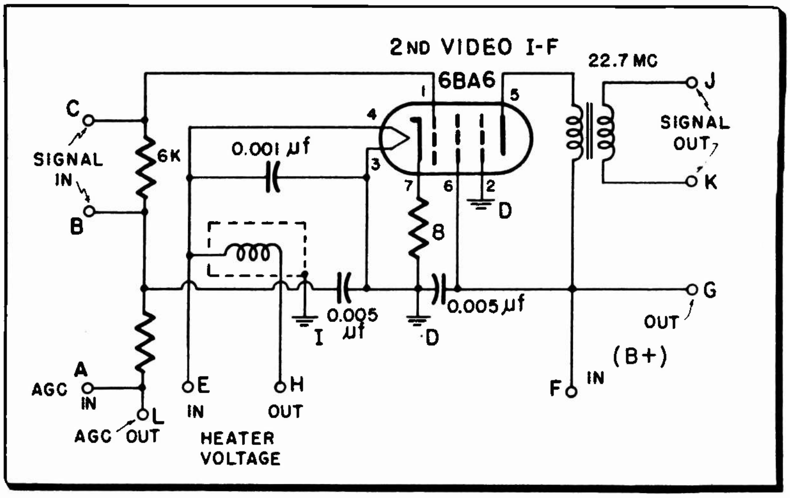




**Fig. 5: Printed circuit layout and schematic of 25 MC I-F stage. Jump connections, except from center of coils, have been eliminated. Feed-through busbars go to B+ and agc**

sockets in assemblies to be dip-soldered have been devised by modifications of commercial sockets and parts. Sketches are shown in Fig. 3.

Two basic construction features are essential:

1. The socket must have mechanical retention to supplement soldering; and

2. The lug ends of the clips have to emerge horizontally and in contact with the conductors on the base material for soldering to be possible. The designs illustrated accomplish this with a minimum of riveting or fastening.

The most direct approach, Fig. 3a, is to use a type of wafer socket having long lugs which may be inserted through punched holes in the deck and bent flat against the conductors. A very neat arrangement results if similar but smaller clips are separately inserted into the etched laminate. This construction, Fig. 3b, was used in the module under discussion. Some pin clips require compression between two wafers for proper functioning and with this type of clip the upper wafer may be retained as shown in 3c. Molded sockets may be adapted by revising these so that they insert from beneath the deck as in Fig. 3d. To do this the top flange is replaced by a snap-ring and an underside flange is provided by addition of an insulated washer which also serves to compress the lugs flush against the circuit connections.

### TABLE II: ETCHED COILS FOR 25 MC IF

| Winding | Etching Stock | O.D. In. | I.D. In. | Line width In. | Total number of turns | Q | L h |
|---|---|---|---|---|---|---|---|
| Single | XXW laminate 1 oz. copper | 1 | 19/64 | 0.018 | 11 | 62 | 2.35 |
| Single | XXXP laminate 1 oz. copper | 1 | 19/64 | 0.020 | 11 | 70 | 2.18 |
| Single | XXXP laminate 1 oz. copper | 1 | 19/64 | 0.024 | 11 | 65 | 2.05 |
| Bifilar | XXP laminate 2 oz. copper | 1 1/8 | 15/32 | 0.020 | 8<br>8 | P-46<br>S-45 | P-2.0<br>S-1.9 |
| Bifilar | XXW laminate 1 oz. copper | 1 1/2 | 31/64 | 0.010 | 12 1/2<br>12 1/2 | P-48<br>S-49 | P-4.8<br>S-4.75 |
| Bifilar | XXW laminate 1 oz. copper | 1 7/32 | 29/64 | 0.020 | 10<br>10 | P-58<br>S-54 | P-2.9<br>S-2.75 |

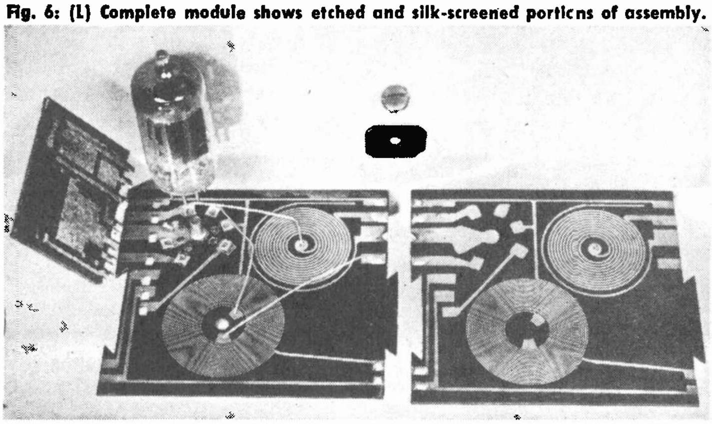
P = Primary Winding S = Secondary Winding

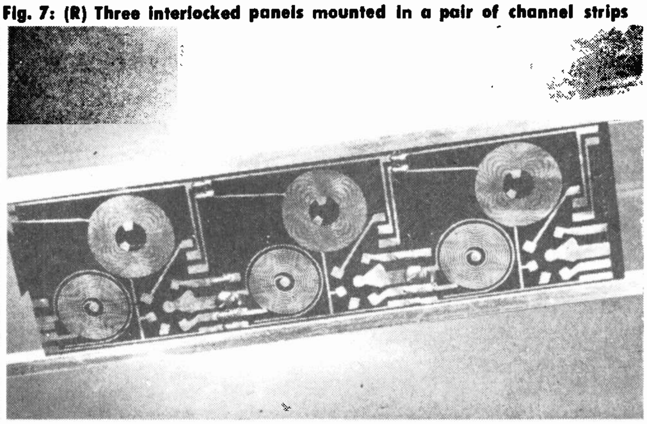
#### *Conventional Tube Shielding*

Tube shielding, when required, may be of the conventional type, riveted to a grounding strip or area provided in the etch pattern, or, as shown in Fig. 3. shield fastening can also be adapted to solder-dip assembly without recourse to rivets.

Planning the circuit layout for two-dimensional reproduction is an essential step in printed circuit design and much of this effort is spent in the elementary but time-consuming process of eliminating cross-overs. Sketches are helpful, but three-dimensional models as previously shown are almost mandatory for proper evaluation of a proposed configuration. To facilitate the reduction of layouts to simplest form a "puzzleboard," Fig. 4, was created. This consists of a harness made up of all the circuit elements

**Fig. 6: (L) Complete module shows etched and silk-screened portions of assembly. Fig. 7: (R) Three interlocked panels mounted in a pair of channel strips**





involved, connected at the high potential end only by long flexible hookup wire. The starting point is the conventional breadboard circuit separate from any chassis. This is used as a fluid three-dimensional model, in which the free ground ends of the components permit rapid manipulation to the simplest layout. Use of the puzzleboard permits both development and design of printed circuits to proceed at a rate comparable with standard chassis layout.

The circuit and a layout for an etched 25 MC i-f stage is shown in Fig. 5. Provision has been made for feed-through busbars for heater, B+ and agc. Jump connections from the centers of the coils are unavoidable, but all other crossovers have been eliminated by relegating this function to the resistors and capacitors.

### *Silk Screening*

In order to have a fully printed module retaining the advantages inherent in the etched deck, silk screening has been employed to produce an RC unit on a high dielectric plate (Fig. 8). This unit is fabricated on material with a dielectric constant of 4,000 and thickness 0.05 in. The material used exhibits a rather high temperature coefficient; the dielectric constant at 85°C being approximately double the value at 25°C, with the "Curie" inflection falling at 74°C. However, this material is adequate to nearly all bypassing and coupling functions. In the card shown for a 2nd video i-f stage there are a 0.001 μf heater bypass and two 0.005 μf bypass capacitors for cathode and screen. The capacity areas on the face of the ceramic as well as all connective wiring have been produced by silk screen stencilling with conductive silver ceramic decorating paint. The second plate for all capacitors is formed by a substantially continuous silvering of the reverse side of the high dielectric card. On this, the ground side, windows are provided in the metallization opposite resistor areas on the front to reduce what might be a prohibitive stray capacitance. The pattern on the ground side is non-critical and is, therefore, produced by a permanent spray painting mask of simple design rather than by a second silk screen printing. Curing of the metallizing paint is feasible by batch firing in a muffle or in a continuous ceramic decorating lehr.

The three resistors on the card are produced by silk screening printing of a resin-graphite-lampblack mixture. Curing and protective coating as well as the composition of the mixture are closely controlled in processing to give resistors of acceptable commercial stability. The screening is done by an all-metal screening fixture of improved design in which the motion, angle, pressure and speed of the squeegee are controlled with precision adjustments. Attempt is thus made to remove all variables in the process which might result from manual operation. After screening, the resistors are cured, insulated, and again baked.

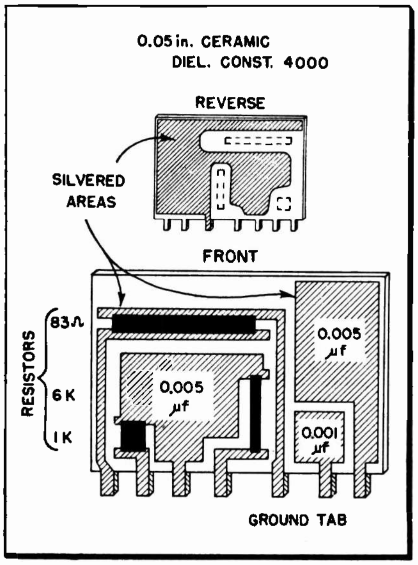



Fig. 8: RC card silk screened on dielectric

The resistors on the card illustrated are simultaneously printed from the same mixture, and three values being determined by variation of the length-width ratio only. This is sometimes referred to as the "aspect ratio." The 1 K agc resistor has a square aspect which shows that the mix used basically produces carbonaceous films having an area resistivity of 1,000 ohms per square. Lengthening the resistive area so that the aspect ratio is 6:1 gives the 6 K input resistor; and making a very wide but short area enables the production of the 83 ohm cathode resistor, which has an aspect ratio of about 1:12. The total range of resistor value on this card, from 83 to 6,000 ohms, is thus a little over 72 times. This approaches the practical limit of variation in resistors which may be printed on the card from one mixture. Consideration must also be given in the design of printed resistors to see that there is a total area adequate to dissipate produced heat; a conservative standard is 1 watt/sq. in.

### *Resistor Functioning Lengths*

It may be noted in the layout of the RC plate above that the functioning lengths of the resistors are set by the spacing of the contacts formed by the conductor pattern, while the widths are set by the pattern in the resistor stencil. This presents an additional problem of printing metallization and resistor mix in registration. Absolute registration between the two superimposed patterns is not of great interest but control of the de facto registration of successively printed samples is necessary to keep resistor variation within tolerance limits. This is accomplished by two register pins on the work holder of the screening fixture plus vacuum clamping which holds the work against these pins. Screen stencils for both capacitor and resistor areas are made on conventional bichromate sensitized film which adheres to the screen after contact exposure and washing out. Preparation of masters by drawing and photo reduction is identical to the procedure used for the etched copper laminate section.

### *Performance*

The performance of unitized stages made up of the combined etched and silk screened components was checked by measuring overall response and i-f response in a Sylvania Model #1-387 receiver, with substitution of printed for standard stages. The performance of the second video i-f module is represented by test results shown in Fig. 9. The solid curves are for a circuit containing the printed stage, and the broken curves for a set with all standard components. Measurement of i-f response was made by injection of signal at the mixer plate in the tuner, and the point-by-point plot of dc potential produced at the 2nd video detector. Overall response was checked by a 30% modulated signal fed into the tuner on Channel 4 setting and the output of the second video detector read by VTVM.

The performance of the printed stage in terms of response is equal to or better than the standard assembly. The skirts of both responses are down on the sound side and the bandwidths through the printed stage are adequate at the −3 db level. The difference at the top of the curves is of little significance except that it indicates that the

(*Continued on page* 43)

# Germanium Diodes for Indicating Instruments and Relays

***DC meters with germanium rectifiers have high sensitivity, wide frequency range and small size. "Chatter" and "arcing" can be minimized with dc relays; circuits require small actuating currents***

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*Commercial and Gov't Equip. Dept.*
*General Electric Co.*
*Syracuse, N. Y.*

BY adding one or two germanium diodes in a suitable rectifier circuit, dc indicating instruments and sensitive dc relays can be used on ac and r-f through 150 MC. Both instruments and sensitive relays utilize similar techniques for the proper use of diodes, and for this reason both applications are covered in this article.

In measurement applications, a dc meter with a rectifier has several advantages over an ac meter. The biggest one is the increased sensitivity. For example, a 0-150 v. moving iron ac voltmeter will take approximately 10 ma. for full scale deflection. A diode type rectifier meter on the other hand can be made with a full scale current of less than 0.1 ma. Other advantages of rectifier type dc meters are wide frequency range, good pointer response, small size and availability for multi-function testers such as ac-dc voltohm milliammeters.

In control applications, ac relays will often chatter and cause arcing. With a dc relay and a properly designed diode rectifier circuit, these troubles are eliminated. In addition, the relay can be made to operate on at least ⅓ the current and has the advantage of size and weight over an ac relay.

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The following list indicates the principal scope of the circuits in the figure indicated:
Figs. 1-3: Temperature effects on diode impedance.
Figs. 4-8: Frequency range limited to 25 cycles to 250 MC by pointer oscillation and relay chatter.
Fig. 9: Meter protection from high reverse voltages. . .
Fig. 10: Sensitivity change with different rectifier types.
Fig. 11: Relay operation with increased sensitivity and no chatter.
Figs. 12-13: Elimination of contact sparking.
Fig. 14: Rectifier arrangements for microameters.
Fig. 15: Dimensions of plug-in sealed assembly.
Figs. 16-19: Typical characteristic curves for different diodes.
Table 1: Condensed specifications for some germanium diodes.

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### Temp. vs Z — Low

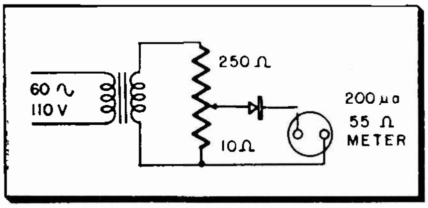



**Fig. 1: When a diode operates from a low resistance source into a low resistance meter load, the meter deflection increases with increased temperature, because the diode forward resistance decreases with increased temperature. The decrease in back resistance which occurs at the same time does not influence the indication to any great extent because the diode back resistance at elevated temperature is still very large in comparison with that of the rest of the circuit.**

### Temp. vs Z — High

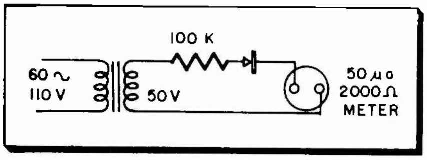



**Fig. 2: When a diode operates from a high resistance source into a high resistance load, the meter deflection decreases with increased temperature, because the diode back resistance decreases with increased temperature. The reduced forward resistance has little effect on the meter deflection in this circuit because it is swamped out by the high resistance of the meter load.**

### Temp. vs Z — Constant

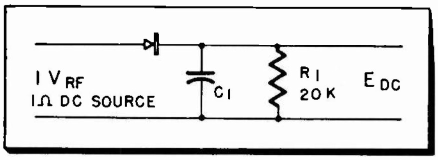



**Fig. 3: A condition in which the meter deflection remains practically constant with temperature results from the combined action of two effects. First, the meter deflection tends to increase with increased temperature since the diode is working from a low impedance source into the relatively low impedance load of the condenser $C_1$. Second, the decrease in back resistance acts as a load in parallel with $R_1$ to effectively decrease the pointer deflection because of the increased temperature. The two factors work together to produce a more or less constant meter deflection with change in temperature. The load resistance in Figs. 1 and 2 can also be chosen to obtain similar temperature compensation.**

### Freq. vs Uniform Output

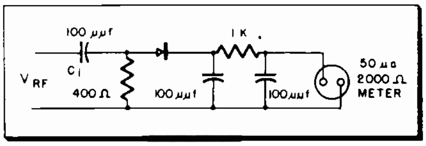



**Fig. 4: The series condenser offers a gradual decreasing input impedance with increased frequency and tends to provide more uniform output with change in frequency.**

### Multirange Rectifier

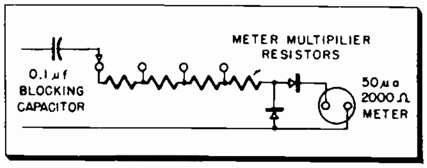
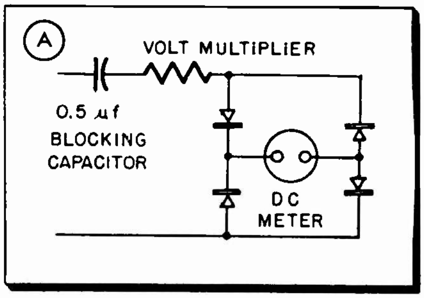
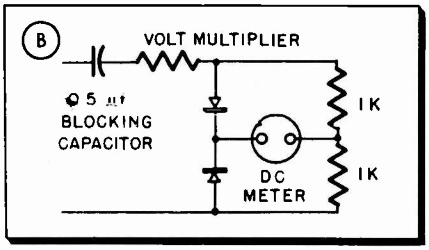



**Fig. 5: With well spaced components and with resistors of low distributed capacitance and inductance, a multirange rectifier type instrument with sensitivity of approximately 10,000 ohms/v may give an accuracy within ± 10% over the frequency range of 60 cycles to 6 MC.**

### Maximum Output




**Figs. 6a, b: Where maximum output with minimum input is of primary importance, these circuits are suggested for frequencies between 25 cycles and 25 K.C. The circuit of Fig. 6a gives about 10% greater deflection than Fig. 6b, but Fig. 6b is less expensive, takes less room and has somewhat better temperature and frequency characteristics.**

### *Advantages of Germanium Rectifiers Over Copper Oxide*

Until the last few years, the best rectifiers for instrument and relay applications were the small copper oxide types. With the advent of inexpensive, stable, small size germanium diodes, such as the GE Types IN48 and IN51, still more advantages have been added to rectifier type ac meters and relays.

Germanium diode rectifiers have the following advantages over copper oxide rectifiers:

1. Completely insulated so they can be mounted in a small space.
2. Enclosed in a sealed protective housing so they are not as susceptible to fumes and humidity as copper oxide.
3. High peak back voltage rating for probe type testing.
4. High back voltage and low forward resistance, which makes it possible to use temperature compensating resistance swamping circuits. This avoids one of the big disadvantages of copper oxide, namely poor temperature coefficient.
5. Wide frequency range running from 25 cycles through 150 MC in the one size unit.

### *Low Forward-To-Back Resistance Ratio*

Germanium diodes can be used for instrument and sensitive relay rectifiers in a number of circuits. The best diode types are generally those with low forward to back resistance ratio and low forward resistance, such as the IN51 and IN48. This is because the instrument or relay is generally a relatively low resistance load, and diodes with a low forward resistance and a fair back resistance work best. The higher back resistance types, such as IN52 and IN63, also work well for this service but are more costly.

The data shown may be applied directly to applications of sensitive relays, in which case the meter is replaced by the relay coil.

## Increased Sensitivity

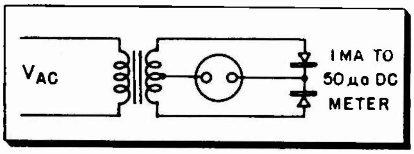



**Fig. 7: For increased sensitivity over somewhat limited frequency range, a center tapped potential transformer arrangement may be used.**

## Temp. — Freq. Response

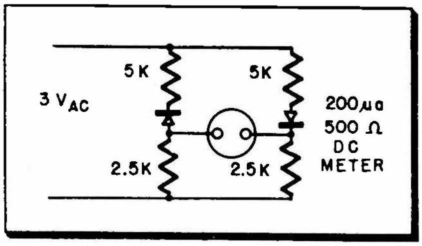



**Fig. 8: Good temperature and frequency characteristics have been obtained with this circuit. Here advantage is taken of the high peak back voltage of the diode as compared to copper oxide. This permits adding temperature compensating resistors in series with each diode to effectively swamp out the change in diode forward resistance with temperature.**

## Meter Protection

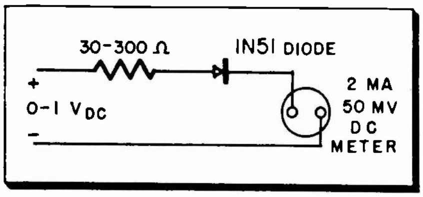
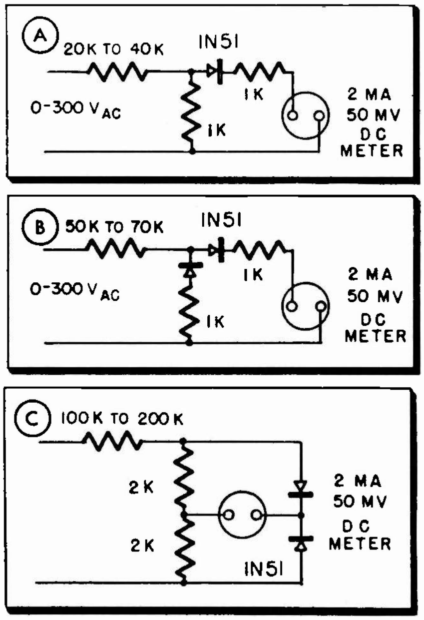



**Fig. 9: Where meter protection from high reverse voltages is desired, a diode may be connected so the reverse current is limited to 3 ma with negative 30 v applied in place of the normal positive 0-1 v. The 30-300 ohm resistor is adjusted to calibrate the meter to 1 v full scale. The normal uniformly divided scale of the meter will be changed by the addition of the diode to one with the divisions contracted near the zero and approximately shown below:**

| Volt | MA | Volt | MA |
|---|---|---|---|
| 1 | 2 | .4 | 0.41 |
| .8 | 1.4 | .2 | 0.1 |
| .6 | 0.9 | | |

**Where the peak back voltage exceeds 50 v, the higher peak back voltage diodes such as the IN52 or IN63 are preferred.**

## Sensitivity changes




**Figs. 10 a, b, c: Actual 30 v. meter rectifier circuits using 2 ma and 50 mv dc meters are good for frequencies from 60 to 5000 cycles with less than ±3% change for the temperature range —25 to +125°F (—32 to +87°C). The main difference in each of the three circuits is the increase in sensitivity in going from the single diode half wave rectifier to the double center tap type. The resistors should be good quality non-inductive type. The scale characteristics will approximate those shown below:**

| Volt. | MA | Volt. | MA |
|---|---|---|---|
| 300 | 2 | 120 | 0.75 |
| 240 | 1.6 | 60 | .4 |
| 180 | 1.1 | | |

**The exact amount of series resistance will depend upon the individual diode.**

## Chatter Prevention

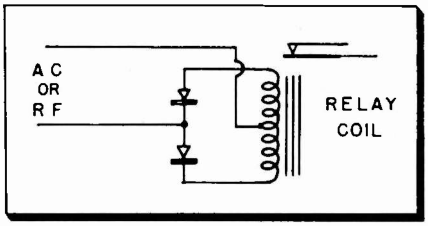



**Fig. 11: Good 400-800 cycle relay operation has been obtained using a center tap brought from the relay coil with three wires connected to the diodes as shown. In this circuit the flux is held constant over both halves of the ac cycle. Greater freedom from chattering and increased sensitivity result from this arrangement.**

## Sparking Elimination

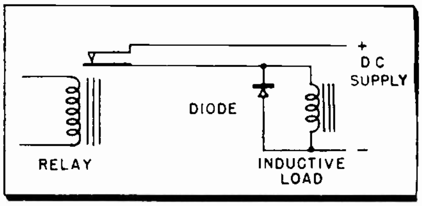



**Fig. 12: Contact sparking can be practically eliminated by the use of a germanium diode connected across the load. With the relay contact closed as shown very little current is drawn by the diode because the voltage drop across the load is in the back direction for the diode. When the relay contact opens, the magnetic field in the load inductance collapses. This causes a forward voltage to appear across the diode and the diode conducts. Sparking is eliminated because the inductive energy of the load is dissipated in the diode forward resistance rather than in the relay contact gap. For most low voltage communication type relay loads a single IN51 or IN48 will be satisfactory. For higher voltage loads use type IN52 or IN63.**

### Heavy Loads

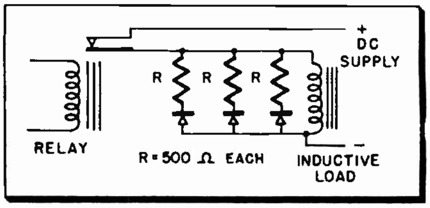
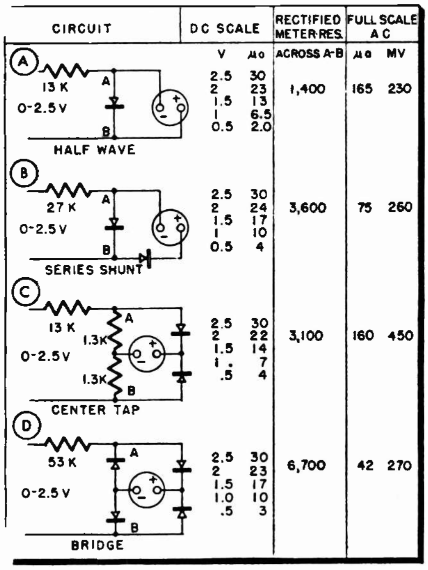



**Fig. 13: For large relay of motor loads several diodes are connected in parallel, still preventing contact sparking. The series resistors help distribute the current more evenly among the several parallel diodes.**

### Microammeters




**Figs. 14 a, b, c and d: The meter rectifier circuits shown are suggested for a 30 μa 2000 ohm meter. They may be transposed to either 20 μa or 50 μa by changing the sensitivity in direct proportion. For example, if the full scale with a μa 30 meter is 2.5 v., then the full scale sensitivity with a 20 μa meter will be 2/3 × 2.5 or 1.7 v. This simple ratio does not hold for higher meter currents due to the change in diode resistance. The meter resistance for the three sensitivities is assumed to be 2000 ohms. The ac sensitivity, the series resistance and the rectified meter resistance (i.e. with zero series resistance) may each vary ± 15 percent depending upon the individual diodes. All data shown is based on IN51 diodes, although any other diode with equal or better forward and back resistance will give about the same characteristics. There is some pointer vibration near full scale in all circuits using the 3 in. undamped meter.**

### Plug-in Assembly

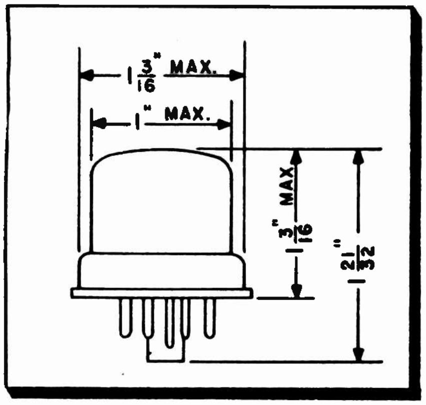



**Fig. 15: Where the increased sensitivity of the 4 diode bridge rectifier shown in Fig. 14 d is desirable, a plug-in hermetically sealed assembly may be used. Some typical units are the type G9B, IN73 and IN74 with overall dimensions shown.**

### E-I Characteristic

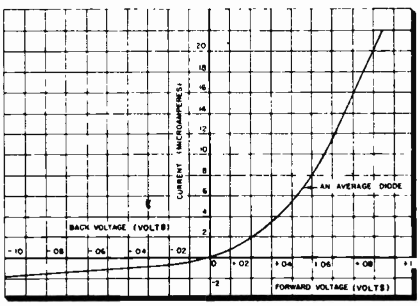



**Fig. 16: Typical low voltage-current characteristic of type IN48 at 25°C.**

### Eff. Characteristic

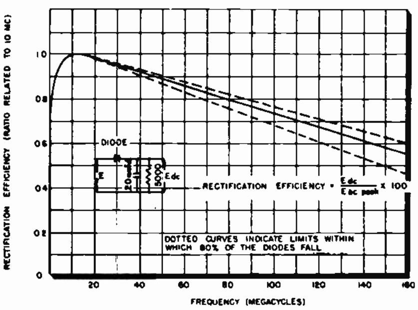



**Fig. 17: Typical rectification efficiency-frequency ratio characteristics of types IN48, IN52, and IN63 at 25°C.**

### I-Temp Characteristic

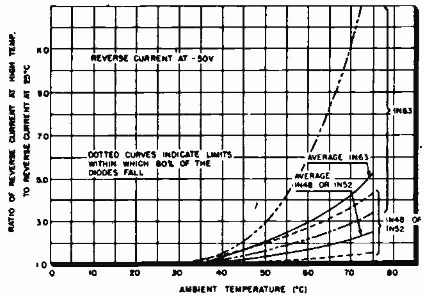



**Fig. 18: Typical reverse current-temperature ratio characteristics with respect to 25°C.**

### E-Temp. Characteristic

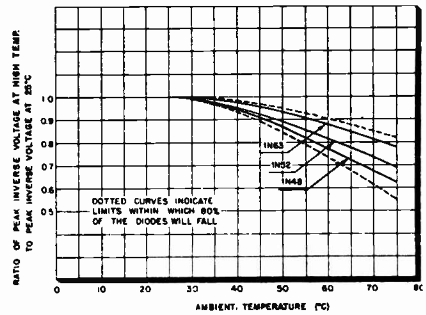



**Fig. 19: Typical peak inverse voltage-temperature ratio characteristics with respect to 25°C.**

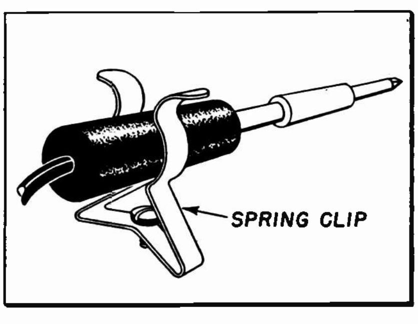
### *Condensed Specifications for Some Germanium Diodes*

| Type | MAX. Forward Resistance (Ohms) at +1 V. | MIN. Back Resistance (Ohms) at —50V. | MAX. Inverse Voltage (Volts) |
|---|---|---|---|
| IN48 | 250 | 60,000 | 85 |
| IN51 | 400 | 30,000 | 50 |
| IN52 | 250 | 333,000 | 85 |
| IN63 | 250 | 1 meg. | 125 |
| IN65 | 400 | 250,000 | 85 |
| IN69 | 200 | 59,000 | 75 |
| IN70 | 333 | 122,000 | 125 |
| IN72 | Tested for efficiency at 500 MC. | | |
| IN73 | Balanced quad. Very closely matched. | | |
| IN74 | Balanced quad. Very closely matched. | | |
| IN75 | 400 | 1 meg. | 125 |

## Bench Shortcut for Faster Repairs

### *Soldering Iron Stand*

This "tip" is so simple that I imagine a lot of servicemen may have thought of it already. The market has been flooded lately with these spring-clip type holders for holding tools, brooms, etc., on a wall. It occurred to me, when I saw a friend of mine using one to hold his shaving brush in the medicine cabinet, that it might work to hold a soldering iron up off the bench, and so do away with the rather cumbersome sling that I had. So I screwed one of these clips down on the bench, and I find that it has quite adequate strength to hold my 125-watt iron. You can either hold the iron or the handle, depending on how large a clip you get. The handle is better, as then the clip doesn't conduct the heat away from the iron and into the bench. *M. LeGoff, New Orleans, La.*



# Installing PA Equipment

## Demanding Only Comfortable Listening and Realism, a Well Functioning

• "Often the name *auditorium* clings to a room which is a marvel of structural engineering; which is perfectly illuminated, heated and ventilated; which is provided with every comfort and luxury; which is a monument to architectural art and beauty; but which is so burdened with acoustical defects that the audition of music is reduced to a confusion of sound and the audition of speech is an utter impossibility." (from "Architectural Acoustics," by Vern O. Knudsen).

While this citation is of a rather extreme case, it is nevertheless true that many auditoriums were designed for appearance rather than good acoustical results. And it is also true that many rooms are being used to present music, drama, political speeches, lectures and the like to an audience—or in other words, are being used as an auditorium—which were never meant to do so in the first place.

It is also true that a relatively small number of persons appearing on the stage or at the lecture stand have the requisite control over their voices—as to loudness, sonority and clarity—to make themselves heard by a large audience.

As a matter of fact, it is no longer considered good practice for players to speak their lines so as to "split the ears of the groundlings," as Shakespeare put it.

### Sales Potential Seen

For these several reasons, speech and music reinforcement systems have come into somewhat general use. Such systems might be said to differ from the ordinary PA function only in that an attempt is usually made to make such systems inconspicuous—to contribute to the illusion that the listener in the audience is actually hearing the person, the performers or the musicians who are before his eyes.

As a matter of fact, many in the audience will actually hear the original sound, without reinforcement. Usually reinforcement will be provided only to fill blind spots and to "boost" the sound to reach distant points.

The alert PA dealer will keep his eyes and ears open to situations which suggest the need of a sound reinforcement system, in order to build up his business with this type of work.

A system of this sort will provide a relatively limited amount of facilities. First, there must be sound pickup at the source of the live performance. The number and placement of microphones will depend on the nature of the sound source emanating from the stage platform.

For instance, a lecturer or a political speaker could have a microphone at the speaker's stand. In a dramatic performance, however, microphones should be invisible, and would have to be placed so that they could not be seen by the audience. In the case of musicians or singers, microphones would have to be placed so as to pick up a balanced coverage of the whole unit.

In the latter case, you must assume that we are not referring to a symphony orchestra, which would probably require no reinforcement, except perhaps in a very large, very poorly designed opera or symphony hall. Rather, however, one might suppose a chamber music group, or individual soloists.

In addition to the live, on-stage pickup, provision might be required for (1) off-stage pickup of live sound, and (2) off-stage pickup of an electrical sound source such as telephone lines, radio,

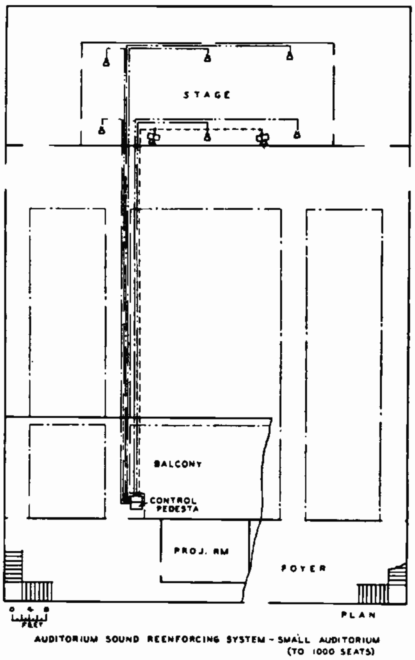



**Fig. 1: Auditorium sound reinforcement system with 2 speakers and 4 mikes on stage.—Courtesy RCA.**

phonograph records, etc. These would depend, as we used to say in the service, "on the tactical situation," or rather on the demands of the users. A third sound pickup need might be in the audience itself, as for instance, for audience participation programs, lectures and meetings where the audience is permitted to ask questions, etc.

All the sound pickup sources would feed to a control panel where an operator could mix them, fade them in or out, adjust the level of each, etc. This would preferably be located in the audience area, so that the operator can judge the results with his own ears.

A power amplifier would then be required, of course, and finally loudspeakers, located so as to accomplish the desired reinforcement.

The possible need for and employment of preamplifiers between the sound sources and the mixing-control panel will be covered below.

For a number of reasons, the use of several loudspeakers operating at low levels is indicated. For one thing, echoes and interferences between speakers is held to a minimum when the level is low. In the second place, realism is better attained when the PA system doesn't sound like a PA system—in other words, like an artificial sound source. In the third place, this system is designed to *reinforce* the sound, not to be a substitute for it.

### Many Auxiliary Functions

One other function that this system may be called on to perform—a subsidiary feature, and not part of its main function—is to feed the sound which has been picked up and amplified to other places besides the auditorium itself. In other words, it might feed a recorder, a telephone line, or other rooms in the building, or all three. Here again, the desires of the users will determine.

We mention these various added features of the input and output circuits of the reinforcement system as a suggestion to the PA man who is selling the job to the customer. He may be able to "sell up" the job to much more than the customer originally had in mind if he suggests uses which the customer would appreciate but hadn't thought of.

Fig. 1 shows a simple speech reinforcement system for a small auditorium. In this installation, six microphones feed to a control console on the balcony in the rear of the auditorium. The seating area is roughly 88 feet from the stage to the rear of the balcony and about 96 feet wide. The average height of this auditorium is about 35 feet. Thus the volume of the listening area is roughly 300,000 cubic feet. To produce the level of ordinary speech would take relatively little power output from an amplifier (perhaps 1 watt), whereas to simulate the power of a symphony orchestra (as for instance,

# for Sound Reinforcement

## System of This Type Should Not Be Conspicuous to the Audience

from a phonograph record, or from the radio), as much as 100 watts might be needed. In this particular case, an amplifier producing 30 watts with relatively low distortion was recommended.

Low impedance microphone lines could be, in this case run all the way from the stage to the control station (88 feet) without undue losses. For ease and versatility of control, it is usually good practice to have a preamplifier stage and an input attenuator for each signal source, feeding into a mixer circuit. In this case there are six microphones, and amplifiers with six mike inputs are not very common; as a matter of fact, even preamplifiers of this capacity are rare. Consequently, at least a couple of preamps would probably be necessary.

A more elaborate setup is shown in figure 2. Here mikes 1, 2 and 3 are for

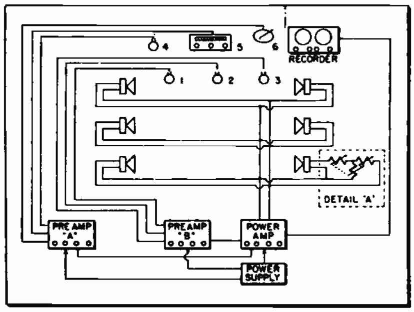



**Fig. 2: Wiring diagram for auditorium reinforcement system similar to fig. 1. Placement of mikes and speakers is described in text.**

speech reinforcement on the stage. Mike 4 is for off-stage (live) sound effects and voices (for instance, simulated telephone conversations or radio voices). Input 5 is a radio tuner and input 6 is a phonograph turntable, which might be used for sound effects or recorded voices. Either 5 or 6 or both might be used to provide music when a radio-phonograph on-stage is supposed to be turned on.

All the inputs are fed to the control position in the rear of the auditorium, since the operator at that position is in a better spot to judge the level coming out to the audience. In a detailed setup, an intercom would be provided between the back-stage and the control positions. Preamp "A" covers the backstage sound sources, whereas preamp "B" covers the on-stage mikes. The two preamps feed into the power amplifier, which is also located at the control position. A separate power supply is shown, although the preamps and the power amplifier might be self-powered.

The power amplifier feeds six small, low level loudspeakers, well spread around on the sides of the auditorium. These are kept at a low level so as (1) Not to create an unreal, amplified sound where the source is actually supposed to be live performers; (2) To prevent feedback to the microphones, and (3) To prevent room echoes and cancellation effects between loudspeakers.

Detail "A" in figure 2 shows a ganged T-pad across the loudspeaker. This type of attenuator maintains a constant impedance both in and out, while permitting the level to the speaker to be adjusted.

### *Selecting Microphone Types*

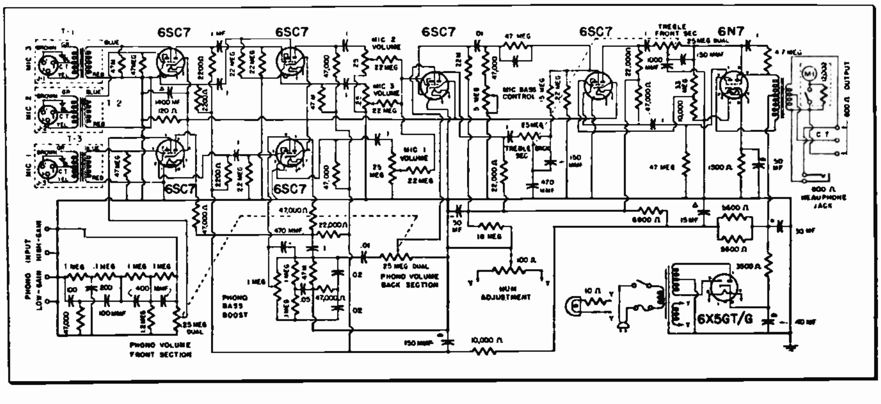
Attenuators of this type on each speaker would permit their level to be adjusted to suit local conditions in the vicinity of the speaker (such as hanging drapes, etc.). They would also make it possible to adjust the speakers in descending loudness as they got farther away from the stage, which would contribute realism since it simulates the decay of sound in air which would naturally occur. It is usually advised, however, not to place any speakers too far back from the stage, else the illusion of sound coming from the stage would be destroyed.

Fig. 3 shows the circuit of a typical high quality preamplifier with 3 mike input channels and one phono input. As shown, the unit provides for 30-50 or 150-500 ohm low impedance microphones. A similar unit, minus the input transformers, is available for high impedance mikes. Gain of the amplifier with low impedance microphones is 86 DB at 400 cycles, which is equivalent to an input sensitivity of 121 microvolts for rated output (63 milliwatts). Tone controls and volume controls are provided for both microphones and phonograph, and the output of mikes and phono can be mixed. A phone jack is provided so that the operator can monitor the amplifier aurally, and an output meter is provided for visual monitoring of the level. As mentioned earlier, the operator would have to depend to a certain extent on his judgment as to the actual sound in the auditorium. It can be seen, however, that with several different input sources, it would be necessary to adjust these individually in order to avoid continuous adjustment of the power amplifier to compensate for the variations in the inputs. It would probably prove most convenient to adjust all inputs to a predetermined output-meter level, and leave the power output level to the speakers more or less constant.

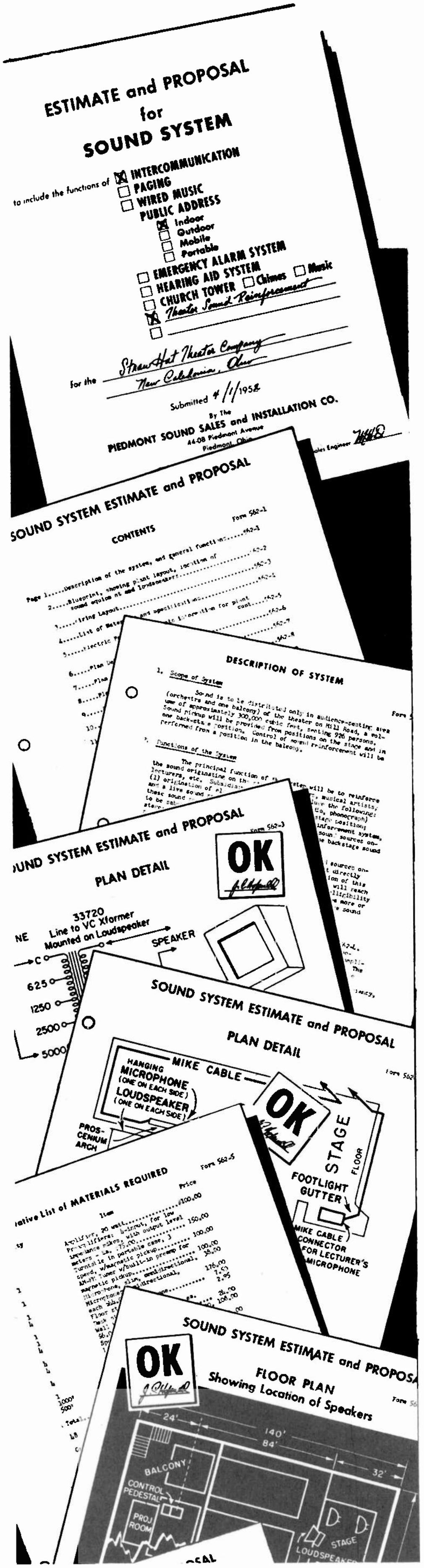
Omnidirectional mikes are handy for picking up sound over a wide area and from all directions. A difficulty may arise, however, which would indicate the need for very directional mikes. This is the fact that omnidirectional, high gain mikes will pick up a lot of extraneous noises, such as the moving of scenery, closing of doors, whispered directions between stage-hands, prompters, etc. This difficulty is often observed on TV programs, where necessity for concealment of not only the mike but its shadow limits the producer in obtaining optimum results.

Such details (concerning the operation of the system) are, of course, up to the user and not the installer. But the installer should be aware of them so as to properly advise the customer of his needs and avoid future complaints.

**Fig. 3: Stromberg-Carlson AV-38 preamp such as might be used in fig. 2, provides input for 3 low impedance mikes.**



# Installing PA Part 2: Step-by-Step Outline for Planning,




• The first part of this article outlined the general considerations for auditorium, theater and other indoor sound reinforcement jobs, and showed how a typical system might be laid out.

Now we will take the same typical installation, and show how the work would be planned, estimated and priced for proper presentation to the customer.

The system is shown in Figure 1. As outlined in part 1, this would be a reinforcement system for a small auditorium or "little theater." Flexibility and versatility have been added to the simple reinforcement requirement, as shown by the addition of the off-stage mike, tuner and turntable. These could be for supplying sound effects for a play; for supplying "demonstration" material for a lecture; for supplying "between-the-acts" entertainment, etc.

Five mikes are provided (four on stage and one off). In this instance, 4 unidirectional mikes are provided (to avoid the pickup of extraneous noises on stage and to avoid feedback and pickup from the audience) and one "slim" type omnidirectional mike. The latter could be used in the backstage position but would be substituted for one of the stage mikes, should the platform be used for a lecturer or musical performer (where an unobtrusive-appearing mike would be desireable).

The turntable is a 16" transcription type, 3-speed, with tone arm and magnetic pickup. The tuner is equipped with a preamp stage for a magnetic pickup, and the turntable feeds through it. The tuner is an AM-FM type. No provision is made in the installation and estimating sections of this plan for antennas. If the location is such that antennas would be required, appropriate additions should be made to the parts list, the labor schedule and the overall price.

### Features of System

Amplification and control is performed in a position located in the balcony. This position enables the operator to judge the results of the system as it reaches the audience. He also has a good view of the stage so that he can follow a cue sheet if there is one.

The on and off stage sound sources feed to two preamplifiers at the control point. Individual level controls are provided for each source (mikes, phono, tuner), and provision is made for mixing them in any desired manner.

The preamplifiers (A and B of figure 1) feed into a power amplifier (C) which in turn feeds four loudspeakers at the front of the auditorium. For purposes of concealment and also for realism of sound, these are fairly good quality 12-inch cone-type speakers, mounted in wall baffles. The two which appear to be on the stage are actually above the proscenium arch.

A recorder is shown as optional equipment.

Two preamplifiers are shown for two reasons: first, amplifiers with more than four inputs are hard to find; second, control is facilitated by having one preamp for off-stage sound sources and one for on-stage; and third, flexibility is provided in that there can be a couple of spare inputs for future changes.

### Writing The Proposal

The proposal or "prospectus" presented to the customer should outline the general features of the system as sketched above and in last month's article and should include a plan as shown in figure 1. The list of equipment to be provided can be specific on the actual job, stating make and model number, and some of the manufacturer's specs on the equipment (such as frequency response, power output, power consumption, etc.). Some details may be over the customer's head, but will protect the installer from later complaints that he didn't provide equipment as originally promised in the estimate.

A typical estimate is shown below. The prices listed are not actual, but merely exemplary of what might appear on a real job.

| Estimate | |
|---|---|
| 1 Omnidirectional mike ...... $ | 38.22 |
| 4 Unidirectional mikes @ 44.10 | 176.40 |
| 1 Mike floor stand ........... | 7.64 |
| 1 Mike desk stand ........... | 2.95 |
| 4 Mike wall brackets @ 6.76 ... | 27.04 |
| 4 12-in speakers @ 27.00 ...... | 108.00 |
| 4 line-voice coil matching transformers @ 3.50 ........ | 14.00 |
| 4 wood wall baffles @ 7.50 .... | 30.00 |
| 1 Turntable in portable case, 3-speed, with magnetic pickup | 100.00 |
| 1 AM-FM tuner with built-in preamp for magnetic pickup | 100.00 |
| 2 4-input preamps for low-imped. mikes, with output meters @ 75 ...................... | 150.00 |
| 1 15-20 watt power amplifier .. | 100.00 |
| 1 Headset for monitoring ...... | 15.00 |
| 1000 feet microphone cable, lowloss ..................... | 56.00 |
| 500 feet speaker cable, 2-conductor ............... | 12.50 |
| Total ......................... | 937.75 |
| 48 Man-hours labor @ 5.00 .... | 240.00 |
| Grand total (ESTIMATE) ...... | 1177.75 |

OPTIONAL EXTRA

| | |
|---|---|
| Tape recorder .............. | $300-$500 |
| Intercom between balcony and back-stage, with wiring and labor, about ............... | $75.00 |

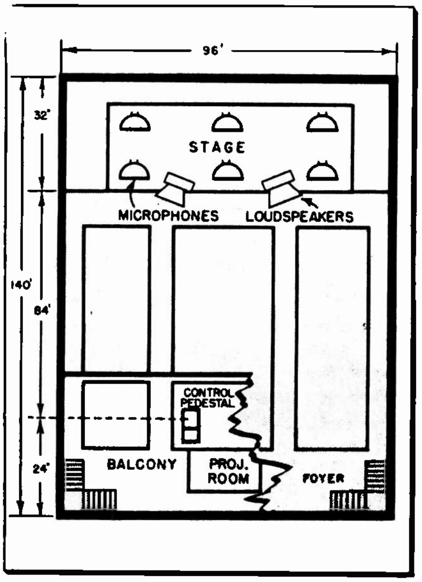
## *Estimating and Pricing a Typical Auditorium Installation*

The labor would, of course, vary all over the lot depending on the nature of the job, the local electrical requirements, etc. Since this particular job is a low-power one, the voltage on the speaker lines could be kept under 70 volts and conduit should not be needed. As mentioned on page 15, an intercom system could be provided between the back-stage sound effects position and the control position for the purpose of passing on cues, instructions, etc. This is listed as "optional."

For the PA dealer to provide such a complete estimate (we will presume that the list, in actuality, would show actual makes and model numbers) to the customer in advance would actually save him time in two ways. First he would have an actual working list for use in installing the system, and second, a ready-made list for computation of the final bill. The latter would probably only need minor corrections to cover the work actually done and the equipment actually installed.

Up to this point, certain more or less technical aspects of the job have been skimmed over. They are: (1) estimating audio power required, (2) determining power handling capacity of loudspeak-

**Fig. 1: A typical layout for sound reinforcement in a small auditorium or little theater. Speakers are above Proscenium arch.**




ers, (3) loudspeaker matching problems, and (4) details of wiring layout.

The first three of these points have been simplified by the relatively limited scope of the installation. High power is not required because (1) the size of the auditorium (roughly 100 x 100 x 30) is small, and the audience is small (under 1000); (2) It is an indoor location, and (3) It is only a sound reinforcement system, not a PA system.

In this 300,000 cubic foot auditorium, 10 watts would probably supply sufficient acoustic power for the needs, and the 15 to 20 watts recommended in the list of equipment should be able to provide *any* needs that would arise.

This may sound small to the dealer who is accustomed to supply 10 to 20 watts for a home installation. Full power of that magnitude is practically *never* actually used in the home, although as much as half of it may be consumed in equalization and feedback. If 10 watts of fairly distortion-free power were available (which might require a 15 or 20 watt amplifier), it should be ample to fill an auditorium of this size.

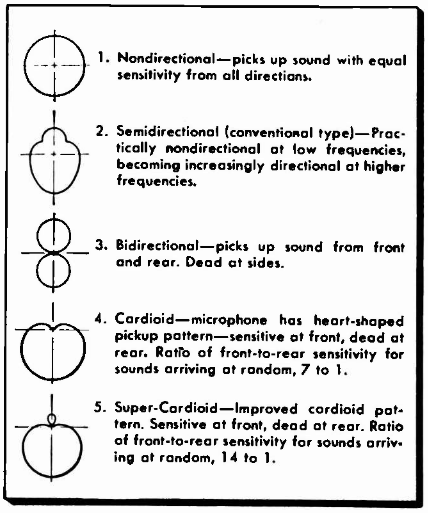
As for the loudspeakers, good quality 12-inch speakers are usually rated for at least 10 watts, and therefore this would present no problem. Actually, connected in parallel, each of the four speakers would draw no more than a fourth of the power.

### *Speaker Impedance Matching*

For the impedance problem, let us suppose that there would be a maximum of 20 watts available, to be on the safe side. There are two ways to figure out the speaker matching problem: one is the old constant impedance method, the other is the newer constant voltage method. The latter is the RTMA-recommended system, and is infinitely simpler for the installer. However, we shall figure out the problem both ways, for the benefit of those who are not using the 70-volt line (the RTMA system) and also to show how simple the latter is.

Under the old way, it would be common to use a 500-ohm output tap, to take a for instance. Each of the four line-to-voice coil transformers would have 2000-ohm secondaries so that the resultant of the four in parallel would be 500 ohms. If it were desired to have unequal powers among the loudspeakers, the problem would be a little more difficult. Let us suppose that we wanted 4 watts each in two of the four, and 2 watts each from the other two, from a 15 watt amplifier. This would be 12 watts, or 12/15 of the total power. If the amplifier output were 500 ohms, then the four speakers should reflect back an impedance which is to 500 as 12:15. 500:X=12:15, then X=625 ohms. The two-watt speakers will absorb 1/6 of the power, the four-watt jobs will absorb 1/3 of the power. The impedances, of course, will be just the reverse of this, so the 2-watt speakers will require 6 x 625 or 3750 ohm line transformer primaries and the 4-watters will require 3 x 625 or 1875 ohm primaries.

With the constant voltage, or 70-volt line system, the output tap of the amplifier is selected for the number of watts required (if it is adjustable; more often, there will be just one output, for maximum output). This is calculated to provide no more than 70.7 volts on the line at maximum output, and lower at




**Microphone types.—Courtesy Shure Bros., Inc.**

anything less than full output. Line to voice coil transformers for 70-volt lines are also marked in watts at the taps, with the impedance arranged for connection to a 70-volt line. One has only to select the desired watts for each speaker at its transformer, without regard to any mathematics (except that the total watts to all speakers should not exceed the output of the amplifier). Thus in our example, if all four speakers were to get equal power from a 16-watt amplifier, each would be tapped at 4-watts. If unequal powers were desired: for instance, two speakers at 2 watts and two at 6-watts, the appropriate taps would be selected without any figuring.

So much for the impedance problem. As to the wiring, this will be done with three requirements in mind: (1) The physical make-up of the building, (2) The desires of the customer, and (3) Local codes. It may be that it will not be permissible to put any wires on the exterior surface of walls; or it may be, on the other hand, that it is not permissible to conceal any wires in the walls; or it may be that existing conduit must be used, or new conduit installed.

It can easily be seen that the choice of one of these alternatives over another could change the cost of the job by 100% or more. Therefore it is obvious that there can be no guesswork here when making an estimate. The wiring plan shown for the job illustrated in figure 1 is merely assumed to be laid by the most direct route along the exterior of the walls.

# The How and Why of

## *Basic Theory Reviewed and Brought Up to Date by Analysis*

• In DC restoration (also called DC *reinsertion* or *clamping*) something is given back to the video signal, which it lost on its trip to the cathode-ray tube. To know what this something is, we must first make sure that we understand the nature of the video signal, as well as its effect on the CRT.

The video signal contains units of picture information representing light intensities varying from white to black. The white sections of the signal are those that have the smallest amplitude, reckoning from the baseline of the total signal (see fig. 1); the black sections of the signal are those that have the greatest signal amplitude. The sync pulses have a greater amplitude than the blackest picture signals, and appear in the "blacker-than-black" region.

### *Nature of Video Signal*

The video signal must be negative-going, when it is applied to the grid of the cathode-ray tube (that is, most negative at greatest amplitude). (If the signal is applied to the *cathode*, which is 180-degrees out of phase with the grid, it must be positive-going.) Then the black portions of the video signal will drive the CRT grid *most negative*, causing *minimum* current to flow through the CRT, and thus producing least light, or no light, on the fluorescent screen; the white parts of the signal will drive the CRT *least negative*, allowing *maximum* current to flow through the CRT, and thus producing maximum illumination of the picture screen. In this way, the picture recreated on the CRT will have the same light values as the televised scene.

Now, such a charming state of affairs will not occur unless the DC level of the received video signal is the same as the DC level of the corresponding video signal at the transmitter. To clarify this statement, let's analyze what we mean by DC and AC signal levels.

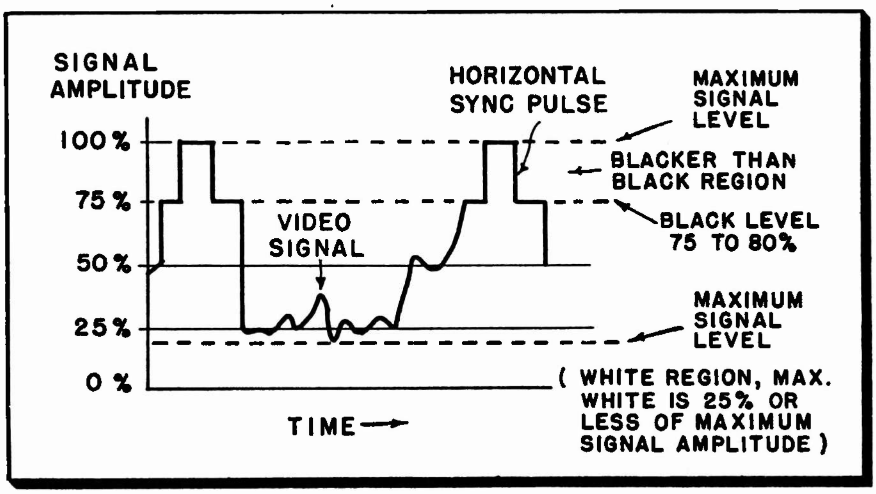
### *DC Is Reference Level*

When an AC signal (fig. 2) is applied to some circuit point, like the grid of a tube, that is at zero potential to chassis, it will cause the grid-to-ground voltage to vary above and below zero, in accordance with the signal's AC fluctuations. When the positive half of the signal is coming in, the grid voltage will rise above zero in the positive direction; when the negative half of the signal makes its bow, the grid voltage will drop below zero—that is, move in the negative direction. The average level, or the DC level, of the grid signal voltage will be zero, because the voltage excursions above and below the zero level are equal.

If the grid to chassis voltage is not zero, but is, say, —3V, the situation will change. The AC signal will now cause the grid voltage to fluctuate around a level of —3V, not zero. That is, the AC signal will add to, or increase, the grid's —3V DC level during the negative part of its cycle; it will subtract from, or decrease, the grid's —3V DC level during the positive part of its cycle. The average voltage on the grid, or the DC voltage, will now be —3, not 0, as in the preceding case.

Now the video signal, after detection, has AC and DC components. The AC component is the picture information itself, which is varying constantly due to the amount of light (or absence of it) which the camera at the Xmitter "sees" in the subject. The DC component is the reference level from which the picture signal varies (fig. 3). This DC component is added to the AC signal at the Xmitter, and establishes the brightness level of the televised scene, since it is the average of all the excursions from light to dark in all the lines in one frame. It is therefore also considered to be the level of background illumination of a scene.

Fig. 1. Amplitudes of different sections of the composite video signal.



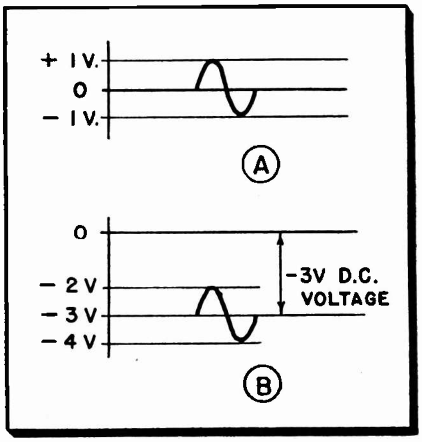




Fig. 2. (A) An AC signal superimposed on zero DC voltage. (B) An AC signal superimposed on minus 3 VDC.

### *DC Component Is Lost*

This DC component, when added to the fixed bias on the kine of the receiver (which is established by adjustment of the brightness control) establishes the operating point of the kine so that the blanking pulses will cut off the beam. In this way we can be sure not only that the average background illumination of the scene is correctly reproduced, but also that the kine will always be cut off during retrace, and retrace lines will not appear.

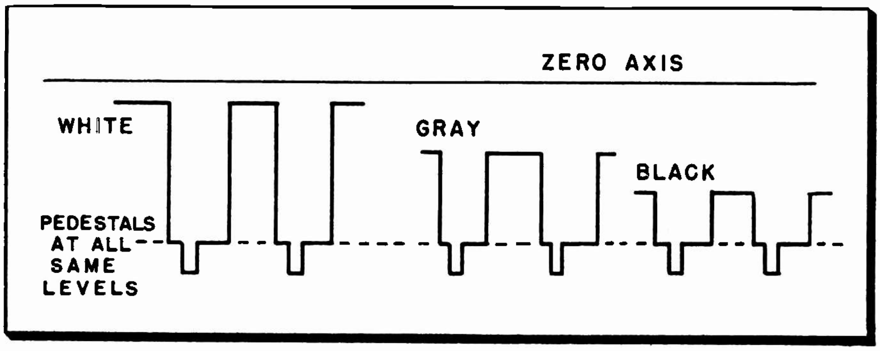
If we did not have this DC reference level (and it can be lost, as is explained later on), we should have to adjust the brightness control every time the average background illumination of the scene changed. As it is, the only time we have to change the receiver fixed bias on the kine (or in other words, the setting of the brightness control) is when changing from one station to another with a vastly different received signal strength. And

# DC Reinsertion in TV Sets

***of Practices Employed in Current Model Sets of Various Makers***

even this change is made unnecessary (to a great degree) in sets with AGC and/or Automatic Black Level.

Now, the indispensable DC signal level is present at the output of the video detector. Between the video detector and the cathode-ray tube, however, the video signal generally passes through one or more R-C (resistance-capacitance) coupling networks. Since a condenser blocks DC, the DC level of the video signal is lost (fig. 4). It must therefore be restored or replaced. This is done by the DC restoration circuit. (It should be noted that in some receivers, no condensers are used in the coupling employed between the detector and the cathode-ray tube. No DC restorer is generally found in such sets.)



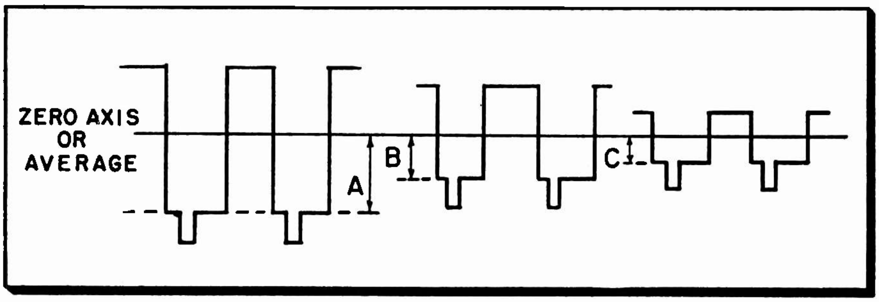




**Fig. 3 (above, top). Light, medium and dark background pictures as they are transmitted. With the correct DC component included, the black and blacker-than-black information will, as shown, always cut off the kine in the receiver. Fig. 4 (above, bottom). The same signals as in fig. 3, but with the DC component removed, and the signals shown averaged around a zero axis as they would be after passing through a condenser. A, B and C show the DC components which must be added in each case to properly line up the black levels once more.**

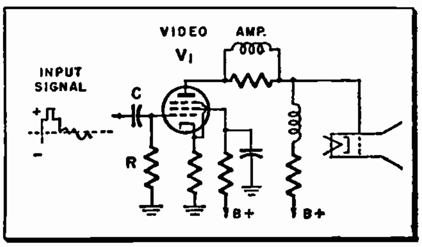
### *Restoring DC Manually*

To better understand the action of the DC restoration circuit, let's consider in detail what would happen if it weren't present.

Suppose that light scene was followed by a dark scene. The set viewer has adjusted the brightness control while the light scene is coming in, to eliminate vertical retrace lines, and to give an approximately correct rendition of the tonal values present. The scene now changes to a much less brightly lit one. The vertical blanking pulses received during such a scene will no longer drive the CRT bias to cut-off, and vertical retrace lines will be visible on the picture screen (fig. 4). Furthermore, black signals will not drive the CRT grid negative enough to reproduce black on the picture screen. Black and grey tones will therefore be too light.

If the viewer reduces the brightness setting, thereby increasing the CRT bias, the undesired symptoms just described will be eliminated. When the scene illumination increases considerably, however, white and grey picture information will appear too dark, and the background illumination will similarly be too dark. Another resetting of the brightness control will now become necessary.

**Fig. 5. Typical circuit showing how DC restoration can be restored by grid-leak bias in the final video amplifier, provided direct coupling is used from the plate of that tube to the grid of the kine.**




The DC restoration circuit eliminates the symptoms cited by restoring the correct DC level to the video signals. Two types of DC restorers are in common use: 1—The grid-leak DC restorer; 2—The diode restorer. Let's consider first how the grid-leak restorer (fig. 5) functions.

### *Grid Leak DC Restorer*

No special circuit is needed for this type of restoration. The DC signal level is restored because of the grid-leak action of R and C. When the composite video signal arrives at the grid of $V_1$, its polarity is positive (courtesy of the preceding stage or stages).

The positive portions of the signal will drive the grid positive with respect to the cathode during the first few cycles, causing grid current to flow, and a negative grid-leak bias to be developed. During subsequent cycles, only the positive peaks of the signal—that is, the sync pulses—will exceed or overcome the negative grid-leak bias, and cause grid current to flow momentarily.

Now, the grid-leak bias developed is a DC voltage. This DC voltage establishes a reference level for the video AC voltage coming in. For correct DC restoration to occur, the DC level must be proportional to the DC level originally present. Let's see how this is achieved.

If we examine the predominantly black and predominantly white signals shown in figs. 3 and 4, we see that the white signal—that is, the signal with a bright background—will, after the loss of its DC component, have a much greater peak-to-peak amplitude than the signal with the dark background. The light background signal has lost more DC voltage than the dark background one, and will need more to be restored to it. In other words, the darker the background of the signal, the smaller is the DC voltage that must be restored to it, and vice versa. Let's see how the grid-leak restorer fulfills this requirement.

When a light background signal is coming in, this high-amplitude signal will produce the largest DC grid-leak bias (since the grid-leak bias is proportional to the amplitude of the incoming signal). On the other hand, with a dark background signal coming in, a small DC voltage will be added to the video signal voltage. Thus the correct DC levels are restored to the signal, and since direct coupling to the CRT is used, no loss of the restored DC component occurs.

The DC restoration process

not only restores the video signal's DC level—it also lines up the vertical blanking and sync pulses, so that they attain the same amplitude. This is the way these pulses are transmitted, and this is how they must be received. If the vertical pulses weren't uniform in amplitude, an inadequately-sized vertical blanking pulse might not blank out the cathode-ray tube, causing vertical retrace lines to be seen on the screen.

The necessary lining up of sync and blanking pulses occurs during the same process that restores the video signal's correct DC level. The grid-limiting action of the video amplifier produces the alignment.

Suppose a large-amplitude vertical sync pulse is coming in. Since the pulse is the most positive part of the video signal applied at the video amplifier grid, and the cathode is grounded, the grid will be driven positive, and grid current will flow. The grid current will be relatively large, because the positive pulse is large. It will produce a voltage in the grid cir-

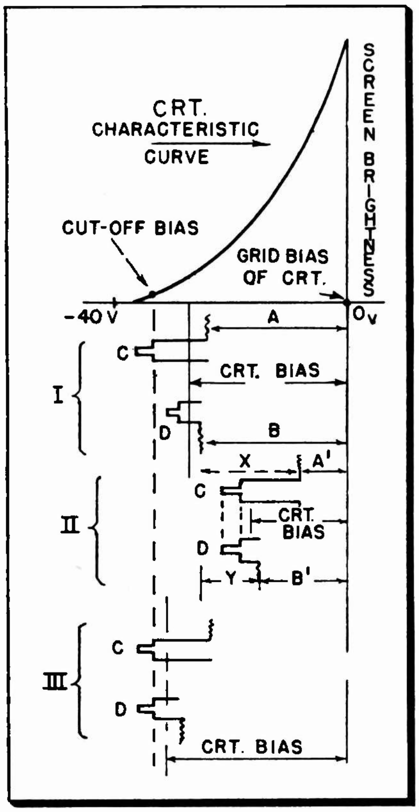



**Fig. 2—Effect of diode DC restorer on CRT bias. C represents a large-amplitude or white-background signal; D represents a small-amplitude or dark-background signal. In sketch I, C and D are shown with unrestored DC levels. Note that the CRT bias gives C a DC level of A; D's level is B. In sketch II, C, bucked by a large DC restoration bias, is reduced to level A¹. D, bucked by smaller DC restoration bias Y, is reduced to level B¹. The blanking levels of the two signals are now lined up, but do not reach cut-off. In sketch III, the CRT bias has been adjusted with the brilliance control to bring both blanking levels to cut-off.**

cuit that is opposite in polarity to the sync pulse voltage. The *net* sync voltage will therefore be relatively low.

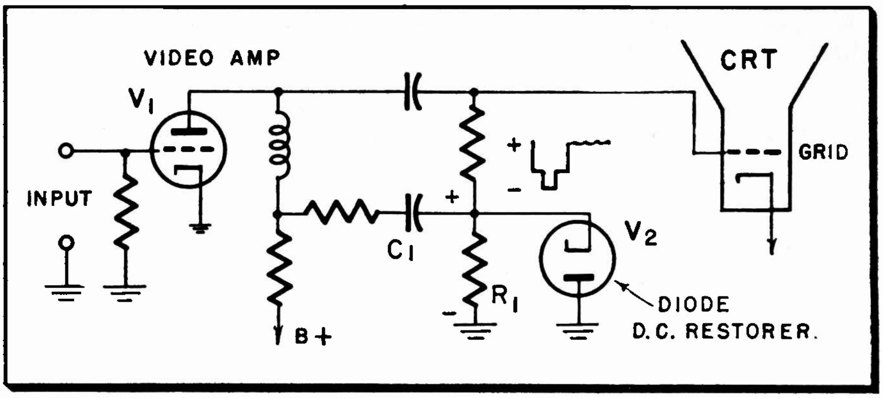



**Fig. 1—Simplified sketch of positive diode DC restorer.**

Say the sync pulse voltage is +5 V, and the bucking voltage it produces is —4 V. The net sync pulse voltage will be +1 V.

Now let's say that a small-amplitude vertical sync pulse follows its big brother. This pulse will not drive the grid as positive as its predecessor. Less grid current will flow, and the bucking voltage produced will be smaller. Suppose the positive sync pulse voltage is +2 V, and the bucking voltage created is —1 V. The net voltage will be +1 V.

The two originally unequal pulses are thus lined up, or brought to the same amplitude, by the grid-limiting action. Small-amplitude pulses are bucked least, and large-amplitude pulses are bucked most, causing all the pulses to line up at the same approximate height.

The operation of the diode DC restorer (fig. 1) is basically similar to the grid-leak type of restorer. Negative or positive DC restorers may be employed, depending on the polarity of signal needed for correct CRT operation. The positive DC restorer illustrated in fig. 1 works as follows:

The composite video signal is applied through $C_1$ between cathode and plate of the restorer ($V_2$). $V_2$ will conduct only when its cathode is driven sufficiently negative to its plate (which is another way of saying that the plate must be driven positive to the cathode), so a negative-going video signal is needed here. During the first few cycles of $V_2$'s conduction, a positive charge is built up across $C_1$, making $V_2$'s cathode positive to plate. (This positive voltage between cathode and plate is, in effect, a bias voltage.) When the subsequent video signals applied between cathode and plate are large enough to overcome the positive voltage between cathode and plate, $V_2$ conducts. Only the most negative portions of the composite video signal — i.e., the sync pulses — will be large enough to overcome the bias voltage and cause $V_2$ to conduct. The resultant DC voltage developed across $R_1$ will be proportional to the amplitude of the sync pulses. This voltage is in series with the AC signal voltage applied across $R_1$. Thus a DC level is added to the video signal.

This DC level is proportional to the DC level originally present in the signal, for the same reasons that the DC voltage developed in the grid of the grid-leak DC restorer is proportional to the signal's original DC level (explained last month).

You may remember that, in our last article, we pointed out that the darker the original background of a signal, the larger is its DC level; the more DC level it loses in passing through RC coupling networks; and the larger the DC level, therefore, that must be restored to it. Also, vice-versa.

This requirement is satisfied by the diode restorer, because the restorer develops a *small* positive DC voltage when a dark-background, or small-amplitude signal is coming in (see fig. 2). The negative bias between the grid and cathode of the CRT is lowered only slightly by this positive bucking voltage that is formed in the grid circuit. The CRT bias therefore remains large, or highly negative, at this time, and the scene is correctly reproduced as dark.

When a signal with an originally light background, or a large-amplitude video signal arrives, the greater conduction of the DC restorer produces a relatively *large* positive DC voltage in the CRT grid circuit. This positive voltage substantially reduces the negative bias of the CRT, causing the picture to be correctly reproduced as light.

How the sync and blanking pulses are restored to the same amplitude by the diode restoration process may be explained as follows: The diode restorer may be considered—in fact, it actually is—a half-wave rectifier, similar to the half-wave rectifiers used in the power supply of AC-DC broadcast receivers. A large AC input voltage will produce a large DC output voltage, and vice-versa. The DC voltage produced by the restorer is opposite in polarity to the sync voltage in series with it, and therefore bucks this voltage. From here on, the explanation is the same as in the case of the grid-leak restorer. A large sync signal will produce a large bucking voltage, and

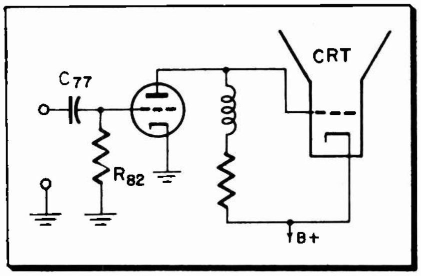



Fig. 3—Simplified grid-leak restoration circuit. Restoration action is achieved through the action of $C_{77}$ and $R_{82}$. This type of restorer has two basic faults: 1—The plate current of the video amplifier is heavy in the absence of a signal input, which does this tube no good. 2—The control grid and cathode of the CRT will be at the same potential when the video amplifier conks out, causing zero CRT bias and permitting a possibly damaging current to flow through the CRT.

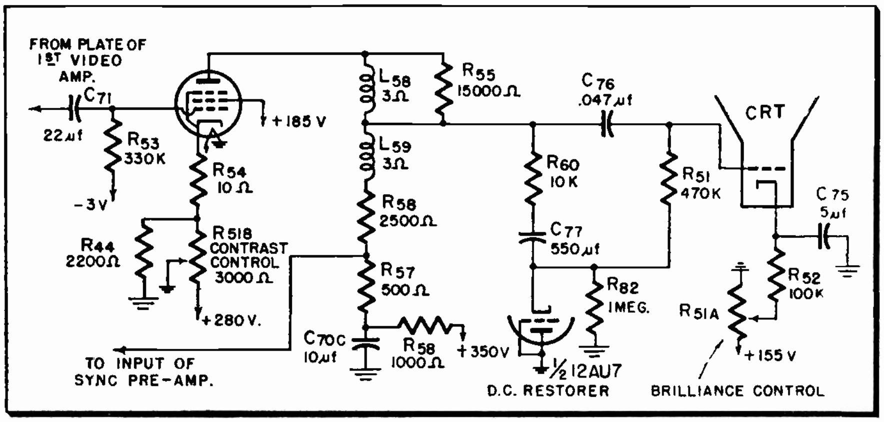



Fig. 4—DC diode restorer used in Philco models 50-T1400, 50-T1401, 50-T1402, 50-T1403. One-half of a 12AU7 is used as a vertical oscillator; the other half as a DC restorer. The triode section used as a restorer is made a diode by connecting grid and plate. A portion of the video amplifier's output signal is fed through $R_{60}$ and $C_{77}$ to the cathode of the restorer.

a relatively small net sync voltage. A small sync voltage will produce a small bucking voltage, and a net voltage approximately equal to that of the preceding sync pulse, etc.

This restorer is called a *positive* DC restorer because it inserts a positive DC voltage in series with the video signal. In a negative-type of DC restorer, the action is the same, except that a positive-going signal is needed at the restorer input, and a *negative* DC voltage is inserted in series with the video signal.

The time constant of the DC restorer is worth mentioning. $R_{82}$ and $C_{77}$ in the grid-leak restorer (fig. 4), and $R_{82}$ and $C_{77}$ in the diode restorer (fig. 5) determine this time constant.

If the time constant is too short (due to changes—i.e., reductions—in the value of $R_{82}$ or $C_{77}$, or insertion of the wrong value of component), the condenser will charge and discharge too rapidly, compared to the time of one horizontal line. The sync and blanking pulses will therefore build up from differently-sized voltage bases, and their effective amplitudes will consequently vary.

Normally, the time of $C_{77}$'s charge and discharge is so long, compared to the duration of one horizontal line, that the level of the sync pulses is substantially constant.

Too short a time constant is apt to result in a distortion, or incorrect reproduction, of the picture's background illumination. Also, white picture information may appear too dark, and black information too light. Retrace lines may appear in the picture at different times, due to the differing amplitudes of vertical sync pulse peaks.

If the time constant of $R_{82}$ and $C_{77}$ is too long (due to an increase in $R_{82}$, or the use of the wrong—i.e., too large—value of $R_{82}$ or $C_{77}$, DC reinsertion may not occur quickly enough, and retrace lines may be seen for a short time after a change in the picture's background illumination takes place. The picture's tonal values might also be incorrect in this brief interval of time.

The correct time constant—T (in seconds) = R (in megohms) x C (in MFD)—varies from a time equal to the duration of 10 to 20 horizontal lines (the theoretical optimum) to about the time needed for 1 picture frame.

DC restorer trouble should be checked for when retrace lines are seen in the picture after changes in scene lighting occur. To test the restorer, apply a modulated RF signal, (of the correct frequency for the channel to which the front end is tuned) to the antenna input of the receiver. Then measure the DC restoration voltage developed. This is the DC voltage across $R_{82}$, fig. 4; and $R_{82}$, fig. 5. Compare the reading to the voltage developed across the corresponding unit in a similar or identical receiver that is operating normally, when the same amount of modulated RF voltage is applied to the latter. If the two measurements are substantially different, trouble in the DC restorer should be looked for.

Since a DC restoration circuit uses very few components, the few possible defects—changes in the value of a condenser or resistor, or a defective tube—should be readily localized. When a crystal is used in place of a diode, the crystal may become defective. To check it, substitute a known good crystal of the same type.

When grid-leak DC reinsertion is employed, trouble in the condenser or resistor will generally introduce other symptoms besides those associated with poor DC restoration. That is, if condenser $C_{77}$ (fig. 4) becomes leaky or loses capacitance, smearing may become noticeable in the picture. If $C_{77}$ shorts, no picture or a very weak picture will be seen. If $R_{82}$ increases greatly in value, smearing may occur. If $R_{82}$ opens, no picture or a very weak picture is apt to be seen. If $R_{82}$ short-circuits, no picture will be seen. If $R_{82}$ decreases considerably in value, the picture will become weaker, and smearing may be present.

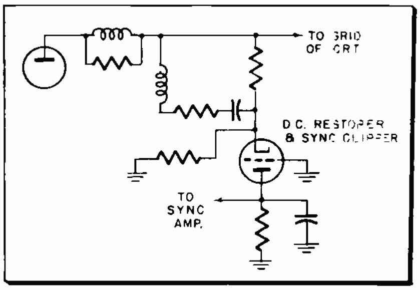
In the diode DC restorer shown in fig. 5: If $R_{82}$ loses all or most of its value, the absence of DC restoration may be secondary to the weaker picture that will result, since a large loss in $R_{82}$'s value will reduce the signal input to the CRT. An open in $R_{82}$ will not only impair DC restoration, but is apt to eliminate the picture as well, since the CRT grid return to cathode is opened.

A shorted tube (plate-to-cathode short) will produce the same symptoms as a short in $R_{82}$. A weak or burnt-out tube will cause inadequate DC restoration. An open or considerable loss of capacitance in $C_{77}$ will result in the transfer of an insufficient input in the DC restorer, causing inadequate restoration.

Sometimes the DC restorer and sync clipper are combined in a single triode (see fig. 7). If trouble develops in such a circuit, the impairment of synchronization is apt to be far more serious than the absence of DC restoration, and the troubleshooter will no doubt be concerned primarily with this first symptom.

In some receivers, the appearance of retrace lines in the picture may be due, not to a defect in the DC restorer, but to a fault in a special circuit whose job it is to eliminate the vertical retrace lines from the picture.

Fig. 5—Circuit commonly employed when DC restoration and sync clipping functions are performed by the same tube.



# Improving the Sound

### *These Modifications Can Better the Response*

• For most American homeowners present-day FM-AM combinations are satisfactory, else people would not continue to buy them. But for a continually increasing number of consumers, many sets in the middle price range do not produce sound quality as good as these consumers would like. Yet new high-fidelity combinations are expensive, costing $400-500, or more.

The wide-awake service department can step in and do a job on existing instruments that is highly profitable, and still save money for the customer. Modernizing his old set may mean only an hour's labor installing a high quality "tweeter" or loudspeaker. Or it may involve replacing everything except the cabinet (in the case of some inexpensive chassis installed in an impressive cabinet). Usually, though, the changer and tuner section of the set at least, and most of the time even the audio section, can be made use of. It is in such cases that the greatest advantages to both the service shop and the set owner are to be had from the improvements discussed in this article.

The first step to take in improving a set with inadequate or distorted response is to examine it carefully. If a small output transformer is noted, it may be that a larger, better quality transformer is all that is needed. But if the transformer looks OK, is working into a good loudspeaker, and has a *pair* of tubes driving it, then the circuit details must be checked.

### *Simple Repair May Do Job*

The set may sound bad because of a change in value of almost any component, or perhaps because of a combination of values each just a few percent out of the way from the design centers originally engineered. Therefore a voltage check should be run on the audio stages with the manufacturer's voltage chart. Often changing one or two resistors to give proper voltage readings will improve the linearity and undistorted (5%) output enormously.

Assuming that the voltages are in line with manufacturer's specifications, the first improvements will be the addition of a good output transformer or of inverse feedback from the present transformer. If inverse feedback is presently employed, but the transformer has a small core, take note of the secondary tap which the feedback comes from. Then employ the same tap on the new transformer, if the feedback is of the type which uses the transformer secondary.

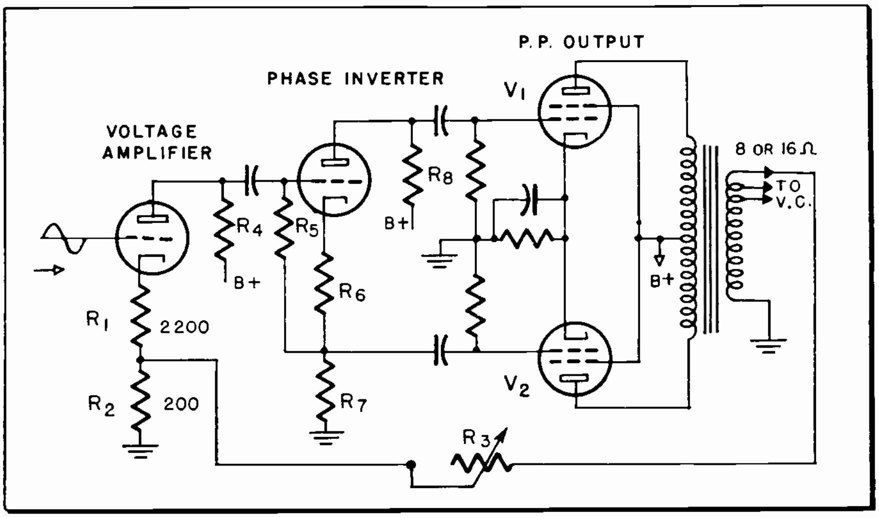



Fig. 1. In adjusting inverse feedback $R_3$ is a variable potentiometer. $R_1$ and $R_2$ may vary. Some designers recommend omitting $R_2$ and connecting $R_3$ to cathode. $R_7$ equals $R_8$.

The output transformer is most often the weak link in the set. Cheap transformers fail both at the low and high end of the band. They have a tendency to distort and attenuate frequencies over 5 KC. They also attenuate the transfer below 150 cycles very sharply.

Also, the speaker often has a pronounced rise in the near-bass region, between 180 and 200 cycles. This rise produces a thump, or "one-note" boominess, an effect which is often made use of to supply the impression of good bass. In fact, a great portion of the public has become so accustomed to this false bass that it sounds good to them!

If the installation is one in which a very high quality loudspeaker is to be used, then one of the top grade transformers, of broadcast quality, should be employed. However, in most situations a good medium grade (usually called "standard", or "commercial," which are better than "replacement" grade) output will do, being flat to over 10 KC and good within 4 or 5 db to 50 cycles. This is more than adequate for all but the very best loudspeakers. There is little point in paying for response of 1 or 2 db flat from 20 cycles to 20 or or 30 KC when it can't be used! Appended is a table showing the impedance and approximate price of output transformers for various push-pull output stages.

If a medium grade output transformer, correctly rated at 20-25 watts, is run at 10 or so watts and less, it will usually display good power transfer characteristics.

If the output tubes are running wide open, that is, if no inverse feedback loop is applied around them, feedback can be added with the assurance that it will materially improve the performance of the receiver. Inverse feedback is one of the most powerful tools known for the reduction of the many types of distortion that arise in audio circuits.

There are many ways of adding this feedback, but the safest method, and the method which is employed today in all conventional top grade amplifiers will be outlined here.

### *Applying Inverse Feedback*

In one of these methods a very small portion of the output signal is taken from the secondary of the output transformer and applied back to the cathode of the first voltage amplifier (or the stage just before the phase inverter). The procedure for determining how much feedback to use, and exactly how to apply it, is much easier than it may sound at first.

Referring to fig. 1, it will be seen that a 200 K potentiometer is connected from one side of the secondary to the un-bypassed cathode of the voltage amplifier. (Use the 8 or 16 ohm tap.) An oscilloscope (AC voltmeter will do—need not be VTVM; this is a low impedance circuit) is connected across the voice coil and a tone injected at the first grid, either from a phono test record or an audio generator. The potentiometer is va-

# of FM-AM Combinations

***and Performance of Any Amplifier***

ried to reduce the resistance between the cathode and the secondary of the transformer to as small a value as is possible without setting up oscillation, and without reducing the gain of the amplifier too much. When the proper setting has been found the resistance of the pot is measured and a fixed resistor is soldered in place. Care must be taken before settling definitely on a value for the feedback resistor that there is enough gain left for proper maximum output from the amplifier with the usual program materials, both radio and phonograph.

### *Alternate Feedback Method*

Another method, safer where any but the very highest quality output transformer is employed, takes the feedback voltage off one of the push-pull output plates. In this case again, the feedback voltage is taken back to the un-bypassed cathode of the nearest (to the inverter) single-ended voltage amplifier stage. The pot used here should be larger, since the source of feedback voltage is much greater. Also, a blocking condenser of .1 to .5, 600 V. should be placed between the resistor and the plate.

Oscillation will be shown by any sudden large increase in the output at the secondary terminals. If the circuit oscillates at almost all settings with no signal going in at the input either the primary or the secondary connections must be reversed. This will reverse the phase of the feedback. (Or use plate of other p.p. tube.)

### *Power Supply Changes*

A more serious defect in some power output stages is the limitation placed on the low frequency output by an inadequate power supply. If this is due to a power transformer having insufficient voltage output, one having proper power and voltage rating may be put in. Such a deficiency may readily be determined by comparing the screen, cathode and plate voltages with the values shown in the tube manual.

If the filter of the power supply uses one or two heavy resistors instead of chokes, the regulation and the efficiency of the power supply can be increased by substituting one or two iron core chokes for the resistors. This is a good modification if the applied voltage to the output tubes is not raised too much thereby. Most of the time this will not happen and the change can be made safely, but check the tube manual to be sure, before making the change. In raising the voltages applied to the screen and plate, be particularly careful to keep the screen voltages no higher than specified.

Another even easier way of getting a little better efficiency, cooler running, and more current out of the transformer without lowering the voltage output is to substitute a rectifier which draws less current for its heater supply. Where 5U4s have been used, usually a 5V4 will help. (This method should not be employed in the power supply section of television or other receivers, where the current drain on the original 5U4 approaches its nominal limit of 225 ma. The 5V4, being rated at 175 ma, is more than adequate for most audio amplifiers, but will become low on emission if made to supply most TV sets.)

Also, the slow heating properties of the 5V4 (and 5T4—a higher current-output tube) allow the other tubes in the set to warm up first, and thus keep from possibly straining the filter condensers. Furthermore, the 5V4 and 5T4 have lower internal impedance. Usually, simply plugging one in in place of the 5U4 will give from 5 to 15 volts more on the plates of the output tubes simply because of the lower voltage drop across the rectifier. This is a very easy and frequently effective way of getting a little better operation (check that tube manual) from the output stage.

Many economically designed combinations have condensers running from the plates of voltage or power amplifier stages to reduce oscillations which would otherwise be encountered. And it is frequently found that there are condensers or R-C combinations off the output tube plates. These measures are taken to reduce the operation of the amplifier at the extreme higher frequencies which can often result in distortion or singing. When a new output transformer has been installed all such counter measures should be removed.

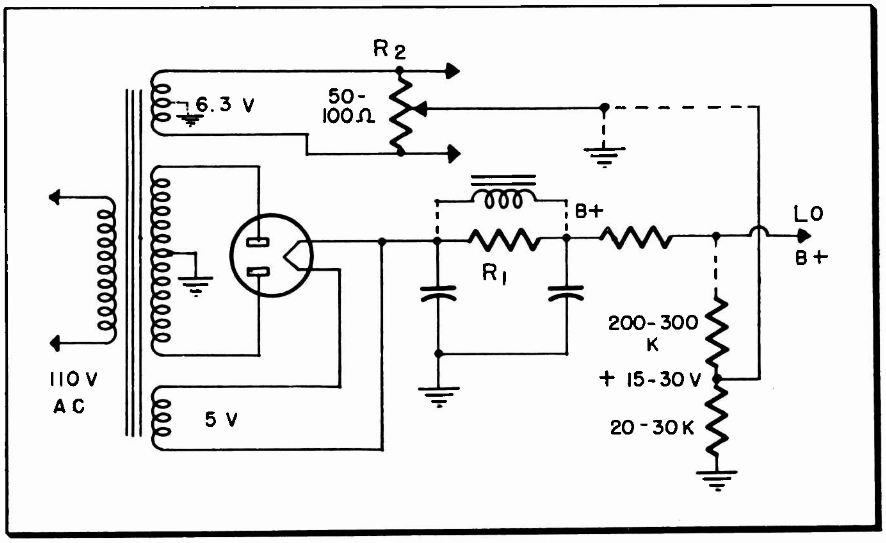



Fig. 2. Dotted lines show various methods for reducing hum due to design (not for hum due to component failures). 15-30 V may be applied to 6.3 winding centertap.

| P. P. Output | Load (ohms) | Approx. Cost Medium Grade (20-25 watt) | Approx. Cost Top Grade Transformer |
|---|---|---|---|
| 6L6 | 6,600 | 6.00 | 17.00 |
| 2A3, 6B4 } 6A5, etc. | 3,000 } 5,000 | 8.00 | 18.00 |
| 6V6 | 8,000 | 5.00 | 16.00 |
| 6K6 | 12,000 | 5.00 | 16.00 |
| 6F6 | 10,000 | 5.00 | 16.00 |

# FM Sound

The most commonly employed method for 60 cycle hum is the use of a wire-wound pot across the heater winding of the power transformer and the adjustment of the center tap connection to ground for minimum hum level. See fig. 2. This is usually effective, but in high-gain preamplifiers additional steps may be called for. Instead of grounding the adjustable tap of the 50 or 100 ohm pot, it may be connected to a point of 15 to 25 volts positive. This potential is easily obtained by bridging two ¼ or ½ watt resistors across the B supply. Typical values are 20 to 30 K and 200 to 300 K. Fig. 3 shows this connection clearly. The placing of a positive voltage on the heaters ensures that there will be no heater to cathode emission. Since the heater is made positive in relation to the cathode, current can flow, if at all, only *from* the cathode.

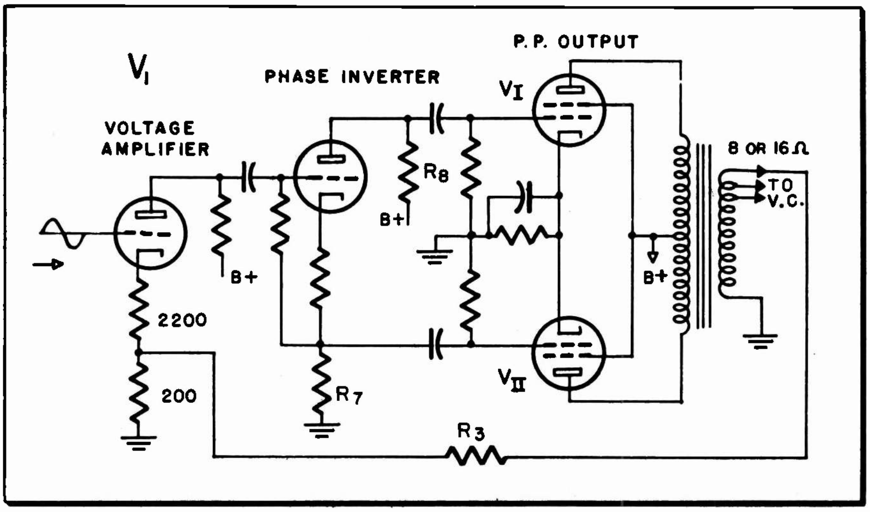
To determine if there is a significant amount of unbalance in the output of a set, all that is needed is a pair of headphones (or an extra loudspeaker coupled to an extra output transformer) and a source of audio tone, either phono frequency record or generator. Bridge the phones (or primary of extra output) across a 1 K, 20 w. resistor connected from the center tap of the receiver output transformer and B plus and feed a tone intot he receiver. If the circuit is unbalanced *some* sound will be produced in the phones or test speaker. The size of the resistors governing the amount of signal fed into the phase inverter tube are then adjusted to produce *no signal* in the test phones or test speaker. In Fig. 1, $R_7$ or $R_8$ would be the resistor to be adjusted. In fig. 3, $R_2$ would be the proper one.

Improper methods of phase inversion to obtain driving voltages for the two output tubes cannot be allowed in a good amplifier section. It is assumed that there will be no trick phase inverter circuits left in. One which was employed not long ago in a commercial combination took the driving signal for the grid of output tube No. 2 directly off the cathode of tube No. 1. Another method, not nearly so bad, but still not satisfactory, is to take the grid No. 2 signal from the unbypassed screen dropping resistor of output tube No. 1.

The best amplifiers today employ the *split load* (also known as *cathodyne,*) phase inverter, shown in fig. 1. Entirely acceptable results have been obtained with the *self-balancing or floating paraphase* inverters also. All other phase inverters should be viewed with suspicion if the audio quality is unsatisfactory.

The conventional phase inverter most often commercially-used in the past has closely resembled the self-balancing inverter. But in the self-balancing type the grid of the driver for V2 was grounded through the same resistor as the driver for V1. In either the conventional type which has the grids grounded separately, or the self-balancing type, the first triode section is the stage which should employ the un-bypassed cathode for application of the inverse feedback. It is highly desirable to apply this feedback voltage back over as few stages (and consequently over as few coupling capacitors) as possible. The cathode most nearly immediately before phase inversion takes place is therefore the cathode to be used. Particularly where the cathode has been grounded and grid-leak bias employed in the voltage amplifier, the cathode should have cathode bias applied, and a suitable (consult the resistance-coupled amplifier tables in tube manual) smaller grid return inserted.

**Fig. 1. Split load phase inverter shown is widely used in high-quality audio amplifiers. Simple to install, inherently balanced for all but extreme high frequencies. Feedback is applied through $R_3$ to $V_1$.**




Since most big sets today use octal or loctal tubes, usually one of the present tubes can be removed and a twin triode installed and wired in place. The phase inverter will become the stage immediately preceding the output grids, and the cathode of the triode preceding it should be left unbypassed so that the feedback may be conveniently applied here.

If the phase inversion in the original circuit is acceptable but there is insufficient gain for the application of feedback, the gain of one of the voltage amplifier stages may be increased by increasing the size of the load resistors. (In general the plate loads should not be made larger than 500,000 ohms.)* Or a twin triode may be installed for the purpose of adding one more stage of amplification.

### Tube Choice for Extra Stage

In choosing a twin triode for either of the above applications the 6SL7 (or 7F7 for loctal) is the best choice. Not only does it draw less plate current (typically 3 ma. per plate) instead of about 10 ma. per plate, but it requires less heater current (.3 amp.) than the 6SN7(7N7) (.6). Also, it has a much higher amplification factor—70, instead of 20. The 6SC7 would be acceptable but for the fact that it has a common cathode.

If the phase inverter is of the type shown in figure 3, referred to here as the "conventional" type (because until recently it was widely used), it may be operating unbalanced due to unequal aging of the load resistors or tubes. *If* the circuit had been carefully balanced when constructed and did not change due to aging, this circuit would allow excellent push-pull driving. But this sort of balancing is not practical in production, due to assembly-line tube and resistor variations. Improvement in this circuit can be made by converting it to the "self-balancing," or "floating paraphase" type. This conversion is simple, involving only one change in the circuit diagram. In figure 3, the ground return of resistor $R_8$ is lifted, and the grid resistor is returned to the junction of $R_2$ and $R_1$, which is marked point X in the diagram. In the circuit of Figure 1, the cathode of $V_1$ would be the proper one to receive the feedback voltage. (In Figure 3, the cathode of the voltage amplifier.)

Today the best sets have both treble and bass tone controls. They must be capable not only of *cutting* the amount of treble or bass, but of *boosting* the bass or high tones, separately. If the receiver being modernized or improved is not equipped with good tone controls, they may be added by inserting the network of Fig. 2, (A) in front of the last voltage amplifier before the phase inverter. Such a tone control network will introduce about 15 to 20 db loss of gain in the set, so an additional triode stage must be added to compensate for the loss.

### *Placement of Stage*

The extra stage should be placed before the tone controls if possible, so that any possible hum pickup by the components being added for the tone controls will be amplified as little as possible. This tone control network is extremely flexible, and will give about 15 or more db of either bass or treble boost or cut (settings of each control are entirely independent). It may be installed in extremely small space, with the two potentiometers mounted on the control panel—one in place of the old type treble cut knob — and the additional resistors and condensers mounted off the lugs of the pots. One precaution to take is to see that the ground returns in this network are all made to points isolated from chassis, connected with a piece of bus wire, and this run to the ground return of the grid and cathode for the stage they are feeding into.

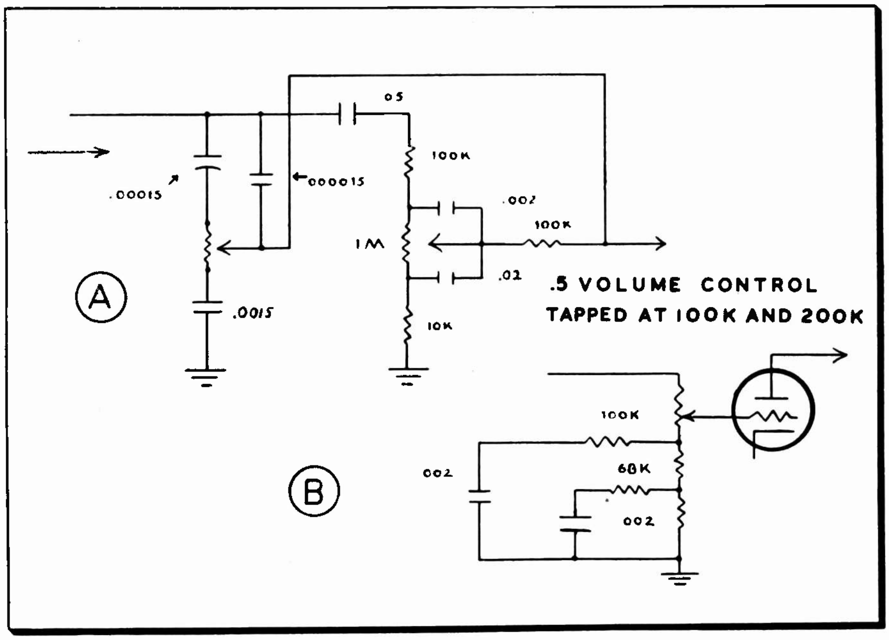



**Fig. 2. (A) Independent bass and treble cut or boost controls. Both pots are 1 M, flat taper. (B) "Loudness" control which boosts bass smoothly as volume is decreased. (Circuits engineered by Howard T. Sterling.**

In many large sets the tone is pleasing to the customer only when the volume is at fairly high levels. If this is because there seems to be a deficiency of bass at the low settings of the volume control, a so-called "loudness" control may be added to the combination, in place of the original volume control. The loudness control works on the principle that the human ear hears less and less of the low notes as the volume is lowered. Consequently the loudness control is designed to give more and more bass boost as the volume is lowered, to keep the *apparent* balance between bass and treble constant at all volume levels.

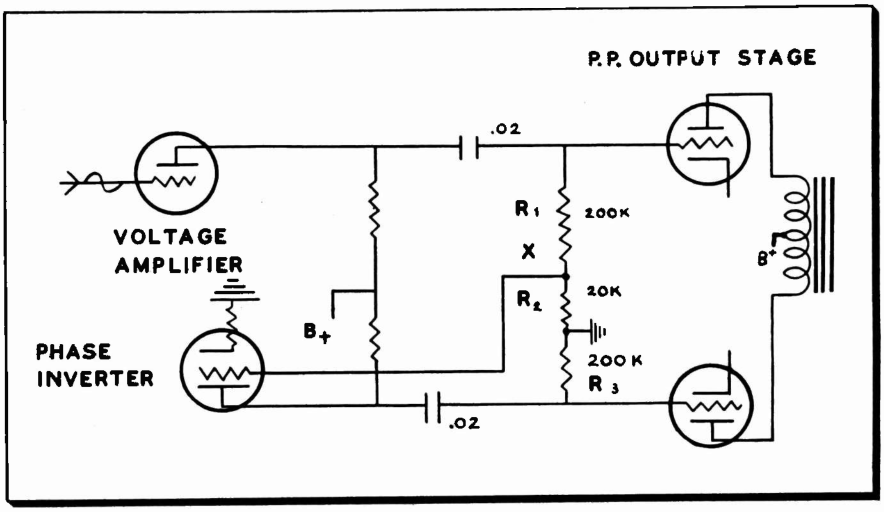
Some of the better big combinations have had tapped volume controls built in for years. But usually they had only one tap, and so only did the job partly. The most expensive loudness controls have twenty-three taps. But it has been found that very smooth action and bass compensation can be had from the proper use of a 500 K potentiometer with only two taps. The diagram in Fig. 1 (B) shows the schematic for this control. The parts may be mounted right on the pot, and inserted on the control panel or chassis in place of the original volume control.

Many of the earlier FM receivers employed 6C4 tubes, particularly as local RF oscillators. These were later found to have considerable drift, and frequently became microphonic. So if an FM set has a 6C4, and is giving trouble, try replacing the 6C4 tube. A new 6C4 will usually only clear up the trouble temporarily. Therefore the 9001 or the 6AB4 should be used. Except for pin 5 connection, which is made internally in the 6C4, but not in the other two tubes, the pin connections are the same. Be certain to use a jumper from pin 1 to 5 if the plate connections under the socket are going only to 5.

In addition to the electronic improvements which can be made in improving the sound of FM sets or FM-AM combinations, the possibilities of the electro-acoustic improvements are great. There is not space here to consider in detail the characteristics of the loudspeakers usually employed in the medium range sets. It may be noted though, that the addition of a medium-price extended-range speaker costing from 12-17 dollars will considerably improve the range of a set, once it has been cleaned up *electronically.* It goes almost without saying, of course, that substitution of a good low-frequency speaker will help any set. Among the physical characteristics to look for are a large magnet, and a big voice coil (2 to 4 inches; the bigger the better.) Stick to reputable makes. "Bargains" are never cheap in speakers.

**It is inherent in the theory of the split-load inverter that its gain to either side of its load cannot exceed unity, so attempts to increase output by altering its circuit will not succeed.*

**Fig. 3. Conventional phase inverter frequently employed until recently. Circuit has high gain; is easily unbalanced. Simple change can improve balance considerably.**



# Automatic Gain Control

## Need for AGC; How the Basic

The automatic gain control circuits in the television receiver keep the output of the video detector as nearly constant as possible. To better appreciate their contribution to optimum set performance, let's consider what might happen if they were absent.

In the first place, when the set viewer switched from a weak station to a strong one, an excessively contrasty picture might result. Worse, the picture might jump, roll, or tear out horizontally, due to overloading of sync stages. Still worse, the picture might suffer a complete loss of synchronization. Such an impairment of sync might be due to a loss of the sync pulses in an overloaded IF amplifier (see fig. 1).

If the set viewer had switched from a strong station to a weak one, the received picture might show inadequate contrast. Some loss in synchronization due to the inadequate size of the incoming sync pulses might also manifest itself.

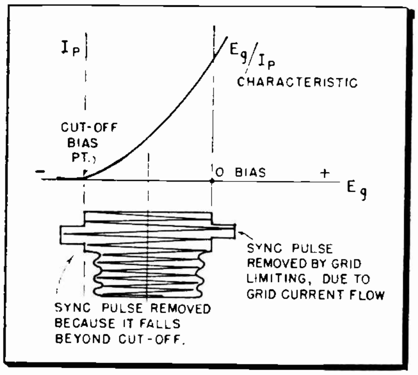



**Fig. 1—A large-amplitude IF signal may force the grid bias to swing beyond 0 volts, into the positive region, on positive peaks of the signal, and to exceed cut-off, on negative signal peaks. This condition is most apt to occur in the last video IF amplifier, where the IF signal level is highest. A sharp cut-off tube is assumed.**

In either case, resetting of the contrast control would be necessitated—an extra chore that would scarcely draw sighs of pleasure from tired set owners.

By keeping the video detector output substantially constant in spite of large variations in the amplitudes of incoming signals, the need for resetting the contrast control when channels are switched is minimized. Even when the incoming signal increases by a factor of 100, the video detector output will be no more than doubled, in the usual AGC-controlled receiver. When the changes in the strength of the incoming signal are moderate, the output of the video detector will remain substantially constant.

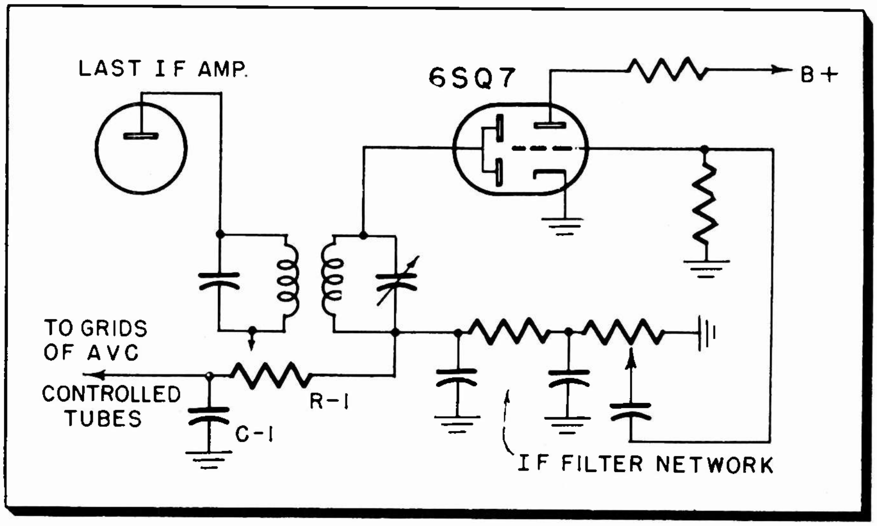



**Fig. 2—Typical AVC circuit used in broadcast AM receivers.**

Other undesirable conditions that are avoided by the use of AGC include those due to: 1—changes in signal strength caused by fading 2—changes in the gain of various amplifiers produced by slow variations in supply voltages and 3—changes in the strength of incoming signals because of signal reflections from moving conductors, such as airplanes.

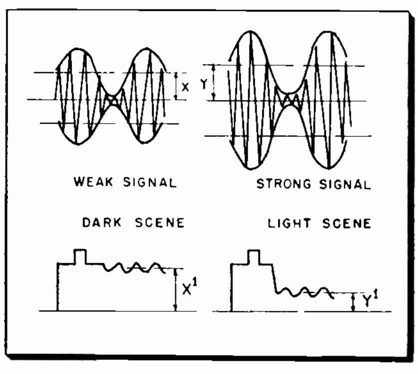
AGC systems may be divided into three basic categories: simple AGC, delayed AGC and keyed AGC. Before we tackle the simple AGC system, a review of AVC action in broadcast AM receivers may prove helpful, because there are several points of similarity between AGC and AVC.

AVC, or automatic volume control, is, as we know, a means of keeping the sound volume constant, in spite of fluctuations in the strength of the incoming RF carrier. A typical AVC circuit is shown in fig. 2. The detector develops a negative DC voltage across R-1 that is proportional to the strength of the incoming signal. This negative voltage is fed back to controlled RF and/or IF stages as a bias. When the carrier tends to increase in strength, a larger voltage is developed across R-1, causing the AVC bias to increase, and the gain of the AVC-controlled stages to decrease proportionately. The signal output of the detector thus remains substantially the same. Similarly, when the incoming RF signal tends to *decrease,* the lowered voltage developed across R-1 causes a lower AVC bias to be fed back to the controlled stages, increasing their amplification. The signal output of the detector again remains substantially constant as a result.

The rate of change of the AVC voltage is determined by R-1 and C-1. The time constant of these components determines how fast the AVC action will be. If the time constant is too long (R-1 or C-1 is too large) the AVC bias may not change as rapidly as fluctuations in the strength of the incoming signal, and proper correction will not be maintained.

If the time constant is too small (R-1 or C-1 is too low in value), C-1 will be appreciably charged by low audic frequencies—i.e., low audio frequencies will develop a voltage across C-1, instead of being filtered out. The AVC bias will, in such a case, fluctuate at an audio rate. A feedback of audio signals among different stages to which C-1 is common may now occur, and degeneration or oscillation is apt to result, depending on the phase of the different signal currents that pass through, and develop voltages across, C-1.

**Fig. 3 (top)—The DC bias developed by an AVC circuit is proportional to the average amplitude of the incoming carrier. The average amplitude of the strong carrier, or amplitude Y, is greater than average amplitude X of the weaker signal. Fig. 5 (bottom)—The average level of the TV picture carrier depends on the brightness of the transmitted scene. $X_1$ is the average amplitude of the video signal carrier between sync pulses in a dark scene; $Y_1$ is the average amplitude in a light scene.**



# Circuits in TV Sets

## Control System Works; Typical Circuits

Note that the AVC circuit, under normal operating conditions, develops a voltage that is proportional to the average amplitude of the carrier (see fig. 3).

Now, an AGC circuit (fig. 4) must, like an AVC circuit, develop a bias proportional to the strength of the incoming signal. A rectifier is employed that changes the applied IF signal into a pulsating DC voltage proportional to the strength of the incoming signal. The pulsating or video-signal component of this voltage is filtered by R-1 and C-1, and a pure DC voltage is fed back to the controlled stages.

The AGC circuit, unlike the AVC circuit, cannot use the average amplitude of the carrier as a base or reference level. This is true for the following reason: While the average amplitude of the sound carrier in the case of broadcast band signals remains substantially constant if the station is not changed, and fading is not present, *the average amplitude of the TV picture carrier does not.*

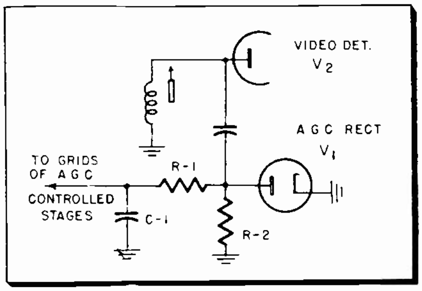



**Fig. 4—Simple TV AGC circuit.**

This is so because the average amplitude of the TV picture carrier varies with the average brightness of the scene being telecast. The brighter the scene, the lower the average amplitude of the carrier and vice versa (fig. 5). If the AGC system developed and fed back a DC voltage proportional to the average amplitude of the carrier, whenever an increase in brightness caused the carrier average amplitude to decrease, the reduced AGC bias fed back to the controlled stages would increase the amplification of these stages, increasing their output, and bucking the tendency of the carrier to decrease. Similarly, when the average amplitude of the carrier tended to increase, the AGC system would counteract the tendency. The picture's illumination would be incorrectly rendered in consequence.

To avoid such an undesirable condition, the DC voltage output of the AGC rectifier is based on the sync and blanking pulse levels. Since these levels are always of the same amplitude regardless of the brightness of the scene (provided that no fading is present, and the station setting is not changed), the AGC bias developed will be proportional to the incoming signal strength, but will not adversely affect the picture brightness.

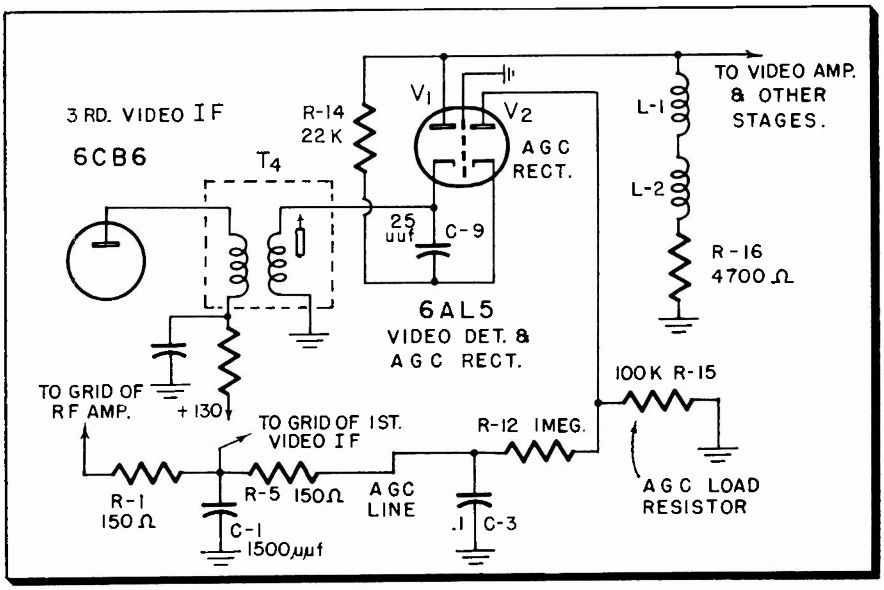
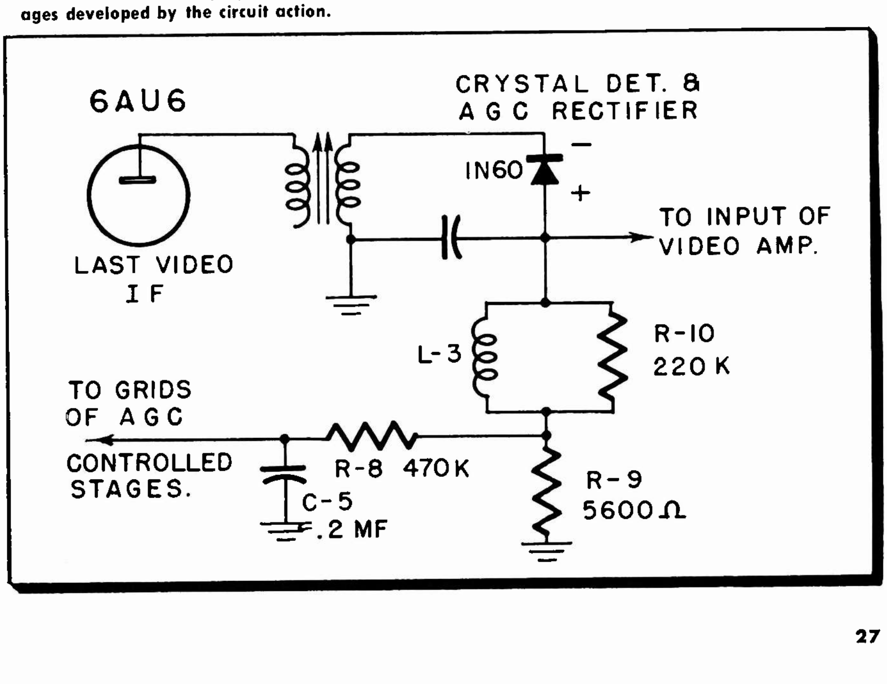



**Fig. 6—Commercial form of simple AGC circuit using separate tube for AGC rectifier. Circuit is used in Emerson, Models 662B and 663B. R12 and C3 form the AGC time constant or filter network. R5, C1 and R1 are additional units, used to remove video signals from the AGC voltage.**

Let's see how the simple AGC circuit shown in fig. 4 works. The video IF signal is applied between plate and cathode of the AGC rectifier V-1 and causes current to flow during the positive peaks of the incoming signal. A rectifier voltage is consequently developed across R-2. This voltage is proportional to the strength of the incoming signal, as represented by its sync and blanking levels. If the incoming signal tends to fade, or fall in amplitude, the input to V-1 decreases, and the DC voltage across R-2 falls, reducing the bias of the AGC-controlled stages, and thus raising the input to the video detector to its former level—or rather, preventing the input to the video detector from dropping below its former level. Similar bucking changes oppose any tendency of the signal to momentarily rise in amplitude.

**Fig. 7—Circuit used in Bendix TV, Models 2051, 3051, 6001, 6003, and 6100. A 1N60 crystal is employed as a common video detector and AGC rectifier. The + and — signs beside the crystal indicate the cathode (—) and the plate (+) sides of the crystal, not the polarities of the voltages developed by the circuit action.**



When the first positive-going signal is applied to V-1's input, V-1's plate becomes positive to its cathode, and the tube conducts. C-1 acquires a charge at this time through R-1. When the incoming signal decreases to the point where V-1's plate is no longer positive to its cathode, the tube stops conducting, and C-1's charge leaks off through R-1 and R-2, developing a negative voltage across these resistors.

After several cycles, the charge acquired during V-1's conduction and the charge lost during V-1's non-conduction become equal, and conditions stabilize. The negative voltage across R-2 has, at this time, become large enough to prevent conduction at any time except the peaks of the incoming signals—i.e., the sync pulses.

The charge built up across C-1 by V-1's conduction is approximately equal to the peak amplitude of the sync pulses. Due to the long time constant of C-1 and R-1 (more precisely, R-1 in series with R-2), compared to the interval between horizontal sync pulses, C-1 does not have enough time to lose much of its charge before the next pulse comes along and replenishes it.

In between horizontal sync pulses, therefore, C-1's charge will not change appreciably. Although video signals are present at the input to the AGC rectifier at this time, they will not appear at the rectifier's output, because the long time-constant of R-1 and C-1 does not permit the output voltage to change at a video rate.

In this way, video signals are filtered out, and the horizontal sync pulse level determines the AGC bias (since AGC condenser C-1 charges up to practically the level of the horizontal sync pulses).

The time constant of R-1 and C-1 is an important feature of the circuit. If this time constant is too short, C-1 will charge up more, since a shorter time constant for a condenser means a faster charging rate, and a larger amplitude of charge acquired in a given interval of time. Now, under normal conditions, when vertical sync pulses are present at the input to the AGC rectifier, C-1's charge will increase from about 75% of the peak amplitude of the input signal, to 88%, approximately, since these pulses have a large amplitude and a long duration. This is an undesirable condition, because it means that the AGC bias will increase when the vertical sync pulses are coming in, reducing the gain of the AGC-controlled stages at this time. The reduction in gain will persist even when the vertical sync pulses are no longer present, because the charge built up across C-1 cannot leak off instantly. The background shading of the picture will be incorrectly rendered as a result of this condition. The resultant distortion is not too noticeable ordinarily, but if the C-1, R-1 time constant decreases considerably, distortion will be apparent.

• The first problem that presents itself with respect to the servicing of a simple AGC circuit is: when to look for trouble in this circuit. If a single diode or crystal is employed as a common video detector and AGC rectifier (see fig. 1), many faults will affect both circuits seriously. When the picture is missing or weak, and other sections of the receiver have been eliminated as possible sources of the trouble, the serviceman will check the video detector, without necessarily thinking of it as an AGC rectifier. When a fault that primarily affects the AGC action, without markedly affecting the video detector's operation occurs, however, a test of the AGC operation is called for.

Only a few such faults suggest themselves in the case of the circuit shown in fig. 1. Changes in the time constant of R-115 and C-110 may be cited as possible defects. If the time constant of this network increases considerably (due to an increase in R-115's value), the ability of the AGC system to counteract changes in the strength of the incoming signal as fast as they occur will be impaired. When channels are switched, in the event of such a fault, improper contrast and/or loss of sync may be noted for a short interval, before the AGC regulation takes hold. Momentary fading that was previously inhibited, may now play tag with the picture from time to time, affecting its contrast and synchronization.

If R-115 or C-110 loses value, reducing the time constant of the network considerably, vertical synchronization and picture shading will tend to be impaired. Let's consider what happens in such a case.

### *Short Time Constant*

The normal time constant of a simple, unsophisticated AGC circuit is around a few tenths of a second. If the time constant is reduced to 1/30 of a second or less, symptoms will probably be noted. C-110 charges faster when its time constant is shorter, and a larger voltage develops across it, particularly when the large-amplitude, long-duration vertical sync pulses are coming in. The AGC bias therefore increases, and the output of the AGC-controlled stages decreases, during vertical sync pulse time. The size of these pulses is therefore reduced with respect to the rest of the composite video signal, reducing the sync pulse input to the vertical oscillator and thus affecting the vertical holding action.

The AGC voltage will, in the case considered, no longer be a relatively pure DC voltage (who is absolutely pure these days?) but will contain a 60-cycle vertical sync pulse ripple in it. This ripple is fed back to the controlled stages, and will tend to modulate the video signal passing through these stages. An undesired low-frequency signal variation that manifest itself in the picture as incorrect background shading may result.

If R-115 decreases to a very low value, C-110 will shunt most of the video information from R-115, weakening or eliminating the picture. The effect on AGC will be as noticeable, in such a case, as a pimple on a broken arm; the serviceman would, of course, be sending out search parties for the lost video, not the missing AGC.

If C-110 decreases very considerably, its filtering action may be reduced to such a point that feedback occurs in the controlled stages, due to the inability of the decoupling networks to remove the excessive ripple that now appears in the AGC line. The result may be oscillation, if the feedback is regenerative in nature; or degeneration (loss of gain), if the feedback is degenerative. Oscillation will tend to manifest itself on the CRT screen as an interference pattern.

Similar results are possible but not likely if one of the decoupling condensers loses considerable capacitance. A far more probable effect of such a loss in capacitance is a loss in set sensitivity. This is to be expected because the decoupling condensers return the tuned grid circuits of the controlled stages to ground. If one of them loses considerable capacitance, or open-circuits—let's say C-101 does so—much more of the grid signal current will have to flow through a decoupling resistor—in the case just assumed, through R-103, then to C-103 to ground. The Q of the tuned circuit affected will therefore be lowered, and reduced set sensitivity, possibly even misalignment, may result.

If the faulty decoupling condenser is in the RF amplifier circuit, more noise can be expected, because a reduction in the Q of the tuned circuit at the RF amplifier grid will reduce the signal-noise ratio, and make noise (snow effect) more prominent on the CRT screen.

If R-115 open-circuited, or C-110 short-circuited, no AGC voltage would be transferred to the controlled stages. Not only would improper contrast and impairment of sync tend to occur when channels were switched; overloading of a controlled—perhaps we should say *decontrolled*—stage might now take place, due to its inadequate bias. Such overloading might manifest itself in the picture as smearing; or it might cause black noise dots in the picture to be followed by white streamers, making the noise effects more conspicuous. In some cases, one or two ambitious amplifiers might be driven into oscillation when strong signals were coming in, possibly producing negative pictures and various unpredictable symptoms.

Open-circuits in decoupling resistors (such as R-103, R-106) and short-circuits in decoupling condensers (such as C-101, C-103) would also remove the AGC bias from the grids of controlled stages, tending to produce the same symptoms.

If any such symptoms are present, and other sections of the receiver seem to have clean bills of health, the AGC circuit action should be checked.

To test the operation of the AGC sys-

## *in Simple AGC Circuits.*

tem, the AGC voltage present across C-110 should be measured, and compared with the corresponding DC voltage cited in the set manufacturer's notes. The conditions under which the voltage is measured should be in accordance with those specified in the manufacturer's notes.

If this data is unavailable, an identical or similar receiver, in good working order, may be used as a reference or standard of comparison. The AGC voltage may be measured in this normal set with a) the antenna connected b) the antenna disconnected, and the antenna input shorted c) the antenna disconnected, and a signal generator attached to the antenna input terminals. The generator is set at some frequency within the range of the channel to which the front end is set, and its output is reduced to a relatively low level for his check.

The receiver under test is then checked under identical conditions, and the voltages obtained compared with those read on the good set.

When the presence of trouble in the AGC circuit is indicated by such checks, conventional DC voltage, resistance and condenser bridging tests should quickly locate the defective unit. It should be noted, incidentally, that improper operation of a stage preceding the AGC rectifier will cause improper AGC voltage readings to be obtained. This is true in all AGC circuits, not merely the one shown in fig. 1.

### *Testing With a Scope*

When a loss in capacitance or open-circuit in the AGC filter condenser (C-110) is suspected, a scope may be used to verify if this is the case. The scope should be set to a low frequency (60-100 cycles), its vertical gain control turned all the way up, and its hot lead attached to the hot side of C-110 (scope ground lead goes to chassis, of course). Normally, very little or no AC voltage should be seen at this point. Just how little is to be expected, can be determined by testing across the AGC condenser of a receiver known to be working properly. If C-110 has lost a good deal of its capacitance, however, its by-passing of video and vertical sync signals will be impaired, and vertical sync pulses may be seen in appreciable amplitude across it.

Suggested DC voltage test points are A, B, C, D, and E. The absence of voltage at any of these points can be readily interpreted. If the AGC voltage, for instance, is present at point C, but not at point D, an open in R-103 or a short in C-101 is indicated.

In the circuit shown in fig. 2, the AGC rectifier is separate from the video detector, and has its own place of business, so to speak. A portion of the IF signal voltage coming from the 4th video IF amplifier and developed across L-102 is fed between cathode and ground of the video detector, detected,

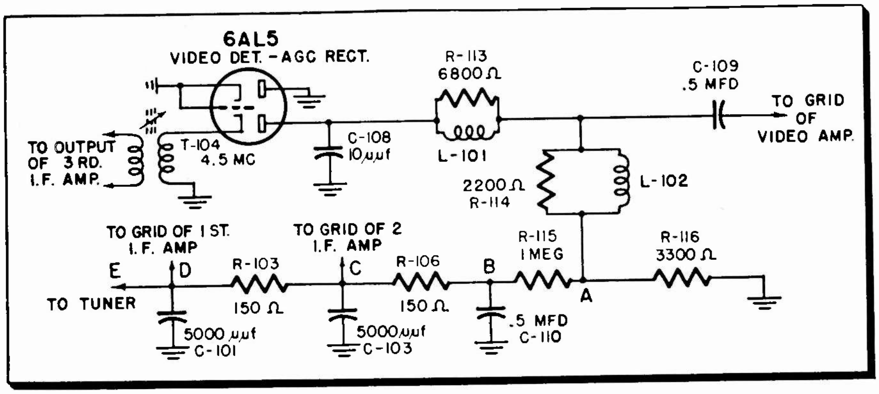



**Fig. 1—Simple AGC circuit, in which video detection and AGC rectification are performed by the same diode. Elements of the unused diode are grounded out. The circuit shown is from the schematic of Hallicrafters Models 810A, 815, 822, 870, 871 and 880.**

and transferred to the input of the video amplifier. The entire IF signal voltage across L-102 is injected via C-125 between plate and cathode of the AGC rectifier.

R-124 and C-128 form the basic AGC time-constant network. A switch providing for modification of the time constant of this network is incorporated. R-123, R-209, C-127 and C-187 are decoupling units.

The correct setting of this switch is generally made at the time of the receiver's installation. When the set is located in a strong signal area, the three-position switch is placed in position 1, its extreme counter-clockwise setting. The time constant network is now made up only of R-124 and C-128.

When noise external to the receiver is great enough to interfere with reception, the switch is set to position 2, or its center setting. In this position R-127 shunts series-connected resistors R-125 and R-214, reducing the resistance in the discharge path of C-128. Noise pulses that tend to charge up C-128 will now discharge faster, reducing the false or undesired AGC bias they tend to introduce. This undesired contribution to the AGC voltage lowers the signal gain at a time when optimum signal gain is very much needed.

In position 3—the last position—C-128 is shorted out, and the AGC bias is completely removed. This setting is intended for use when weak signals are being received, and maximum amplification is desired. The receiver will overload if signals in excess of 200 microvolts are received. For signals under 200 microvolts, the set's sensitivity will be optimum, and the sync pulses delivered to the sync stages will be best able to maintain synchronization in the presence of noise.

When the switch is in position 3, contact 4 connects to 1, returning the bottom of R-218 to ground, and shunting R-136 with a resistor of equal value. The signal input to the DC restorer is lowered as a result. Such a lowering of the input to the restorer is necessary because the AGC bias also serves as bias for the triode restorer, and when this bias is removed, the restorer output will tend to become too large. That is, its plate current will increase, and since this current flows through R-142, the grid resistor of the sync separator, and helps determine the latter's bias, the

(*Continued on page* 42)

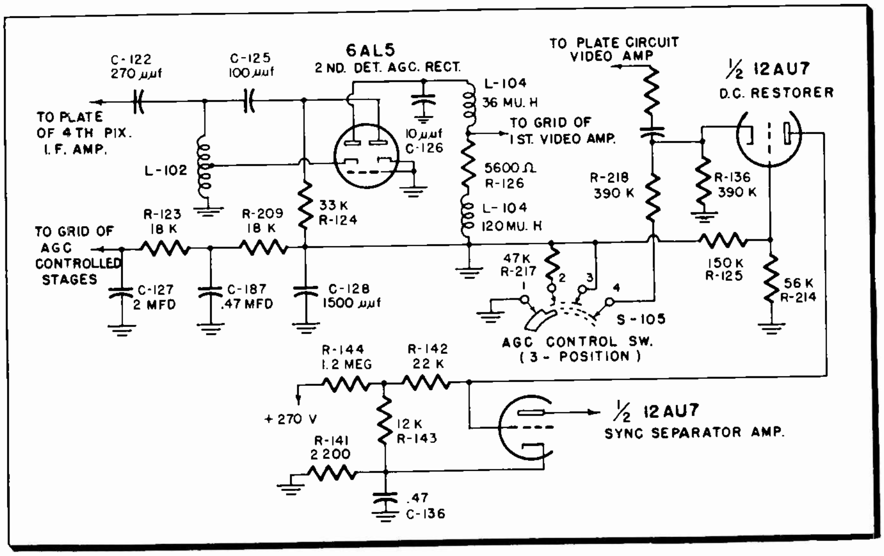



**Fig. 2—AGC circuit used in RCA Models 2T51, 2T60, chassis numbers KCS45 or KCS45A. Only a part of the DC restorer circuit is shown. Separate diode sections of a duodiode tube are used for video detection and AGC rectification.**

# "Direct Drive" System for

***Greater Efficiency Attained with Simpler Circuitry and Components***

*by E. A. Campbell, Technical Editor*

• Among the features of the original 630 circuit which have become "classic" to the TV technician is the horizontal deflection-output-high voltage system utilizing the "flyback transformer." For the 9.5 KV-50 degree deflection as needed with the 10BP4, this was a very efficient and ingenious system. But as tubes got larger, and deflection angles increased to 67 degrees and more, the requirements of high voltage and deflection power surpassed the limits of that system.

Voltage doubling with two 8016's was employed to get higher voltages, and paralleling 6BG6's was at times used to increase the drive, but these methods were obviously in the direction of increased cost, and in the latter instance an increased drain on the B supply.

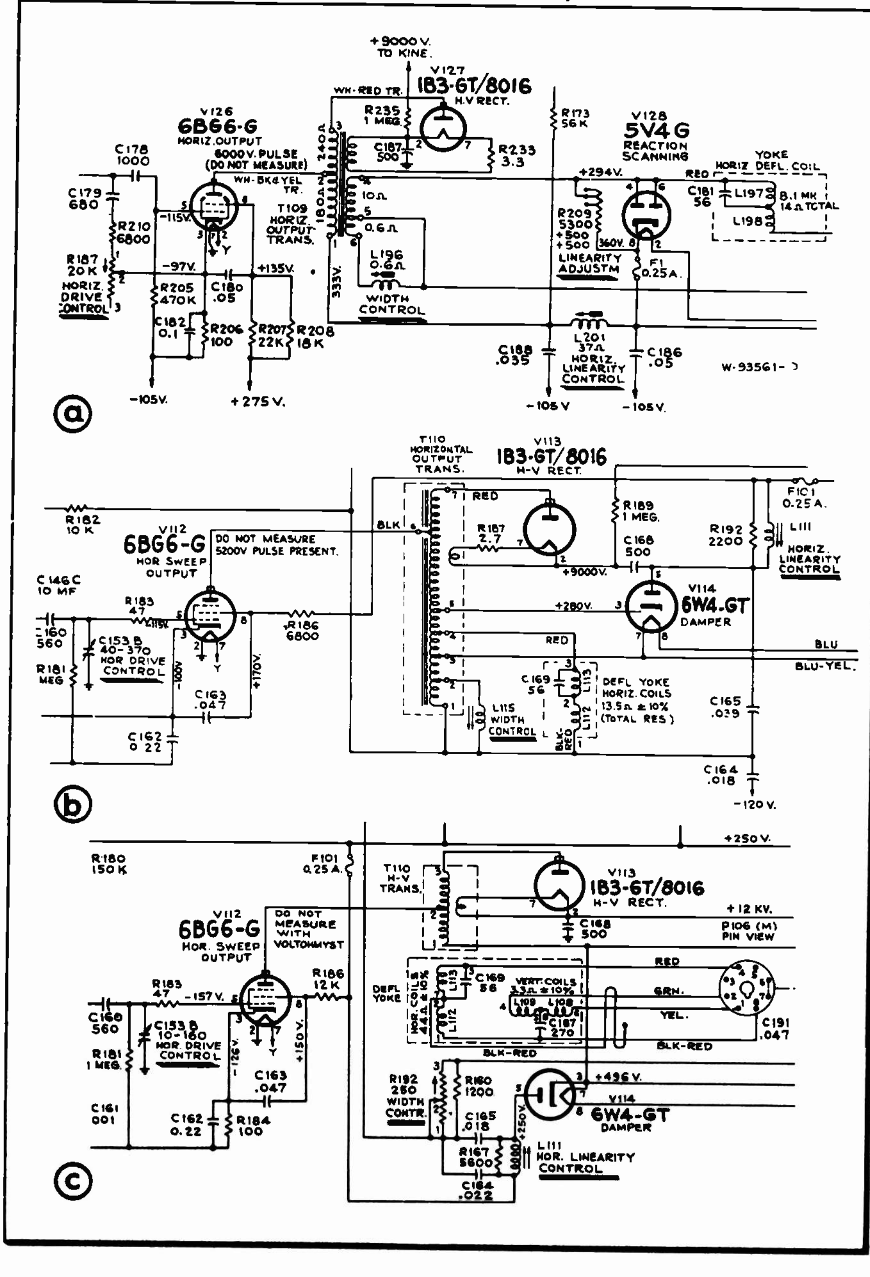
Faced with the paradoxical problems of getting almost twice the deflection power (for 70 degree tubes, as compared with 50 degree deflection) and at the same time meeting the demand for lower priced receivers, the industry came up with ceramic core output transformers and yokes and new output tubes such as the 6AV5 and 6CD6 which would supply more current to the system without additional drain on the B supply.

The ceramic core material is characterized by almost ten times the permeability found in powdered iron cores used previously, permitting higher voltages to be developed with equivalent amounts of driving current.

The most recent development toward the improvement of efficiency in the horizontal deflection and high voltage system without increasing costs is the "Direct Drive" system introduced in RCA receivers in 1950.

This system dispenses with the output transformer, which was essentially an impedance matching device similar to the audio output transformer, and connects a relatively high impedance yoke directly into the plate circuit of the output tube. This is a logical step, since it to a large degree saves the energy which would otherwise be lost in a transformer due to leakage, heat, etc.

**Fig. 1—Horizontal deflection circuits showing transition from multi-winding output transformers to autotransformer type employed in direct drive system.**




### *Like Conventional System*

Operation of the system is similar in many ways to the conventional systems. The transition from the 630 to the autotransformer type to the direct drive system is shown in figures 1a, 1b and 1c. Briefly reviewing the earlier circuit, we recall that the output tube is driven by the oscillator with a waveform suitable to produce a sawtooth of current in the yoke. The output tube is essentially conducting in brief pulses at a repetition rate of 15,750 cps. When the output tube is cut off by virtue of its grid being driven negative, the magnetic field induced in the yoke by the previous pulse tends to collapse rapidly, generating a back EMF which is high due to the relatively high resonant frequency (71KC—see explanation below). This high voltage was stepped up in going from the secondary to the primary of T109, and is further stepped up by autotransformer action in the primary, placing a positive voltage in the neighborhood of 10KV on the high voltage rectifier.

In the 9T246 circuit (b) shown, an autotransformer is used instead of the conventional output transformer with primary and secondary, but the principle of creating and stepping up the high voltage is essentially the

# TV Horizontal Deflection

same. In the T164 circuit (c,) the output transformer section has been dispensed with, and we have only a high voltage transformer (operating still on the same general principle). The yoke (plus this high voltage winding) is the load for the output tube. The increased efficiency of high voltage formers using ceramic core material, as mentioned above, contribute to the capabilities of this circuit.

To discuss the operation of the deflection portion of the circuit, it would perhaps be in order to review the function of the damper tube. The importance of this tube to all the three circuits under consideration is much greater than the word "damper" implies.

We can consider the output tube plate current as having been utilized to drive the trace over to the right side of the screen. Then suddenly that tube is cut off, the field collapses, high voltage is produced and is utilized to supply the 2nd anode voltage. This does not, however, use up much of the energy in the yoke.

### *Using the Energy*

The first use to which we can put this energy is to accomplish retrace. The requirement of our present system is that the beam must get back quickly to the left side of the screen after the trace is completed: approximately 7 microseconds are allowed for retrace as compared with 53.5 M sec. for the visible trace.

When the output tube is abruptly cut off and the high back EMF is produced due to the rapid collapse of the magnetic field, the system is said to be "shocked into oscillation." It has been found useful to design the circuit constants of the output system so that, when this shock excitation occurs, the system will oscillate at approximately 71 KC. Thus in one half cycle of oscillation (7 M sec.) retrace will have been accomplished. A relatively small portion of the energy available is used up in this operation.

At this point we must stop the oscillation or else the beam will oscillate back and forth at a 71 KC rate until the energy in the yoke is consumed (since a good deal of energy remained after retrace). It would be highly desirable to utilize this energy to satisfy the next demand of the system, which is to start the visible trace across the tube again. To do this, we need to control the oscillation so that the current passes through the yoke at the slower (and at the same time, linear) rate required for the trace. An RC network would accomplish this, but a good deal of energy would be wasted in the resistor in the form of heat.

The damper tube, however, permits this energy to be efficiently utilized. The functioning of the damper tube is already familiar to the TV technician, and is therefore very briefly described as follows: When the output tube is cut off and the high voltage is developed as a result of the collapsing field, this voltage is negative at the damper tube plate and therefore cuts that tube off also. After the retrace is completed, however (or in other words, after a half cycle of oscillation) the plate of the damper is driven positive and the tube conducts. This places a low resistance across the oscillatory circuit and stops oscillations. Due to the resistance of the tube, and the circuit constants associated with it, the energy which had been momentarily stored in the yoke is allowed to decay at a relatively slow and linear rate to start the visible trace on its way. Thus the damper tube in a sense supplies some of the energy to scan the tube—actually, it would be more correct to say that it makes this energy available—and so it was that in the 630 circuit it was called the "reaction scanning" tube.

In the 630, the 5V4 had control of the beam for considerably less than the first third of the trace, possibly no more than 30%. In the direct drive system, however, due to the more efficient transfer of energy to the yoke, almost half the trace is accomplished during the "reaction" part of the scanning cycle (that is, while the 6BG6 is cut off). It can be seen that, by this more efficient utilization of the 6BG6 plate current, more deflection power can be derived without an increase in current.

As the stored energy which is being made available by the damper is almost used up, the field decays at a faster (that is, non-linear) rate. But just before it becomes non-linear, the 6BG6 takes over again. Actually, it had started to conduct a moment before and had by this time gotten to the point where it was conducting in a linear fashion and insufficient magnitude to do the job.

The conduct of the 6BG6 and the 6W4, therefore,

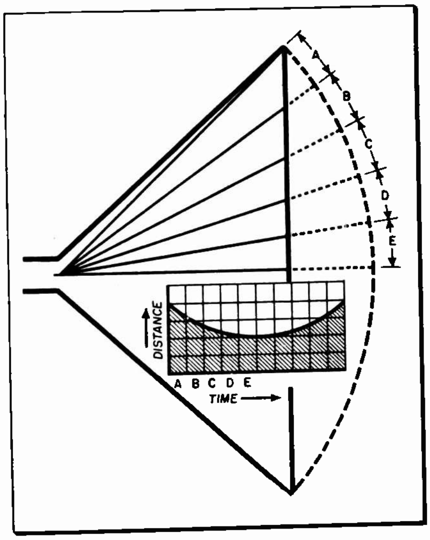
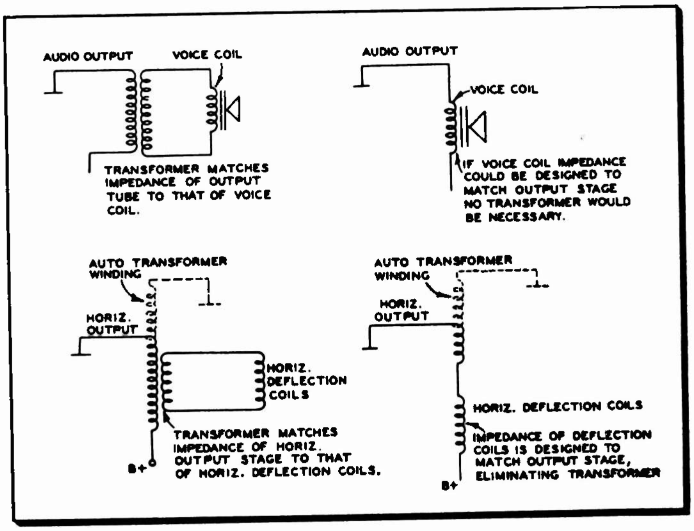



Fig. 2—Comparison of distances traveled in the same time period by the electron beam in curved or flat faced TV picture tubes.

can be likened to a relay race. When runner # 1 (6W4) approaches runner # 2 (6BG), runner # 2 starts moving so that when runner # 1 reaches the point where he will pass the baton, he will be able to pass it smoothly and no speed will be lost. In other words, one runner is standing still while the other is running the major part of his course, but the baton tends to continue around the track at a uniform speed.

The third important function of the damper (the first two were: to dampen the oscillations, and to make the stored energy in the yoke available for the beginning of the trace) is to supply the "boosted B." The manner in which this was done in the 630 is familiar: a pair of condensers in the cathode circuit of the damper were charged up to plus B potential, then when the damper conducted, the "kickback" voltage rectified by the 5V4 was added to this charge, mak-

(*Continued on page* **44**)




**Coupling methods employed to connect loudspeakers to audio output stages as compared to the methods employed to couple the deflection yoke to the horizontal output tube.**

# Reception Characteristics
# TV Antenna

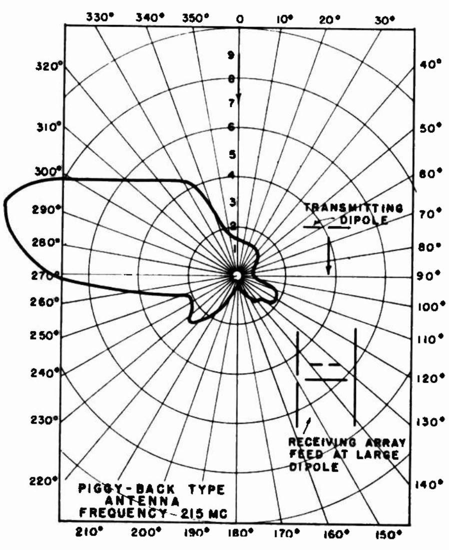
***An Analysis of Some of the Factors Which Must Be Considered in***

• It would be a great convenience for the TV installer if one type of antenna were suitable for all locations. It is unfortunately true, however, that every type is designed to do a certain job or achieve a certain result, and the technician cannot oversimplify the situation without costly compromises. It is rather troublesome as well as expensive to try every antenna available in each situation, so it follows that the installer may profit from advance knowledge of the factors to be considered and the results to be expected.

Probably the most exacting requirement to which an antenna system may be subjected is that it must operate over all 12 channels. The gain of the antenna is likely to be different on every channel; the impedance may change, and therefore the power delivered to the set will vary; and the directivity pattern may alter radically throughout the band.

It is axiomatic of some types that the radiation p a t t e r n becomes more sharply directional as the frequency increases. It is probably less obvious that side and back lobes develop on

Figure 1-A




**Choose an "all-channel" antenna which is the best compromise between the requirements of the local situation and the characteristics of the different antennas available, on both high and low bands. Some of the factors to be weighed are outlined here, along with the response of some of the popular antenna types. All these diagrams were made by, and are reproduced through the courtesy of the American Phenolic Corp. (Amphenol) of Chicago.**

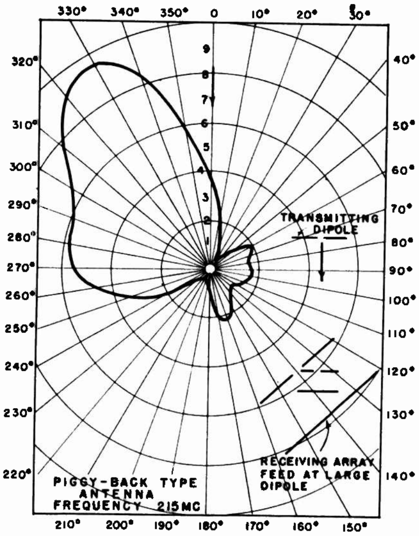



Figure 1-B

some types at higher frequencies, and in some cases to such an extent that the maximum pickup is no longer in the forward direction.

Before discussing the radiation patterns shown below, however, it would be well to consider what sort of directivity is desirable. In an area where all stations lie in the same general direction, a fairly sharp lobe in one direction which remains constant throughout all the channels covered is desirable. Where the stations lie in the same general direction but are not closely grouped, such an antenna would provide only compromise reception on all stations unless a rotating device were used. Where stations are in different directions (for instance one East and one South), two antennas would be desirable in the absence of a rotator, since utilizing the side-lobes of an antenna which does not have a uniform pattern over the whole

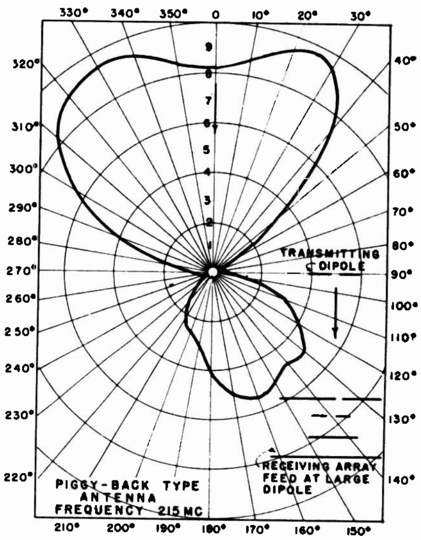
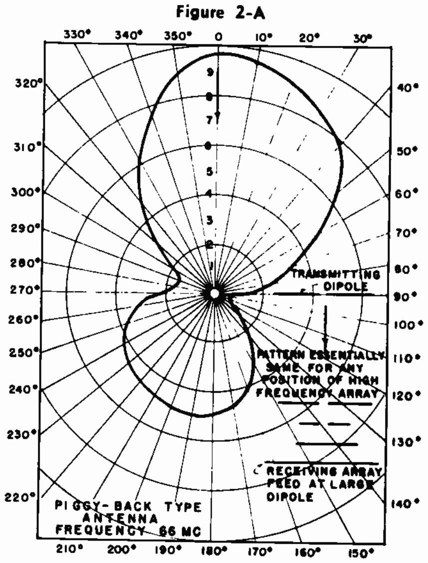



Figure 1-C

**Figures 1-A, 1-B and 1-C show a Hi-Lo or Piggy-Back antenna at 215 MC, with the high band antenna always directed at the station, and the low-band unit oriented in different directions. Notice how orientation of the low-band unit changes the pattern of reception even at this (high) frequency. Figures 2-A, 2-B, and 2-C show the same antenna at 66MC, with the low-band unit stationary and the high-band unit oriented. Very little change is noticed in the pattern. Figs. 3-A and 3-B show a Bat-Wing antenna at low and high frequencies. This type develops side-lobes on the high band, but maximum pick-up is still in the "straight ahead" direction. Figs. 4-A and 4-B (next page) show a conical on high and low bands. Like the Bat-Wing, maximum pickup is maintained in the forward direction throughout the 12 channels; the main lobe narrows as the frequency gets higher, and some side-lobes appear. Figures 5 and 6 are explained on page 102.**

Figure 2-A



# of Some Popular Types

***Choosing the Proper Antenna for a Particular Situation***

band is at best a game of chance. In the first place, the side-lobes rarely provide even half the power of the main lobe. In the second place, such secondary lobes shift in number, in strength and in direction with almost every channel, as can be seen in some of the accompanying diagrams. In the third place, the patterns shown are not a fixed, permanent condition, but rather represent tests made under optimum conditions. The terrain, the height above the terrain, the type of transmission line, and the length and geographical path of the transmission line can change the results obtained at the receiver. The most reliable reception characteristic of an antenna to figure on is the *main* or principal radiation lobe.

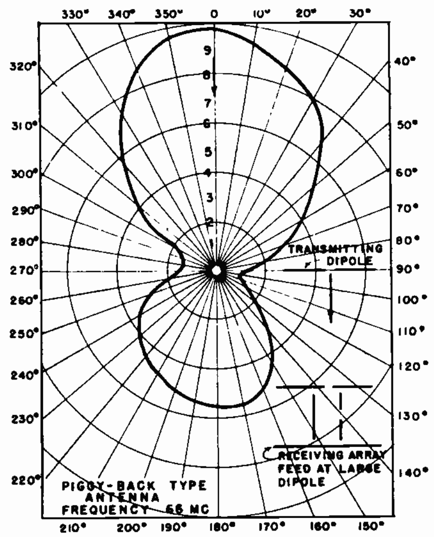
### Narrow Beam Types

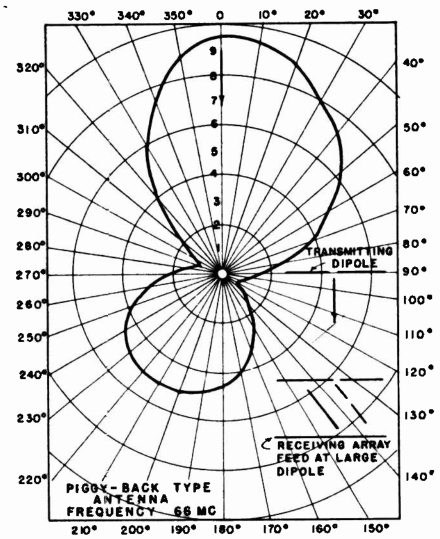
The sharper the directional pattern of the antenna, the more the gain may be considered to be concentrated in the desired direction. A pattern may be too sharp, however, in which case it will be extremely difficult to orient, and especially with a rotator. If too sharp, also, it may be affected by winds and vibration. The actual optimum beam width will vary with the distance from the station and the number of stations desired.

Where high and low band stations are in different directions, the separately orientable "hi-lo" type of antenna suggests itself. No doubt many installers have discovered, however, that one of these two elements cannot always be completely ignored when orienting the other. The accompanying patterns of "piggy-back" antennas show that on the high channels, the low-band antenna still has control over the radiation pattern. On the low-band, the high frequency antenna can distort the pattern a little, although the reception results are still basically that of the larger antenna. Separate lead-ins would be more apt to produce the desired result, and separate masts would be even more of an improvement.

The gain of an antenna is taken to be the relation between the power delivered by that antenna on some frequency and the power delivered by a simple half-wave dipole cut for that frequency. Parasitic elements and stacked arrays are probably the most readily effective means of increasing the gain of an antenna, if it is borne in mind that the impedance is lowered and the frequency-sensitivity increased with these additional elements.

Figure 2-B



Figu e 2-C

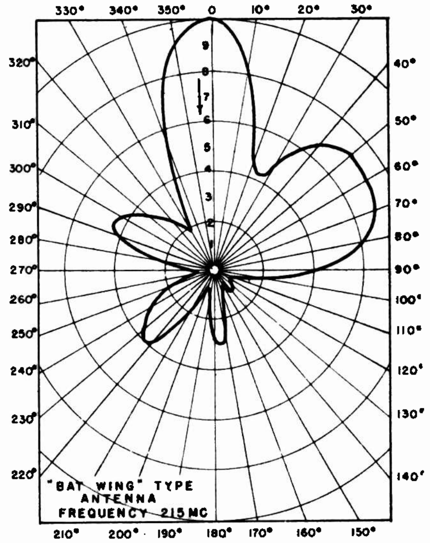


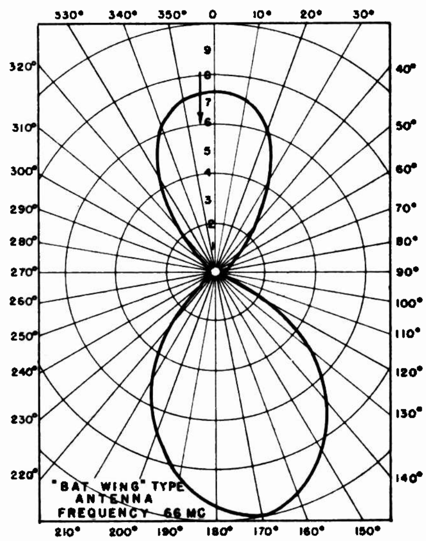
Figure 3-A

### Improving Antenna "Gain"

The gain of an antenna without the use of parasitic elements or stacking, however, depends on its constructional features. A simple straight dipole cannot have any "gain" since the standard against which it is being compared is also a simple straight dipole, cut for the frequency at which measurments are being taken, and properly matched to the load.

Improving the impedance characteristics of an antenna may improve the results obtained with it over a broad

Figure 3-B



number of channels when compared with a similar antenna which does not provide a proper match, but will not result in "gain" over the standard antenna, because the latter is by definition cut especially to each channel, and properly matched. When considering actual practice, however, as opposed to theory, some improvement is possible. For instance, a folded dipole has a theoretical radiation resistance of 300 ohms at its cut frequency, and therefore provides a perfect match for 300-ohm lines and 300-ohm receivers,

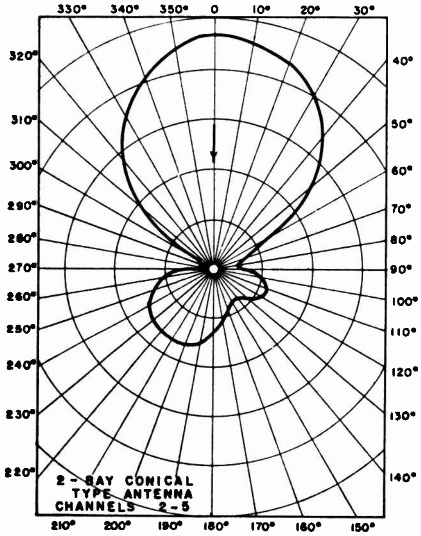


Figure 4-A

both of which are most commonly found in practice. The use of a straight dipole with 300-ohm line in the field, for best results, would require some sort of matching (pad or transformer) in which some losses would inevitably occur. Therefore, the folded dipole could be considered to have provided an improvement. Similarly, any antenna which is designed to provide a better impedance match over the whole band (such as a conical-type) may effect an improved power transfer when compared with some other antenna for which no such provision has been made, although it is does not provide a better impedance match than a "standard reference dipole" which is by definition perfectly matched.

## Harmonic Response

Response falls off more sharply below the resonant frequency of an antenna (the frequency for which it is a half-wave in length) than it does above that frequency; and, as a matter of fact, it reaches resonant peaks at odd harmonics. The third harmonic is generally the only usable odd harmonic. For instance, an antenna cut for channel 3 (as many popular low-band antennas are) will have a response peak at channel 9 in the high band. Even-numbered harmonics are relatively poor response points. The principal reason why a channel 3 antenna is usually not good at channel 9 is because the single main forward lobe is replaced by two side lobes about 35 degrees displaced from "straight ahead." However, an antenna which, because of its mechanical design, is able to achieve maximum gain in the forward direction on high as well as low band channels can operate over the whole TV spectrum fairly well provided it is a broadband design. That is, the Q cannot be too high, for we already know that the higher the Q, the sharper the response and the higher the gain—and also, the narrower the bandwidth.

## Weigh All Factors

In selecting an antenna for a situation, the installer must consider how many channels are to be received; whether both high and low band channels must be received; whether (if more than one channel is desired) the stations are in the same or different directions; whether sharp directivity and good front-to-back ratio is desirable for either fringe area high gain or for metropolitan area ghost elimination; whether the noise or weather conditions prevailing necessitate shielded transmission-line (which may suggest special impedance matching considerations in the choice of an antenna); and even physical conditions must be considered: such as whether there is space or sufficient support available for the antenna which is thought to be most desirable. And by no means last and least, the price of the installation must be considered. Where only one low-band station is to be received in a normal signal area presenting no particular problems, the installer cannot justify the extra expense of what may be his "favorite" antenna because it is designed to overcome problems which do not exist in this instance.

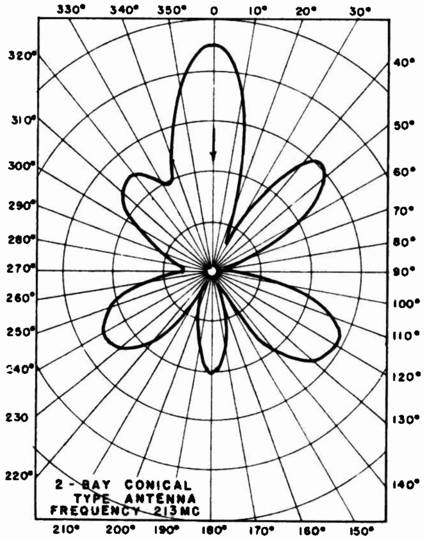


Figure 4-B

The foregoing discussion and the reception patterns reproduced on these pages are designed to facilitate the consideration (or re-consideration) of many of these problems in the selection of an antenna, and to assist in the evaluation of the different types which are available to solve different problems. The ultimate solution will inevitably be a compromise, but let it be the best possible compromise available to insure a satisfied customer, avoid costly call-backs, and stimulate word-of-mouth advertising which brings future business.

Fig. 5: Gain of a simple dipole and reflector over the 12 channels compared to the "standard" cut for each frequency. The antenna under test was 90" long (approx. Channel 3). Note 3rd harmonic response, as described above.

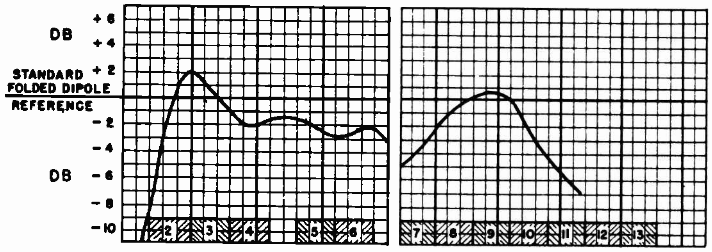
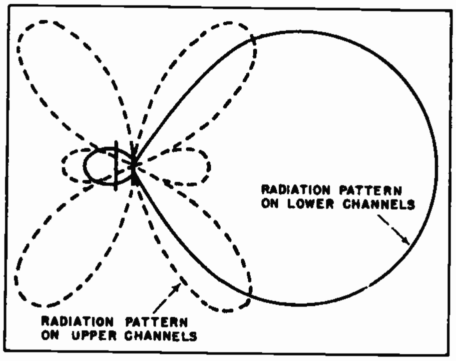



Fig. 6: Horizontal radiation patterns of a simple dipole (90" long) and reflector on low and high channels, showing development of side and back lobes on the high band, with change in direction of maximum pickup.



# UHF Reception on VHF Television Receivers

### *Block Analysis of UHF Converters and Tuners. Important Design Factors. UHF Strip Circuits.*

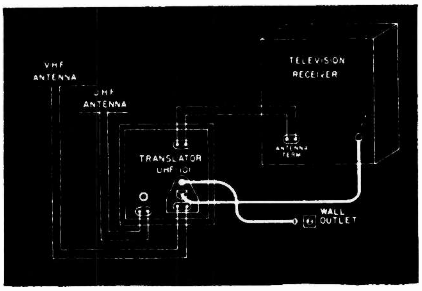


**Fig. 1—Connection of the GE UHF Translator to a GE receiver, showing facilities for switching antennas, as well as provision for a single AC power connection controlled at receiver.**

● The TV serviceman may be called upon to recommend a good UHF converter or tuner, or possibly he may buy one to install in a customer's set. A knowledge of the factors or points that must be considered in judging a converter or tuner should consequently prove helpful. This knowledge is apt to prove particularly useful in those instances where the serviceman must decide whether poor UHF reception is due to a fault in the antenna system or the VHF receiver, or the converting device. In addition, servicemen will eventually need to repair these units, and should therefore know a good deal about their operation.

The UHF tuning inductances, as well as the symbols used to represent them, may be unfamiliar to many servicemen. A tuning unit is shown in fig. 4, which is a photograph of the UHF converter made by the Kingston Products Corp. Note the symbols for the variable inductances, shown in fig. 3.

The preselector circuit in the UHF converter or tuner must adequately separate UHF and VHF signals. It should help prevent radiation from the UHF oscillator from getting into the antenna. Such radiation may impair the reception of TV receivers in the immediate vicinity—it may, in some rare cases, also interfere with the operation of the converter or tuner producing the radiation.

The mixer used in practically all cases is a crystal. Interestingly enough, no RF amplifier precedes it. One might think that an RF amplifier would improve the signal-noise ratio in the UHF tuner, and help prevent oscillator radiation to the antenna. This is true enough at VHF. At ultra-high frequencies however, the noise factor of an RF amplifier increases with frequency. There is an increase of 6 db when the frequency of operation is raised from 100 to 500 MC; it goes up to 10 db when the frequency is raised to 890 MC. An RF amplifier cannot therefore be counted on to improve the signal-noise ratio at UHF.

Furthermore, an RF amplifier—even a tuned RF amplifier—will not effectively suppress oscillator radiation at UHF. Better, more economical suppression is achieved with a good preselector and crystal mixer circuit (combined with adequate shielding of the converter).

A crystal rather than a tube is used as a mixer because it costs much less than a tube would; it makes a simpler circuit possible (fewer connections, no filament needed, etc.); its noise characteristic is better than that of a tube; and its performance in general is quite satisfactory. The oscillator output can be lower when a crystal mixer is employed—a factor that helps minimize oscillator radiation.

Silicon or germanium crystals are employed. The silicon crystal is regarded as superior to the germanium in that it will generally introduce less noise, and will deliver a higher, more uniform output. The germanium crystal, on the other hand, is far less expensive, will withstand a higher inverse voltage, and has the ability of healing itself after an electrical breakdown.

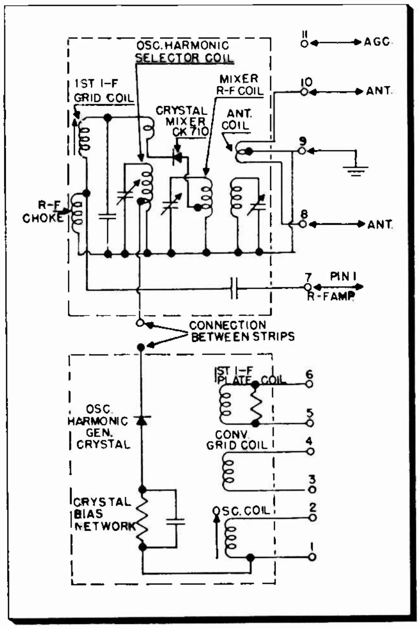



**Fig. 2—A UHF strip circuit. (see text)**

One of the primary factors in UHF oscillator performance is stability. Since the UHF oscillator is operated at a much higher frequency than a VHF oscillator, the allowable frequency drift, on a percentage basis, must be much smaller.

The stability of the UHF oscillator is much better when the TV receiver to which the converter or tuner is connected is intercarrier in type, than when it employs a split-sound system. When the set is intercarrier, the converter stabilizes during the time the set is warming up (app. 1 minute). In the case of a split-sound receiver, a 3 to 5 minute interval may elapse before oscillator stability occurs. The TV serviceman may have to instruct the converter owner that such an unusually long stabilization period is to be expected of most, probably all converters used with split-sound TV sets.

When the line voltage varies, oscillator drift will be enhanced. If the line voltage should vary between 95 and 125 V, a maximum drift of 70 MC may take place in the UHF oscillator. Constant-voltage transformers may prove necessary adjuncts to converters, in localities where severe fluctuations in line voltage take place.

Resonant suck-outs are a problem in the UHF range. Since the frequency of operation is so high, the tuning inductors present have very small inductive reactances, and can readily resonate at undesired frequencies with the small capacitances introduced by nearby wiring. The resultant suck-out can kill the oscillator output at certain frequencies. Special circuit arrangements are made to avoid such undesired resonances, in the oscillator as well as in other UHF circuits.

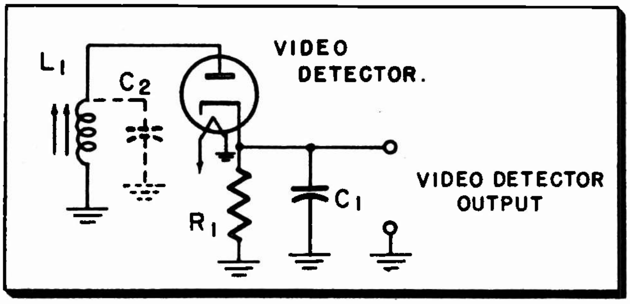
The UHF oscillator is generally operated at a frequency lower than the incoming UHF signal, to present an inversion or reversal of the sound and picture carrier positions on the video IF response curve of the TV receiver.

Oscillator tubes used on the UHF band are apt to be sources of microphonics. The microphonic problem is less severe when the set to which the converter or tuner is attached is inter-

*(Continued on page 45)*

# Servicing Video Detector

## *Function, Method of Operation and Types of Circuits Used*



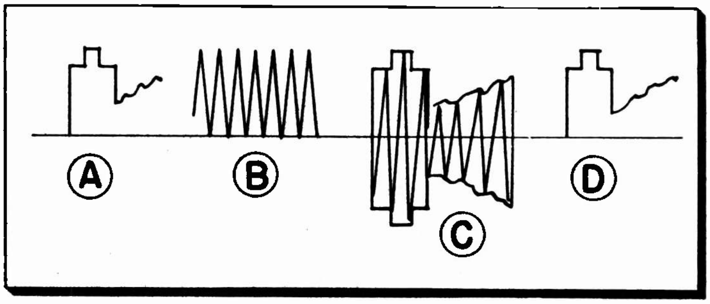




**Fig. 1 (above, left): Simple diode detector circuit. L-1 resonates with C-2, the stray capacitance in shunt with it, to form the tuned input circuit. Fig. 2 (above, right): (A) Original video signal. (B) RF carrier with which the video signal is mixed. (C) Resultant modulated RF carrier. Note that this is a bi-directional signal. Note also that when the carrier is mixed with the video signal, its envelope acquires the shape of the video signal. The peaks of the carrier, in other words, vary in accordance with the video signal. At the receiver, the modulated RF carrier is stepped down in frequency, and becomes a modulated IF carrier. (D) In the video detector, the IF carrier is removed, and ½ of the signal is eliminated, restoring the video signal to its original, uni-directional form.**

• The function of the video detector in the TV receiver is to remove the video modulation from the incoming IF signal. Diodes are commonly used as detectors, because they are capable of better fidelity than triodes. A simple diode detector circuit is shown in fig. 1.

The modulated video IF signal is applied between plate and ground of the diode. Since the cathode is bypassed to ground for IF by C-1, the signal is effectively applied between plate and cathode. Current flows only when the incoming signal makes the plate positive to cathode. The diode thus acts like a half-wave rectifier. Rectification is necessary because the original video signal is a uni-directional, not a bi-directional one (see fig. 2), and it must be restored to that same form. If the video detector output was bi-directional, the video signal would have a net average amplitude of zero.

Let's see what the diode detector must do, then we can consider how it does it. We want the diode to give output only at the *peaks* of the incoming signal, since these peaks vary in accordance with the video signal (see fig. 2C). In between peaks, the incoming signal is varying at an IF rate. We don't want output from the video detector at these times, because IF signals are undesired in the detector output circuit.

Peak detection in the diode is achieved in this way:

When the positive half-cycle of the modulated IF input signal is coming in, the diode conducts. The upper end of R-1 is made positive to ground, by the flow of conduction current. The voltage across R-1 charges C-1.

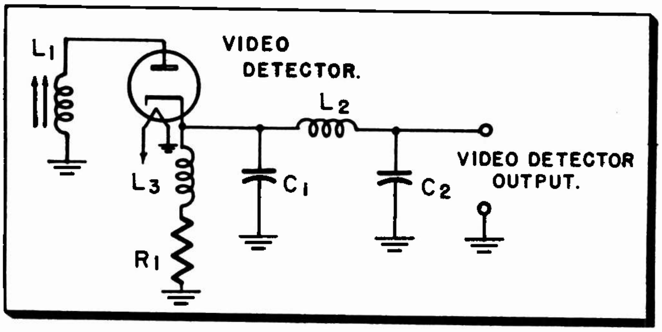
After a few cycles, C-1 becomes charged to the average level of the positive half-cycles of incoming signals. The voltage across C-1 is the diode's cathode-to-ground voltage. This voltage reduces the diode plate-to-cathode voltage. For instance, if the plate-to-ground voltage is +3V and the cathode-to-ground voltage is +2V, the plate-to-cathode voltage is +1V.

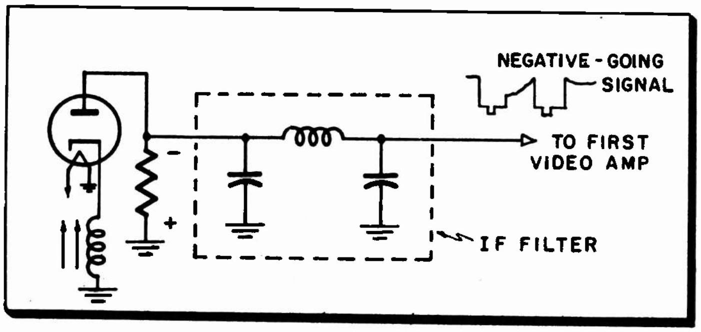
The diode will (after the first few cycles) no longer conduct during the entire positive half-cycle of incoming signal, but only during that portion of the half-cycle when the plate-to-ground voltage exceeds the cathode-to-ground voltage. In other words, the diode will conduct only at the *peaks* of the incoming signal. In between these peaks C-1 discharges through R-1 (since the diode, its source of voltage, does not conduct at these times) keeping the voltage across R-1 substantially constant, in spite of the signal voltage changes taking place at the diode input.

At the peak of the incoming signal, the plate-to-ground voltage of the diode exceeds the cathode voltage, the diode conducts, C-1 charges, and a change in diode output voltage takes place. This change occurs at a video rate, and represents the desired video signal.

Looking at the matter in another way: Because of C-1 R-1's long time-constant, the output voltage cannot follow the rapid IF variations in the incoming modulated IF signal, but only the relatively slow variations in amplitude corresponding to the signal envelope, or the video modulation. The output voltage across R-1 therefore reproduces only the video modulation.

**Fig. 3 (Below, left): Video detector with π-type filter. L12, C-1 and C-2 comprise the IF filter. L-3 acts as peaking coil. L-2 generally acts as a peaking coil as well as an IF filter, resonating at about 4 MC with the capacitance in the circuit to boost the HF response in this vicinity. Fig. 4 (Below, right): Diode detector with negative-going video signal output.**



# Circuits in TV Receivers

## to Remove Picture Information from the Composite Video Signal

C-1 thus acts as an IF filter in this simple detector circuit, bypassing IF from the load. In practice, C-1 is not an efficient filter. It is inefficient because the undesired IF (an approximately 26 MC signal) is too close to the highest video frequency to be bypassed (about 4 MC).

If C-1 is used by itself, and is made sufficiently large in capacitance to remove the IF, it will also attenuate high video frequencies as well. If C-1 is made small enough to prevent the attenuation or reduction of high video frequencies, it will be too small to completely remove the IF. A better filter must therefore be used.

The kind employed is a π-type unit or a variation thereof (see fig. 3). This band-pass filter effectively removes the undesired IF, without reducing the detector response at high video frequencies.

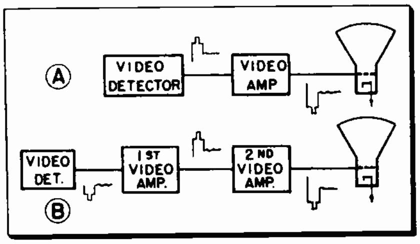



**Fig. 5: A negative-going signal is needed at the CRT grid. Such a signal will drive the CRT to cut-off on sync pulses and black signals. (A) If one, or an odd number of amplifiers, is used between the video detector and the CRT, the video detector output will have to be positive-going. (B) If two, or an even number of amplifiers, is employed between the video detector and the CRT grid, the video detector output will have to be negative-going. (It is assumed in both cases that the signal is applied to the CRT grid.)**

The output signal of the video detector may be either positive or negative (see fig. 4). Let's see what determines the polarity required.

The video signal applied to the CRT grid must drive the CRT to cut-off on black signals; and must reduce the bias on white signals sufficiently to cause white to be reproduced. In other words, a negative-going signal must be applied to the CRT grid (see fig. 5). (If the video signal is applied to the CRT *cathode*, it must be *positive-going* to achieve the same results.) The polarity of the video detector's output signal must therefore be such that the video signal will be correctly phased at the input to the CRT.

If an *even* number of amplifiers is used after the video detector, and the signal is fed to the grid of the CRT, the video detector output will have to be negative in polarity (see fig. 5B). If an *odd* number of amplifiers follows the video detector, and the signal is fed to the grid of the CRT, the detector's output will have to be positive-going (fig. 5A). If the video signal is fed to the cathode of the CRT rather than its grid, the polarity of the signal needed at the video detector output in each of the above cases will be reversed.

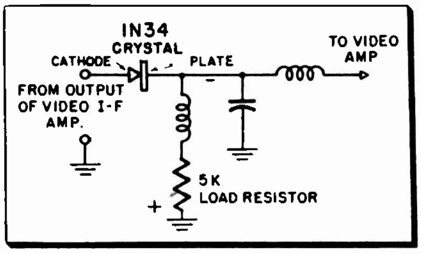



**Fig. 6: Crystal detector circuit. A somewhat greater video output is possible with a crystal, due to the fact that 1. its internal resistance is lower than that of a diode and 2. the absence of interelectrode capacitance permits a higher value of load resistance to be used.**

R-1, the load resistor (fig. 1) is small compared to the diode load resistors used in broadcast AM detectors. Large values cannot be used because of the shunting capacitance present across R-1. This shunting capacitance, which is composed of the tube inter-electrode capacitance and the stray capacitance present in the circuit, offers a decreasing reactance with increasing frequency. The load impedance therefore tends to be considerably smaller for high video frequencies than for low and middle ones. The larger R-1 is, the greater will be the shunting effect of the capacitance across it at high frequencies, and the larger will be the difference in the low and high frequencies. To avoid such a condition —i.e., the attenuation of high-frequency video signals—R-1 must be kept low. It is generally somewhere between 2000 and 5000 ohms. Use of a low value of load resistance causes the output of the video detector to be reduced in proportion.

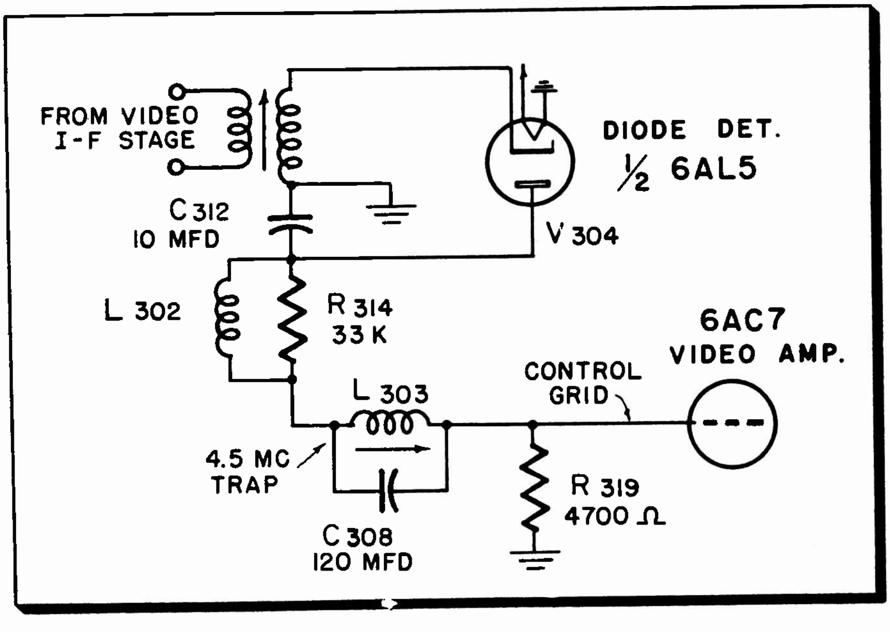
A peaking coil is often inserted in series with the load resistor to improve the high-frequency response (see fig. 3).

Crystals are sometimes used as detectors (see Fig. 6). The crystal functions as a rectifier, and is comparable in its action to a selenium rectifier. Advantages offered by a crystal over a conventional diode detector may be listed as follows: 1—The size of the detector unit is smaller. 2—Less wiring need be used, since only two terminals need connecting into the circuit. 3—No filament heating is necessary. 4—No hum is likely to be introduced into the detector circuit, since the crystal has no filament to act as a source of such hum.

The cost of a crystal was once too high to prevent its widespread use, but currently, relatively low-cost units can be obtained.

Crystals must, of course, be hooked up with the correct polarity, otherwise they will not function correctly. One

**Fig. 7: Video detector circuit used in Admiral 20A1, 20B1, and 21A1 sets.**



side of the crystal acts as a cathode, the other side as a plate. In other respects, the crystal circuit is similar in its operation to that of a diode tube.

One kind of video detector circuit used in commercial receivers is shown in fig. 7. Let's analyze the circuit, or at least those parts of it which may seem unfamiliar.

The video detector employed is ½ of a duo-diode tube used as a combination video detector and sync limiter.

C-312 is a plate bypass condenser that removes the unwanted IF signal from the detector load resistor R-319. This resistor, incidentally, also acts as the grid resistor of the 6AC7 video amplifier. No capacitative coupling is employed.

L-302 is a peaking coil used to filter out IF, as well as to boost the high-frequency response. R-314, the resistor in shunt with it, is used to dampen, or broaden, the high-frequency response, and prevent excessive peaking at the high-frequency end of the video band-pass.

L-303 and C-308 form a tuned circuit that resonates at 4.5 MC. This circuit is used to trap out a 4.5 MC video signal. Where does this undesired signal come from? Well, the sound traps used in the video IF stages are not always 100% efficient. Some sound IF signal that is left over may therefore get into the video detector. This signal, which is often 21.9 MC, will beat with a video IF signal of 26.4 MC in the detector, and produce a difference frequency or beat-note of 4.5 MC. Such a beating action occurs because the video detector, being a rectifier, not a class A amplifier, offers a non-linear impedance to incoming signals, and whenever two signals meet in a non-linear impedance, they beat against each other as enthusiastically as a drumstick against a drum.

The parallel tuned circuit offers a very high impedance to such a 4.5 MC beat-note. The beat-note will therefore use up most of its energy developing a voltage across this tuned circuit, and very little of it will be left to develop a voltage across R-319, at the input of the video amplifier.

• Slug-tuned L-52, in combination with the stray capacitance in shunt with it (not shown) acts as a tuned circuit common to both the plate of the 4th video IF stage, and the detector cathode circuit. The signal voltage developed across L-52 is the detector input voltage.

R-32, L-53 and C-66 act as an IF filter, preventing an IF signal voltage from being developed across R-29, the detector load resistor.

L-69 isolates to some extent the interelectrode capacitance between grid and cathode of the 1st video amplifier from the detector load resistor (R-29). L-69, in other words, reduces the shunting effect of the 1st video amplifier's input capacitance on R-29, preventing an attenuation of high video frequencies. It thus acts as a peaking coil.

C-67 is a coupling and blocking condenser. It couples the video detector output signal to the 1st video amplifier, but keeps the DC voltage output of the detector from being imposed as a bias on the video amplifier.

### Use of Direct Coupling

A fourth video detector circuit is shown in fig. 2. ½ of a 6AL5 is used as the video detector. The other half is employed as a sync limiter.

C-125 is a decoupling condenser, that prevents IF signal voltage from getting into the -125 V DC supply.

L-102, R-119 and C-126 form the IF filter network. L-102 also acts as a peaking coil. R-119 dampens it, preventing excessive response at the frequencies to which L-102, in conjunction with the stray capacitance in shunt with it, resonates. These frequencies are, of course, at the high end of the video bandpass.

L-103 also acts as a peaking coil. Together with R-120, with which it is in series, it acts as the grid load impedance for the first video amplifier.

A voltage of approximately -125 V DC (to ground) is present at both plate and cathode of the video detector in the absence of IF signal input. The direct coupling employed between the video detector and video amplifier necessitates the presence of this high negative voltage.

If the plate of the video detector was returned to ground, instead of to the -125 V source, the grid of the 1st video amplifier would automatically be returned to ground too, making this grid highly positive with respect to the video amplifier's -124 V cathode. When the video detector plate is fed -125 V to prevent it from destroying the harmony of the video amplifier's home life, the video detector cathode must likewise be fed a similar voltage, or conduction between the two couldn't be persuaded to occur. Conduction takes place in the video detector when the incoming IF signal makes the cathode-to-ground voltage slightly more negative than the plate-to-ground voltage.

### Troubleshooting the Detector

*Symptoms of video detector trouble.*— Trouble in the video detector circuit can be responsible for any of the following symptoms: a) Loss of picture. b) Loss of picture and sound (in intercarrier sets). c) Weak picture. d) Weak picture and sound (in intercarrier sets). e) Impaired picture resolution. f) Interference pattern in picture. g) Hum bars in picture.

*When to check the video detector.*— A check of the video detector seems logical when one of the symptoms cited above is present, and the stages following the detector have been eliminated as possible sources of the trouble.

*How to check the video detector.*— A quick check of the video detector may be made by tuning in any station, and measuring the DC output voltage developed across the video detector load resistor. A VTVM or high-resistance voltmeter should be used for most accurate results. The voltage measured is compared with the detector output voltage developed for the same channel in a similar set, operated under similar conditions. If the manufacturer lists the voltage that should be present with a TV channel coming in, his figure may be compared with your measurement.

This check will, of course, be conclusive only when the correct voltage is obtained. If the correct DC voltage is *not* measured, one of the stages preceding the detector, as well as the detector itself, may be the source of the trouble. To further localize the defect to the stage at fault, a signal generator and voltmeter may be employed.

Set the signal generator dial to the video IF of the receiver under test, and apply its output between grid and ground to the tube preceding the detector. Then connect the voltmeter across the detector load resistor, and measure the DC voltage developed

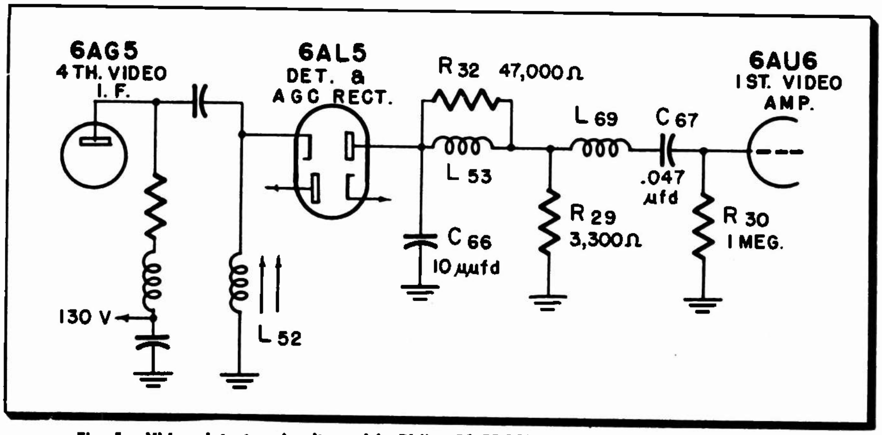



Fig. 1—Video detector circuit used in Philco 50-T1443. Filament circuit is not shown.

# *Basic Faults in Video Detectors*

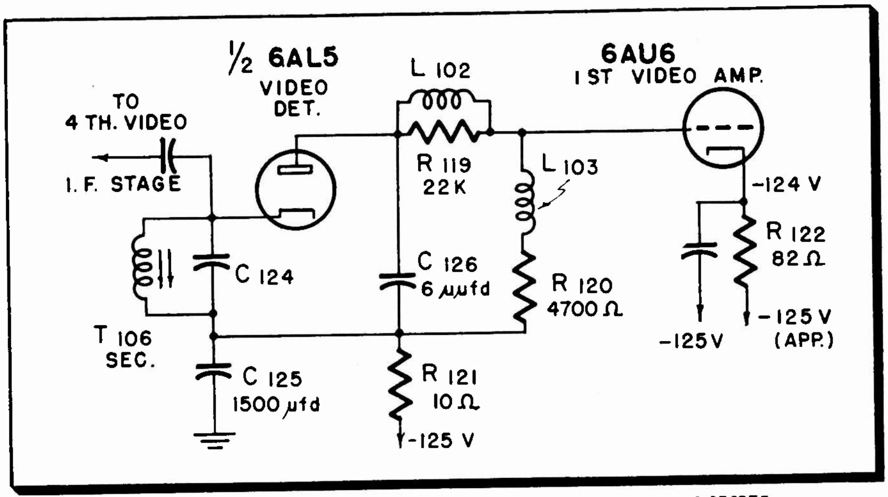



**Fig. 2—Video detector circuit used in RCA models 9T270, 9TC272 and 9TC275.**

there. A comparison of this voltage, and the voltage developed in the detector output circuit of a similar receiver, tested under identical conditions, will reveal if trouble is present.

### *Defective Components*

If the measured DC voltage is considerably below what it should be, trouble in the video detector or the stage preceding it, may be present. Simple voltage, tube substitution, resistance and condenser bridging tests should readily localize the fault.

In some cases, an *above-normal* video detector output may be measured. Oscillation in a preceding stage or stages is generally the cause of such a symptom.

*Possible troubles in diode detectors, and symptoms they are likely to produce.*—The following defects may occur in the basic video detector circuit shown in fig. 3:

*Reduction in the value of R-1.*—A division of video signal voltage takes place across R-1, Rp and Rx (the DC resistance of L-1). If R-1 loses value, less signal voltage will be developed across it, and more will be dissipated across Rp and Rx. The reduction in signal voltage output will decrease picture contrast. (Picture *and* sound will be weakened, if the fault occurs in an intercarrier receiver.

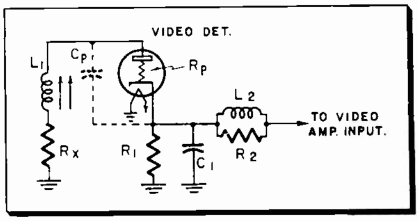



**Fig. 3—Basic video detector circuit. Cp is the plate-to-cathode capacitance. Rx is the DC resistance of coil L-1. It is not actually a separate resistor, although it is represented as one.**

If R-1 loses all, or almost all, of its value, or C-1 short-circuits, no picture (no picture and sound in intercarrier sets) will result.

*Increase in value of R-1.*—A considerable increase in the value of R-1 will increase the shunting effect of the capacitance in parallel with R-1, impairing the receiver's high-frequency response. Fine detail in the picture will be degraded, and the resolution of the vertical wedges in the test pattern will be impaired, in such a case.

If R-1 increases very greatly in value, the current flowing through the diode may decrease to such a point that a very small signal voltage is developed across R-1, weakening or eliminating the picture (sound too, in intercarrier sets).

*Defects in C-1.*—If C-1 becomes leaky or short-circuits, the effects will probably be the same as when R-1 loses value.

If C-1 loses capacitance, no symptoms may be observed in many cases, because the stray capacitance present in the circuit may be sufficient to effectively bypass the IF signal. In rare cases it is possible that the insufficiently bypassed IF signal may get through to the video amplifier and CRT, causing an interference pattern to be seen on the screen.

A decrease in IF signal input to the detector occurs when C-1 loses capacitance or open-circuits. This is true because the signal voltage applied to the video detector in the circuit of fig. 3 divides between the plate-to-cathode capacitance of the video detector, and the cathode-to-ground capacitance. If C-1 is relatively large—i.e., at least ten times as large as the plate-to-cathode capacitance—very little signal voltage will be wasted across it. When C-1's capacitance has been reduced, however, a substantial percentage of the total signal input is wasted across it, decreasing the input to the detector, and thus reducing the strength of the picture signal (picture and sound signals in intercarrier sets) to some extent.

Sometimes the wrong value of C-1 may be present. In one case known to the author, a factory employee used a 100-mmfd instead of a 10-mmfd condenser for C-1. Picture strength was in consequence poor, and fine detail worse. The condenser was placed under the load resistor, and was not clearly visible. The set passed through quite a few servicemen's hands before the trouble was finally localized. A visual inspection by a serviceman who knew his theory turned up the defect.

### *Detector Tube Troubles*

*Defects in L-2.*—If L-2 shorts (a most unlikely eventuality) the receiver's high-frequency response may be impaired, and fine detail degraded.

If L-2 opens, the video signal will be transferred through the small capacitance present between L-2's open ends, and the large resistance in shunt with L-2. Weak picture, and poor low-frequency response, manifested in smearing, are possible results.

*Defects in R-2.*—An open or radical increase in the value of R-2 may result in excessive h-f response. The trouble will be most evident on a test pattern, where small sections of the vertical wedges will be seen to be excessively contrasty.

A short or radical reduction in the value of R-2 may result in impaired h-f response.

*Video detector tube troubles.*—If the filaments of the video detector open-circuit, no picture will generally be seen. (Sound will be missing also on intercarrier sets.)

If the tube loses emission, the picture's contrast will be reduced. Synchronization may be impaired too, since the sync pulses will be below normal in amplitude. Sound volume may be lowered in intercarrier sets.

In the case of commonly-used duo-diode tubes, aging of one section is apt to be accompanied by aging of the other tube section. More than one symptom will result, depending on the purpose of the other diode.

Cathode-to-heater leakage in the video detector may produce a hum pattern in the picture (several alternate dark and light bars). The hum may be heard in the sound, if the fault occurs in an intercarrier receiver.

*Troubles in L-1.*—Trouble in L-1's circuit will eliminate or greatly attenuate the IF signal input to the detector, reducing the strength of or eliminating the picture (picture and sound in intercarrier sets).

*Trap troubles.*—If a 4.5 MC trap in the video detector develops a fault, like a shorted coil or condenser, or open connection between coil and condenser, an interference pattern may be seen on the CRT screen. If the trap is used to transfer an intercarrier sound signal to the sound IF stages, the sound may be lost in such a case.

An open coil in a trap circuit may cause the video detector to become inoperative, since the DC current path is

*(Continued on page 42)*

# Servicing Low Level High

## *Appearing In Greater Numbers In Home Equipment,*

● Since the average radio tuner and crystal phonograph cartridge feed at least one volt to the first stage of an audio amplifier, servicemen handling mostly run-of-the-mill home equipment in former years were not too much concerned with the problems inherent in very low level, high gain input stages. These sensitive critters were usually encountered only in mike preamplifiers found in PA systems, and in broadcast and recording equipment.

The post-war years, however, have brought a good deal of equipment incorporating such features into the home in the form of such things as preamp

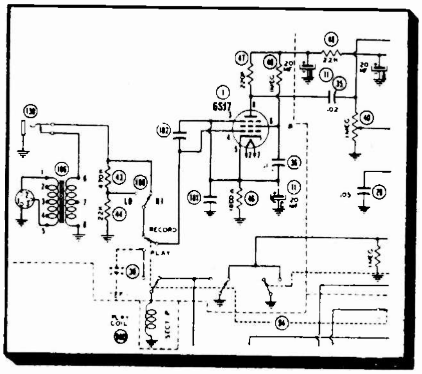


**Fig. 1: Mike input stage for Brush Soundmirror BK403 uses a single-ended 6SJ7 (metal) for a gain of at least 40 DB, which is common for such stages. R49 and C11A and B provide isolation and additional filtering especially for this stage. On playback, the playback head feeds directly into this stage without additional compensation.**

stages for variable reluctance magnetic pickups and mike input stages in tape and wire recorders.

Troubles in such stages come to the servicer in one of several ways. First, a fault may develop in a unit which originally functioned OK; second, the compact design of some of the less expensive units make good isolation, shielding and lead dress difficult to achieve in their manufacture; and third, some customers become more critical and discerning as they get used to something which at the time of purchase was not carefully evaluated.

Successful troubleshooting of such stages requires a painstaking attention to all small details, for they are susceptible to all sorts of little annoyances which would be negligible in later stages.

Many servicers have found it advisable to develop a pre-arranged checklist covering *every* technique which would possibly cure these troubles, and to go through these checks in order, one by one, on every job. The reason for this is that often a trial and error method may take longer and still overlook some of the less obvious points.

In isolating a trouble to the input stage, the conventional elimination method can be quickly employed, which consists of shorting out grids, preferably through a condenser. When you short out the grid of the second stage, the objectionable hum, noise or microphonics will disappear if the trouble is in the previous, or input stage.

Microphonics of small or large degree probably represent the most common complaint. While the practice of tapping tubes and parts to locate the offending one will sometimes prove helpful, many troublesome jobs come across the bench which do not respond to this technique. That is, microphonics are heard every time *any* part or tube is touched, including the knobs.

Of course the first thing to try is the tube itself. Tubes (even new ones) vary in their inclination to microphonics and it is wise to try several. A time-saving method is as follows: when a new tube immediately and definitely cures the trouble, label this tube "non-microphonic," put it back on your shelf, and find another one to use in the equipment. Then you will have a tube in stock which you can rely on in the future to tell you immediately when a microphonic tube is the trouble. After a while, you will have non-microphonic tubes of all the types usually found in

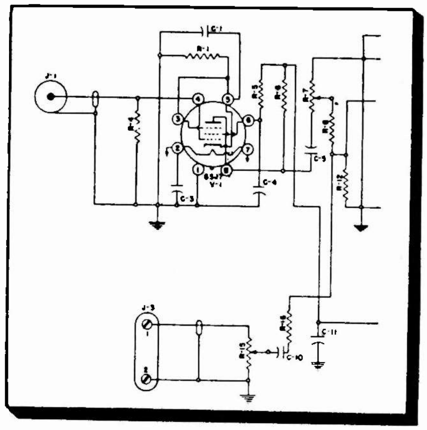
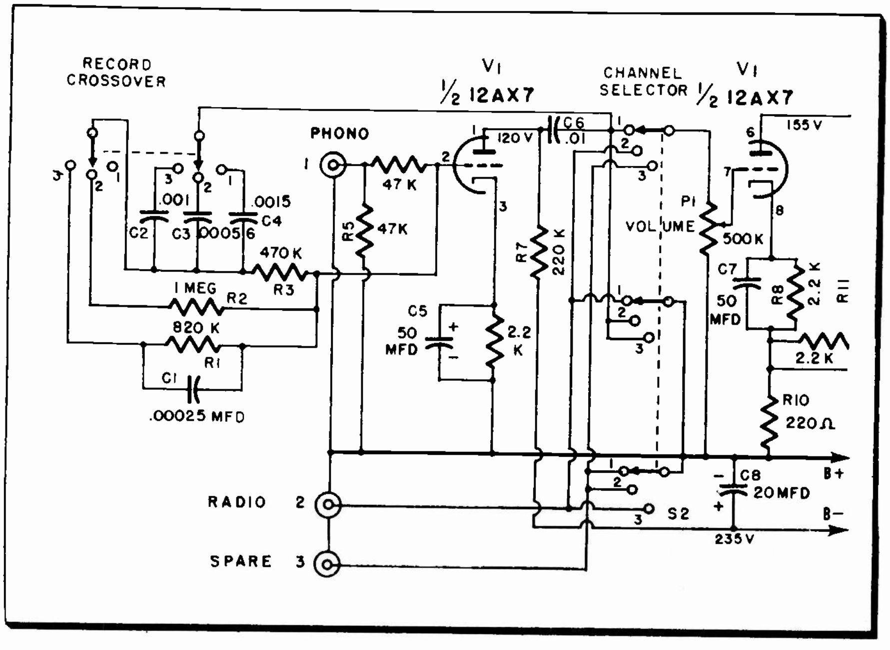


**Fig. 2: Stromberg Carlson amplifier AU29 uses a 6SJ7 for mike input (J-1). J-3, the phono input, feeds the second stage. Circuit components are chosen for slightly lower element voltages on the tube and consequently slightly lower gain than the stage in fig. 1, which must handle the extremely low output tape head.**

these stages and then the full benefit of such a method can be realized.

Where the tube is not at fault, it may be in a part, a connection, or in the socket itself. See that all leads (including point to point resistors and condensers) are short and preferably tight, so that vibration of the parts and leads is kept at a minimum. With a hot soldering iron, go over every joint in

**Fig. 3: Altec Lansing remote-control-preamplifier with very low level input for magnetic pickup and a higher level input for radio tuner and one other piece of equipment. Only the magnetic pickup is fed into the first stage. Use of a miniature twin triode in this stage is typical of current equipment. Feedback is utilized even in the first stage to keep distortion at a very low figure.**



# Gain Audio Input Stages

## *Preamplifiers Present Problems of Hum, Noise and Microphonics*

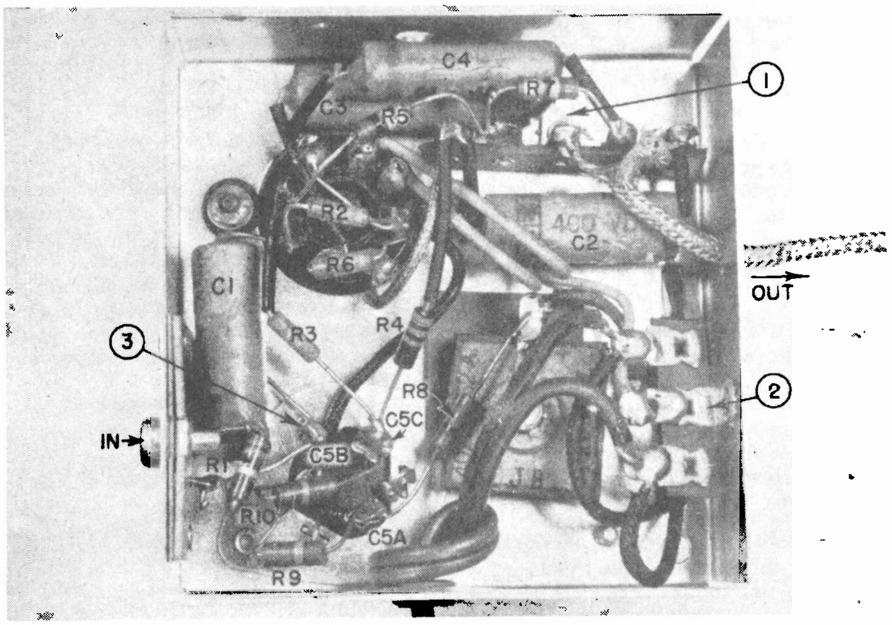



**Fig. 4: Chassis view of GE preamp UPX-003, shown as typical of good layout practice in low level input stages. All grounds are connected to chassis ground at point 3 except the output cable shield (point 1) and the transformer center tap (point 2). Unit is completely isolated from the AC line by the power transformer and a good husky filter keeps down the hum. All leads are minimum length, filaments are dressed well away, and the 6SC7 is shock mounted on rubber. Gain of the amplifier is 35DB at 1000 cps, with proper compensation for the LP characteristic. R1 can be varied for HF response.**

this stage to make sure that there are no loose or broken solder connections. Give special attention to shields, and particularly if they go through a hole in the chassis or touch it in any way.

Most low level input stages utilize shock-mounted tube sockets. Where the socket is not cushioned, it may be checked and sometimes cured by filing off the top of the rivets and letting it hang by its own leads. This is, of course, assuming that there are enough, and strong enough leads to do this. This is more of a test technique than a repair, since it isn't a good idea to leave the socket in that condition permanently. "Floating" the socket will usually reveal the neccessity for cushioning. To permanently shock-mount the socket, use long screws to bolt it back in place, and put a small rubber grommet over each one.

Microphonic-type noise sometimes results when the leads to the phono cartridge are reversed, or in other words, when the pickup arm (and sometimes the changer chassis, too) are connected to the hot side. This is quickly revealed by tapping the pickup and should not be confused with microphonics in the input stage.

Hum, noise pickup and sometimes detection of AM signals are common in input stages. Tube noise, evident when the gain is wide open, is usually brought about by low gain in the stage or reduced output from the signal source, making it *necessary* to run the gain wide open. That is, every tube has inherent internal noise which will be revealed when a low level, high gain stage is pushed to the limit. Some tubes, however, are noisy even under ordinary conditions and can be checked by substitution. Stage gain checks should reveal the reason for this particular type of noise (which we differentiate from "noise pickup").

Hum can be induced from filament leads and from heater-cathode leakage. Filament leads should, of course, be twisted, and kept away from the grid lead to the tube.

Sensitivity of the grid side is the reason why many of these input stages use grid-cap type tubes such as the 6J7. Where single ended tubes ar used (as they are in most recent designs) lead dress with relation to the grid is much more critical.

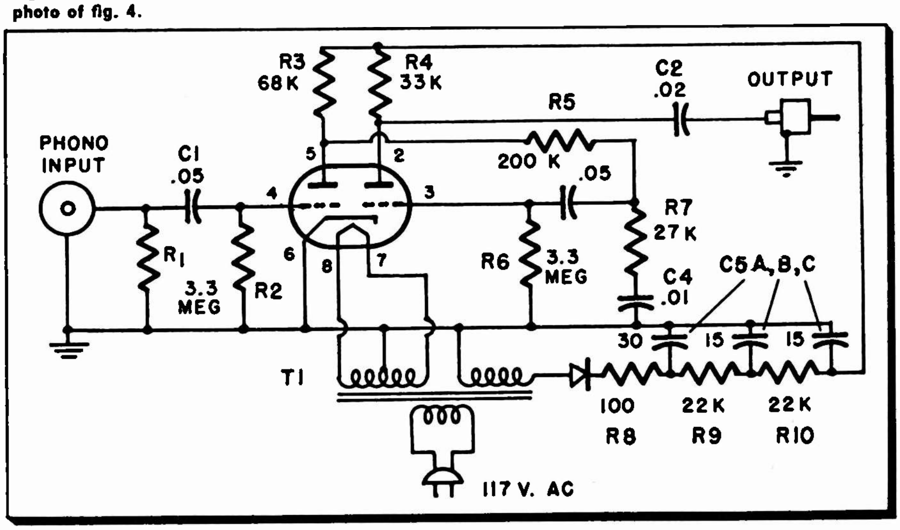
When AC hum is suspected but is difficult to track down, the filament connections can be temporarily lifted off and DC put on the filaments. Either a socket-powered DC power supply or a filament-type radio battery (that is, capable of supplying adequate current) will serve.

It is to avoid just this trouble that some equipment is already provided with a DC source for the filaments in low level stages Such a supply can be added by the servicer if the customer will OK the expense.

In the case of a separate preamp for a GE-type pickup, haphazard placement of the unit may cause hum pickup from a phonograph motor or a power transformer. Relocating the preamp will quickly reveal this trouble. Faulty filtering in the preamp's B-plus power supply (in the case of a self-powered unit) or in the main equipment's power supply will, of course, put hum into the stage. In the latter case, the trouble usually wouldn't be confined to the input stage, and therefore would have been revealed in the grid-shorting test mentioned earlier.

Since this stage is more sensitive, however, B-plus to it should be adequately isolated by an RC filter. If one

**Fig. 5: Circuit diagram of GE preamp, shown for better identification of the parts labelled on the photo of fig. 4.**



# Audio Input

is present, it should be checked, and if there is none, one should be added.

Hum, noise pickup, detection and microphonics can be caused, as mentioned above, by insecure solder joints and connections, and another place to check is at the jacks and plugs used at the input, if any, and at the volume control and/or equalizer, especially if it is on the input side. If the controls *are* on the input side, it would be wise to move them to the next stage, since noise pickup is emphasized otherwise.

Long leads, especially at high impedances, should be avoided, and where they exist, consideration should be given to their possible re-routing. Long shielded leads should preferably be grounded in several places and should be securely anchored for as much of their length as is possible.

Grounding properly is, of course, important as in any other equipment. All grounds at the input stage should preferably be made to one point to avoid ground loops which may, due to the resistance of the chassis, introduce unwanted impedances into a circuit.

Anyone who has experimented with grounds in an attempt to eliminate hum knows that the behavior of such curcuits often defies theory and no stone should be left unturned. The writer experienced a case of input hum which was traced to the place where the phono cable was plugged into the amplifier with an RCA-type phono jack. Although the cable shield was well soldered to the plug, and although the plug made good contact with the jack, and the jack was (in this particular case) grounded to the chassis, hum and pickup microphonics could not be eliminated until an *additional* grounding wire was connected between the cable braid and the chassis.

Hum in the input stages of tape recorders can be troublesome due to the fact that these units, which are usually portable, must combine in a relatively compact case one or more motors, an AC operated power supply and an extremely high gain input stage for both mike and recording head.

### *Hum Balancing Pot*

Orientation of the power transformer, shielding and grounding of low level leads, and proper lead dress are of course important in these cases.

Using a pot to balance the AC filament leads may also be helpful in all types of equipment. Where the filaments have one side grounded at each tube socket, it would be necessary to rewire them, and where the center tap of the filament transformer was grounded, it would be necessary to lift this ground and ground the slider of the pot. In order to balance this pot, it is then necessary to run the gain wide open (with no input) in order to have as much hum as possible while listening for a maximum reduction.

Although the redesign of equipment is usually beyond the average serviceman because the customer is not prepared to pay for it, a certain amount of this work can be sold where the customer feels that he must protect his investment in the equipment he bought.

This might include the relocation of tube sockets and components, and the re-routing of leads for better protection and isolation of the stage. In some cases of extremely compact equipment, where the initial design is inadequate for the grade of operation desired by the customer, and where any relocation and rewiring job would be too complicated and unpredictable (due to the small space available), moving the whole preamp stage may be possible.

This can be considered because, although the equipment is by definition portable, it is not often used that way by the particular customer in hand. In this case a new preamp stage is made *external* to the main equipment, where all the proper techniques for handling such stages can be employed.

Long leads external to the amplifier (such as mike and phono leads) are conducive to input hum. While the original design of the equipment is usually such that the leads are not longer than they should be, it often happens that, for convenience purposes, they are extended. High impedance microphones should only be used close to the amplifier, whereas low impedance mikes can be used as much as 1500 feet away with low loss of cable. Sometimes it may be necessary to change the type of mike, where the use to which it is put dictates.

The remote preamplifier control unit, which is growing in popularity due to the convenience and flexibility it offers in multi-unit installations, suggests itself where a phonograph and/or mike are to be used at some distance from the power amplifier. With such a unit, long low-level leads can be avoided and the actual input cable to the main amplifier is operating at a high enough level that critical conditions are usually not encountered.

These units have many other advantages, of course, in that control of many functions can be grouped in one convenient place, and some additional functions may be introduced, such as elaborate equalization networks. It is a good idea to suggest such a unit where practical, and the extra sale will be decidedly advantageous.

An expedient which can be used in a few cases where layout of the input stage seems poor, and space requirements do not lend themselves to improvement, is to rewire the stage on a can-shielded vector socket; or it might be helpful, where the input tube is a pentode, to substitute a 6J7 and get the grid lead up out of the way.

# Automatic Gain

(*Continued from page* 29)

separator's bias may become excessive. Lowering the signal input to the restorer when its bias drops tends to maintain the restorer's plate current at its former amplitude.

The servicing procedures used in this circuit are the same as in the preceding one, with some additions.

First, the possibility of the switch being in the wrong position exists.

Second, the presence of a separate AGC rectifier diode brings up the possibility of this section of the duo-diode tube going weak, while the video detector section stays OK. In such a case, the AGC bias would be insufficient, and overloading would tend to occur at all settings of the AGC control switch, when strong signals were coming in.

# Video Detectors

(*Continued from page* 39)

interrupted, and the picture (picture and sound in intercarrier sets) is likely to be eliminated.

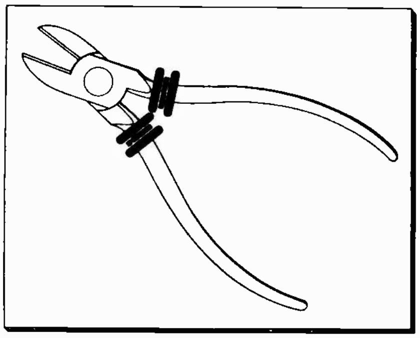
Tube substitution, voltage, resistance and condenser bridging tests should localize all of the troubles discussed.

When a crystal used as a video detector is suspected of being faulty, substitution of an identical unit known to be good will serve as a check.

## SHOP HINT

### *Spring Pliers*

Often I have to use snips, long nose pliers or cutters where it is a great disadvantage not to have a spring opening device. I have found the solution shown to be a great help. Just slip a rubber grommet over each handle, up to the very head. This automatically pro-



vides spring tension on the tool. To adjust the amount of spring return, merely slide the grommets up or down as is necessary until the desired amount of tension is achieved.—*Nick Capellini, 639 N. 25th St., Camden 5, N. J.*

# PRINTED UNIT ASSEMBLIES

(*Continued from page* 10)

alignment of the staggered circuits could be slightly improved. During development of the RC plates some difficulty was encountered by signal being bypassed by stray capacitances about the 6K input resistor. This situation was corrected by re-design of the layout of the silvered ground area on the reverse side as well as by shortening the printed connections to this resistor.

The combination of etched and silk-screened portions of the assembly into a complete module is shown in Fig. 6.

Assembling of all parts including the tube clips and connections to the coil centers is done by dipping in solder. The coils are protected during dipping by an adhesive paper mask.

The RC card is provided with legs which fit into punched holes in the etched plate, thus dispensing with wire leads. All crossovers have been eliminated from the layout except the necessary connections to the coil centers. For illustration purposes the etched plate is shown reversed with respect to the other parts, the RC card, tube and coil connections going above deck with all protrusions on the etched lower side for convenience in soldering. The brass tuning slug (not shown in Fig. 6) is inserted in the threaded hole in the bifilar i-f transformer. Tuning may be done with the head portion on either upper or lower side of the etched deck.

As a module of construction, the manner of connection to the next stage is of vital importance. A butt joint of the etched plates is affected with a punched dovetail between sections which is supplemented by a single screw and a pronged nut plate fastened through the ground bus. This arrangement holds two adjoining plates quite rigidly in all dimensions so that the abutting conductors may be soldered directly together without wire. This may be done in the same dip-soldering, during which the RC card is attached, so that at least two modules may be assembled and joined simultaneously. While this joint has proven satisfactory to normal handling it is anticipated that improvement may be made by interleaving or dovetailing conductor ends.

Extension of the principles embodied in this i-f stage to the overall unitizing of a receiver is illustrated in Fig. 7. Here, three of the interlocked etched panels, which replace the conventional steel deck, are shown in place in a pair of alu-

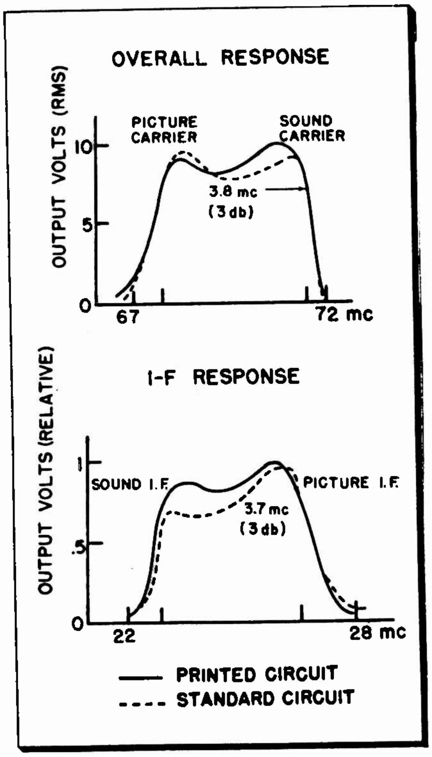



**Fig. 9: Comparison of response characteristics of printed and standard 25 mc i-f circuits**

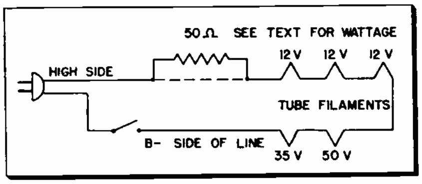
minum channel strips. Such channels are used as a rack into which unit assemblies may be inserted vertically as well as in both planar dimensions.

It is believed that such a module represents a considerable saving in critical materials as well as offering a method for more close integration of printed components and methods into receiver manufacture.

## SHOP HINT

### *Protect AC-DC Filaments*

Many AC-DC radios of past years have had trouble with frequent filament burn-outs. To prevent this, when such a set has come into the shop, I insert in series with the high side of the AC line (in the filament string only, of course) a resistor of about 50 ohms to limit the initial surge of current which normally takes place when the set is first turned on. The

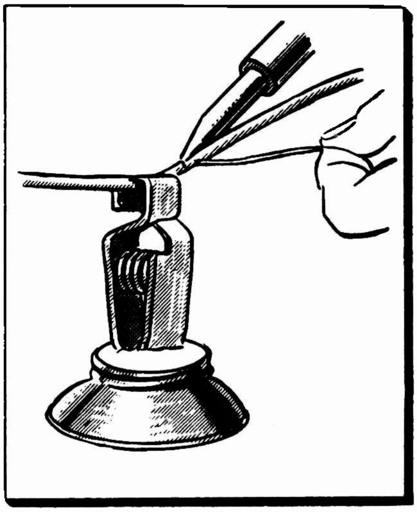



reason this current is so much greater is because the filament resistance when cold is very low, and a great deal of current flows for a few seconds, before warming up, when the resistance rises to its normal fairly high value, limiting the current flow. The resistance during operation totals over 700 ohms, so the extra 50 produces little change in current flow during normal operation, but does serve to limit the initial current and increase the life of the tubes.

The wattage rating of resistors in .150 amp strings (128, 35Z, 50, etc.) is (minimum) 2 watts. Preferable would be 5 watts. In sets using 6 volt tubes, with their 300 ma drain, a 5 watt resistor is minimum, and close. Better use a 10 watter. *A. Westlund, Topeka, Kansas.*

### *Radioman's Third Hand*

A heavy battery clamp which has had the teeth filed down makes a handy small table vise for freeing one hand in doing small soldering jobs, as shown in the drawing. One easy way to mount the clamp is by melting some lead into any metal jar lid, and



letting the lead (or solder) solidify while the end of the battery clamp is held in it. This "third hand" is a good item to carry along in the tool kit for those outside calls, too. *M. Quisenberry, Bucks Radio & Appliance Co., Lexington, Va.*

### *Repairing GE TV Sets*

I have experienced trouble in GE TV sets that could happen in any of the 14C-, 14T-, 16C-, 16T-, 17C- and 17T- models. The characteristics are: no raster, high voltage OK, CRT filament lights, but 1st anode voltage is very low. The remedy is to replace C-311, the .01 coupling condenser feeding the grid of the vertical blanking tube V9A. When shorted, this capacitor can cause a positive voltage to appear on the grid, and the resultant grid current causes the plate voltage to drop. This plate is tied directly to the 1st anode of the CRT, therefore the anode voltage is lowered.—*Melvin Parks, 621 S. Hosmer St., Lansing 12, Mich.*

# Direct Drive TV

(*Continued from page* 31)

ing a voltage higher than plus B available. This was used for the 6BG plate, and subsequently at other points in the receiver, such as the vertical oscillator.

In the 630, this boost added about 50 to 75 volts to the plus B. In the direct drive system, due to the relatively high impedance of the yoke, a much larger boost is realized (from 200 to 250 volts). This makes it possible to have available a high plate voltage for the horizontal output tube, the vertical oscillator and the kine $G_2$ with a lower initial plus B voltage.

As in the 630, a ripple is introduced into the 6BG plate supply by the charging and discharging of the "boost condensers." The linearity coil forms a tuned circuit with these condensers so as to buck out this ripple. Since a certain amount of non-linearity is desired, however (as will be explained in the next paragraph), this circuit is made tunable.

As can be seen in figure 2, the scanning of a (relatively) flatfaced tube results in a situation at the edges of the tube in which the beam travels farther in a given length of time than it would at the center of the tube in the same length of time. This results in non-linearity at the sides of the picture. Actually, the beam is slowed down during its trip across the screen by the resistance of the yoke, so that on a round-faced tube it *wouldn't travel as far* at the right side in a given length of time as it would at the left. These two facts (non-linearity due to flat-faced tubes and non-linearity due to decay of the scanning velocity) tend to buck each other out at the right side of the screen, but are additive at the left.

The linearity control can compensate for this tendency to be non-linear at the left of the picture, by introducing the proper amount of non-linearity by adjustment of the coil slug.

Lest the reader pooh-pooh this contention due to observed results in the field, let us remind him that there are other reasons why the picture may not look at good at the sides as in the middle. Referring again to fig. 2, we can see that if the beam is focussed on the screen in the center, it will focus a little short of the screen at the edges of a flat-faced tube. Furthermore, on a wide-angle tube, there will be some tendency toward an elliptical (rather than round) spot shape at the sides, due to the beam tending to hit the screen a glancing blow. These factors may be and are reported to be corrected in varying degrees by various set manufacturers.

The non-linearity of the picture which was described before as being considerably corrected by the linearity control can also be limited by the use of a so-called "assymetrical" yoke.

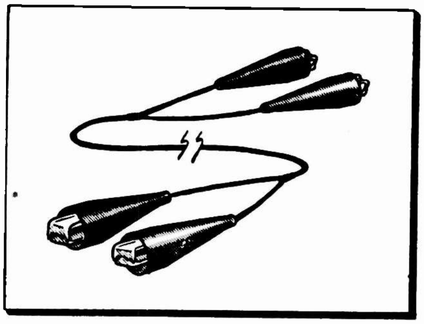
Summing up the advantages of the direct drive system, we find a much more efficient utilization of the energy supplied by the output tube, making it possible to scan large screen, wide angle picture tubes and at the same time supply adequate second anode voltage using the old reliable 6BG6 and *drawing less current* from it than in the 630 (630 plate and screen currents 77 and 11.5 ma., respectively, T164 plate and screen currents 67.9 and 8.1 ma. respectively). At the same time, with a greatly increased B boost due to the efficiency of the circuit, additional conservation in the low voltage power supply is possible.

A footnote to the circuit arrangements of the direct drive system is that, with the yoke connected across the output tube, it is not possible to use DC for centering, as there would be no way to buck it out. Therefore, in order to keep the plate current from decentering the beam, it is blocked out of the yoke with a condenser. Centering is then accomplished mechanically, with the focus magnet.

## Tips for Home and Bench Service

### Universal Patch Cords

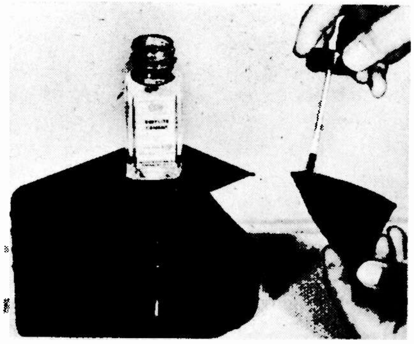
Anyone who has been in the middle of making a test set-up and wanted to connect two units together, and found he had to take time out to make a cable to do the job has wished he had a few patch cords at hand. The properly equipped shop will save several minutes every day always having two or three double patch cords around. These cords require four small battery clamps, four rubber or plastic clamp covers (two black and two red), and about five or six feet of heavy flexible rubber coated wire. The wire is cut into pairs of equal length, taped together every foot or two, and the covers and

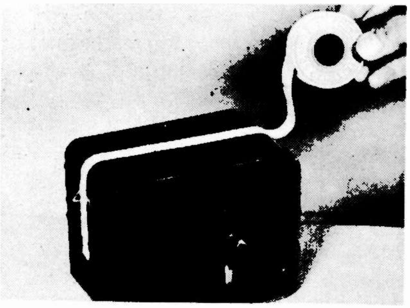


clamps attached at the ends, matching red and black on the same conductors of course so that the patch cords may be used in extending not only AC signals, power, etc., but DC potentials, speaker lines whether grounded on one side or not, etc. *McDonough's TV Service, Rockville Centre, Long Island, New York.*

### Cabinet Repairs

Plastic cases of boosters and small radios often become broken. It is possible in many instances to repair these cases to last a considerable time. In the case shown, the broken piece was first coated along the broken edges with Vinylite Cement (made by General

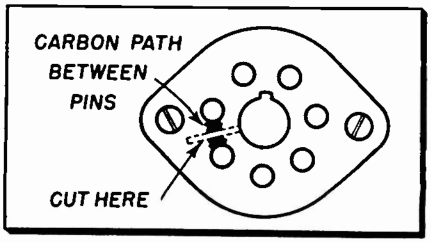




Cement Co.) and then it was firmly placed in original position. Adhesive tape was then used around the entire case to hold the broken piece in place until the cement had set.—*H. Leeper, 1346 Barrett Ct., NW., Canton 3, Ohio.*

### Salvage Tube Sockets

More than once I came across octal wafer sockets that broke down between pins. After replacing quite a few over a period of time, I devised the following procedure: Since the breakdown occurs in the form of a carbonization between adjacent pins, an air gap introduced between two pins would be as good an insulator as




can be devised. So I used a key-hole hack saw to cut a slot from the center key of the socket to the space between the pins.
*David M. Rice, TV Station WABD,*

# UHF Converters

*(Continued from page 35)*

carrier in type. TV servicemen should remember this, when they find a converter performing without noticeable microphonics on an intercarrier set, while an identical-type converter attached to a split-sound receiver produces quite audible microphonic effects in picture and sound.

A screwdriver or other adjustment of the oscillator tuned circuit may have to be made in converters or tuners when the UHF oscillator tube is replaced. One series of tests showed that a maximum detuning of 6 MC took place in the oscillator circuit, when a number of identical-make tubes were used to replace the original oscillator. Most of the tubes produced a frequency change of 3 MC or less.

The choice of the first intermediate frequency involves a design compromise. If a high 1st IF is chosen, oscillator radiation through the RF tuned circuit to the antenna will be reduced. Oscillator microphonics will also be cut down. On the other hand, better gain will be realized at a low IF.

The gain of the 1st IF amplifier section is very important, since this is the only part of the UHF tuner or converter which provides a gain. The crystal mixer causes a loss in signal amplitude; so does the preselector circuit. The IF must therefore be low enough to permit adequate gain in the converter or UHF tuner to be attained.

"Gain" is really a misnomer here. If the signal comes out of the converter as strong as it went in, it can pat itself on the back. The converter tends to introduce a signal loss (since the small IF gain may not equal the signal losses in the preceding circuits), and this loss must be minimized.

To keep the noise in the converter as small as possible—a very vital point, since the UHF signal-noise ratio is established in the converter—a cascode (low-noise) IF amplifier is often employed. A 6BK7 is generally found in this section, due to its relatively low cost and favorable noise factor. The dual-triode construction of the 6BK7 makes it possible to economically obtain two stages of IF amplification. Two stages, rather than one, are considered necessary, not only because of the requisite gain they provide, but also because the VHF oscillator is better isolated from the UHF oscillator under these circumstances, preventing undesired interaction between the two.

The bandwidth of the 1st IF amplifier is very broad—approximately 7 MC or more—to allow for mistuning and drift in the UHF oscillator. Designers try to keep the bandwidth as narrow as possible, because higher gain and better attenuation of undesired VHF signals can be obtained with a narrower bandpass. Due to the broad bandpass present, either of the two alternate channels to which the TV receiver may be switched for VHF reception can be selected, without the necessity of retuning the UHF IF circuits.

The IF trimmer or other adjusting device must be reset, however, in cases where it is desired to change the 1st IF. The need for such a change may arise when interference is noted on the VHF channel setting on which converter operation is recommended.

### *Retuning Converter IF*

Let us suppose that the manufacturer has recommended that the converter be operated at Channels 9 or 10. (A choice of two adjacent channels is generally provided because one of these channels is most likely not being used to receive on; the transmission on that channel is very weak in such a case, making the possibility of interference more remote). A VHF station is, let us say, coming in at Channel 9, so 10 is switched in on the VHF receiver. What if interference is present at this setting, as well as at Channel 9 setting?

Channels 8 or 7 may be tried in such a case, provided the 1st IF in the UHF converter or tuner is capable of being suitably retuned to the new frequency range.

Types of interference that can occur when the choice of 1st IF permits them to get through, are worthy of mention. One kind can take place when a harmonic of the VHF oscillator feeds back to the RF circuits. Suppose the desired VHF carrier is 630 MC, and the VHF oscillator is operating at 158 MC. The fourth harmonic of 158 MC is 632 MC. The UHF RF circuits will not reject the interfering signal in such a case, since they are tuned to it.

A similar trouble, called osc-2nd-harmonic image response, can be produced by the beating of the UHF signal against the UHF oscillator signal, *and* the 2nd harmonic of the UHF oscillator signal. Suppose the desired UHF signal is 630 MC, and the oscillator is working at 420 MC, and the 1st IF is 210 MC. The beating of the 630 MC signal with the 420 MC signal will produce the desired 210 MC IF. But the beating of the 630 MC signal against the 2nd harmonic of 420 MC, or 840 MC, will also produce a 210 MC difference frequency. Both the desired and undesired IF signals will be accepted by the 1st IF amplifier, and interference will therefore occur.

The type of interference just described is possible when a channel between 7 and 13 is used for the 1st intermediate frequency.

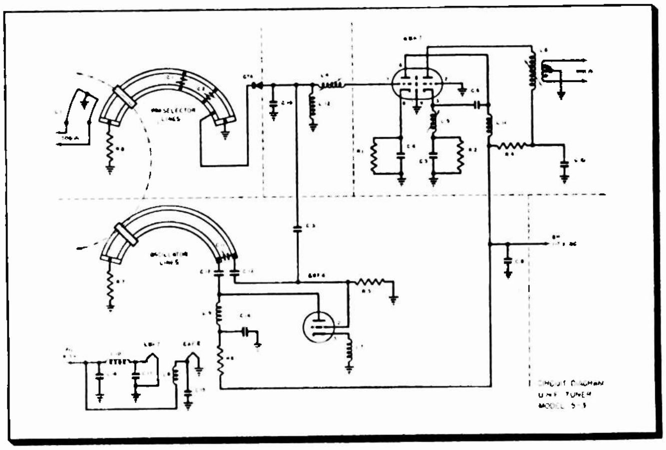
A simple solution that can be tried for the cases of interference cited is the substitution of a different 1st IF. This is done by switching the VHF channel setting, and retuning the IF adjustment on the converter.

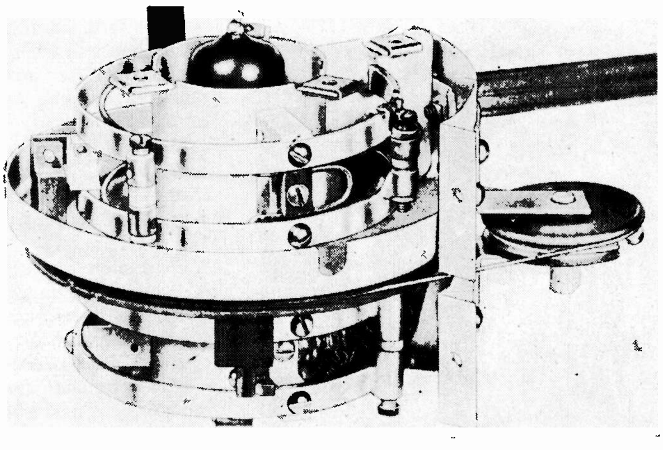
We can now start to consider specific circuits used in UHF conversion devices. The simplest such device is the UHF strip, which is employed in VHF receivers with turret-type tuners.

A strip circuit is shown in fig. 2. It is similar in design to the UHF converter or tuner, except that it omits two stages of IF amplification. The possibility of interference due to the beating of the UHF and VHF oscillator output signals is enhanced by such a design. Radiation of the UHF oscillator is sometimes a problem, due to the absence of sufficient preselection and inadequate shielding of the strips. The signal-noise

*(Continued on page 48)*

**Fig. 3—Schematic circuit of the tuner shown in Fig. 4. G7A is the mixer crystal. The 6AF4 is the oscillator. The 6BK7 acts as the IF amplifier. Fig. 4—Top view of UHF Tuner Model S-3, manufactured by the Kingston Products Corp. The tuner's upper shield has been removed. Note the circulator inductors, the shorting sliders, and the trimmers. The antenna coupling loop is at the rear. The uppermost part of the cascode IF amplifier tube is visible in the center of the tuner. The low noise twin triodes, 6BK7 and 6BQ7, are used in many of the UHF tuners and converters.**





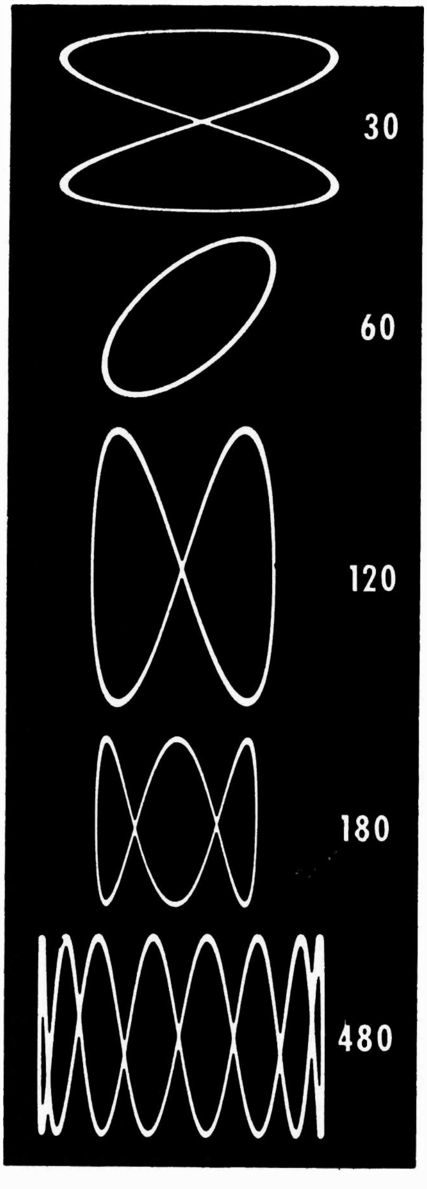
# How to Interpret AF

## *Useful Information Can Be Obtained Without Accurate Laboratory Equip-*

• It would be a great convenience if we could say that, in making service tests, one would either get the correct result or no result at all. This, unfortunately, is not the case. By making tests the wrong way, or by using the wrong equipment (or defective equipment) it is possible to produce a set of results which bear no resemblance whatsoever to the actual conditions. Or, as they say in the movies, any resemblance to actual persons living or dead is purely coincidental.

In making service tests, extreme accuracy is not so important, but it is important that all the results bear more than a coincidental resemblance to what is going on in the equipment.

**Fig. 1: Waveforms obtained with 60 cps horizontal input and AF oscillator on vertical, at frequencies indicated.**




Most servicemen learned a long time ago that a meter with 2% accuracy is more than competent to determine the value of a resistor whose accuracy is plus or minus 20% . . . and especially when you're mostly interested in whether it's shorted, open or greatly changed in value. Similarly, when reading DC plate and screen voltages, something near the voltage on the diagram is a pretty good indication that there's no trouble in the circuit.

When reading small DC voltages (such as bias) or AC voltages (AF, RF), a VTVM is indicated, not so much for extreme accuracy as to avoid the loading and detuning effects which are obtained with the usual non-electronic voltmeter, even 20,000 ohms/volt, which like as not will indicate nothing at all on small voltages, especially in high resistance circuits. These effects (loading and detuning) have been amply covered in previous articles, and we won't bother to go into details about it here.

At high frequencies, capacitance becomes important—in the probe, probe leads, probe connections to the circuit, etc.—and special RF probes are indicated. At audio frequencies, however, the writer has found that the common garden variety AC probe associated with the general run of VTVM's is quite adequate.

As a matter of fact, although some RF probes are stated to be usable over such ranges as 20 cps to 200 MC, we have found them to be quite unreliable at audio frequencies. By unreliable, we mean extremely non-linear and non-uniform.

Referring back to our remarks about accuracy, it isn't mandatory that any of your equipment be perfectly linear, but it is important that it produce the same results under the same conditions every time it is used. If it does this, you can then use it with a correction table, much in the same manner that a mariner corrects his compass readings, or a flyer his air-speed indications.

But when the results are extremely non-linear, corrections become cumbersome, and in addition, one is led to suspect that something is wrong with the equipment.

Therefore, naturally, the first thing one should do is to check the equipment which will be used for testing. This means the signal generator, the VTVM and the oscilloscope, if any.

The precise frequency which the generator puts out is not too critical as long as it covers the range you desire, and you use the same check points every time. If you have a fairly good ear for music, you can establish check points by comparing the output of the generator (on earphones) with a known frequency and then marking the harmonics.

Three standards which may be used (and have been used by the writer) are (1) 60 cycle hum, (2) Tuning fork —one can be obtained from a music store for a dollar or less, and (3) the NBS broadcasting station WWV in Washington puts out a 440 cycle tone (A above Middle C), and so do some TV stations with their test patterns.

Once you have the known standard—60 cps, 440 cps, or whatever it may be—you can pick out by ear the octaves of this tone. Each octave above the fundamental is double the frequency of the one preceding it (that is: 60, 120, 240, 480, 960, etc.). These are harmonics, or rather, some of the harmonics. The term "harmonic" means any multiple of the fundamental (that is: 60, 120, 180, 240, 300, 360, etc.).

It is also possible to check frequency by Lissajous figures on an oscilloscope, using 60 cycle AC on the horizontal input and the signal generator on the vertical. Above 480, however, it gets difficult to count the loops. These figures are shown in figure 1.

So much for the frequency, the exact calibration of which, as we said before, is not too important. In making amplitude-vs-frequency measurements with your generator, there are three things which you must consider: (1) the setting of the gain control, (2) the setting of the attenuator, and (3) the resistive termination across which the measurements are taken.

Frequency response and purity of the sine wave output may be affected by the setting of the gain control. On high quality equipment this need not be so, but it's a good idea not to take it for granted without checking. The same thing may be true of the attenuator setting, and the resistive termination.

The latter is the first thing which must be attended to before making any tests. Every generator works most efficiently and effectively when properly terminated in a load equivalent to its internal impedance. The output voltage will, of course, increase with increased load resistance up to a certain point. The open circuit voltage of a generator (or an amplifier) *may* not correlate at all with the output across the proper load with respect to amplitude, linearity and distortion, so this must always be attended to. When testing a power amplifier, the load resistor which is substituted for a voice coil must also be of

# Response Measurements

***ment But Care Must Be Exercised in Making Tests and Analyzing Results***

## AUDIO RESPONSE CHECK POINTS

**Signal Generator: Is it properly terminated; is it linear at all settings of gain control; is it linear at all settings of attenuator; is it properly matched to the unit under test; is there hum or harmonics in output?**

**VTVM: Is the response of the voltmeter and its probe linear over the audio range?**

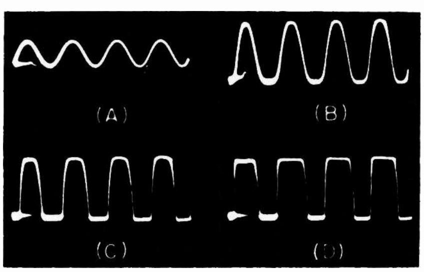
**Amplifier: Is proper input being applied to it (no overloading); is it properly loaded on the output side; is there hum or harmonics in output?**

adequate wattage to accommodate the output of the amplifier.

If the signal generator does not have an output attenuator (and many of the less expensive ones do not), the technician would do well to install one if he intends to make useful employment of the unit. The reason for this is one of the cardinal points of testing of this type, namely that the input voltage to the unit under test should be proper for its design. If the unit under test is overloaded, the results may be absolutely meaningless.

An example of this is a preamp for a magnetic pickup—or for that matter, any low level input stage. The output of a GE magnetic pickup is about 10 millivolts and the input to the preamp is therefore of that order. Where the output of the signal generator may be anywhere from a volt to 10 volts, the preamp is obviously extremely overloaded. That is to say, with the bias set for small input voltages, the tube will in effect operate with insufficient bias, and saturation, clipping and distortion (production of harmonics, among other things) will occur. You can easily observe this by observing the output of such a stage on a scope. With excessively high input voltages, the output waveform becomes an almost perfect square wave (see fig. 2).

**Fig. 2: B, C, D show distortion of sine wave input (A) with too large an input signal. In the extreme (D), squaring of the wave results.—Illustrations from "Encyclopedia on Cathode Ray Oscilloscopes and Their Uses," published by John F. Rider.**




Which fact brings us to the generator's gain control setting. In the first place, it may not be possible to reduce the gain sufficiently with the gain control (in the absence of an attenuator, that is). In the second place, the generator may not operate satisfactorily at very low settings of the control.

As an example, the writer one time made a frequency run on an amplifier with a very low gain control setting of the generator. The results obtained were so linear that they were suspect, since the amplifier had compensation circuits which would have precluded such results. The tests were then repeated with an oscilloscope and it was discovered that all the signal generator was putting out at this setting was 60 cycle hum, and therefore the entire "frequency run" was actually done at a single frequency.

The output attenuator, of course, must also be checked at different settings, as mentioned earlier, since such devices are usually frequency sensitive. This is especially true if the attenuator is only a "volume control" type unit. Such a unit reflects different impedances at different settings, and also varying distributed capacitance due to the wiring. A constant impedance T-pad is a better solution.

Not only should the generator be properly terminated, but also the input impedance of the device under test should be properly matched. To connect a low impedance device across a high impedance generator will seriously affect the operation of the generator. To merely mismatch the output of the generator will, of course, affect its output voltage.

Several frequency runs on the generator itself, at different gain settings and different attenuator settings, while tedious, will clear the atmosphere for all future work. The technician will either find that the output of the generator is linear to a useful degree over the main part of its ranges, or else he will find out what allowances must be made for non-linearities in future tests.

There is yet one big "except" to the foregoing statement, which is that the results depend on the reliability of the VTVM. It is highly desirable that some comparative tests be made in order to establish the validity of the VTVM readings. For instance, the same tests can be made with some other meter; or the meter can be tested on some other generator; or the observed readings on the VTVM can be compared with visual results on a scope. Any two sets of readings which were close to being the same would put the technician's mind at rest on this score.

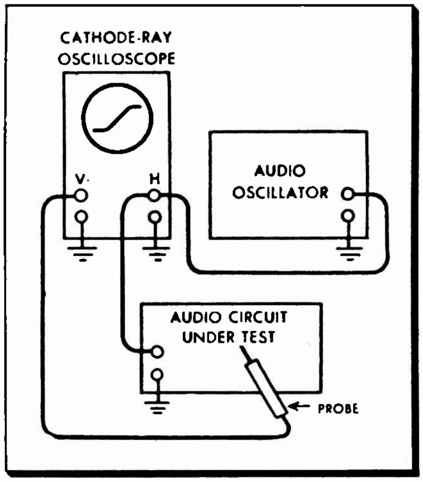



**Fig. 3: Arrangement for estimating both frequency and amplitude distortion at a glance, making it easy to monitor oscillator output for uniform input to the device under test.**

The usefulness of an oscilloscope for audio testing cannot be overemphasized, for the scope reveals distortion and amplitude at the same moment. As mentioned before, it is practically impossible to tell whether (for instance) the voltage on a meter contains a lot of 60 cycle hum, or whether it contains harmonics, etc. In this respect, the writer recalls a frequency run on a 3 or 4-year-old tape recorder. Fairly good (voltage) output was observed to 10,000 cycles, but when the results were observed by listening to the tape, it was found that above 6000 there was nothing but a wild jumble of whistles and birdies which resulted from intermodulation between the signal input and the bias, which was in that case 20 KC. In

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# Audio Response

(*Continued from page 47*)

addition, there was some hum.

The oscilloscope has a very critical eye for such details, on the other hand. When reading amplitude of the trace, it should be remembered, of course, that the trace is a peak-to-peak indication which is 2.83 times RMS readings obtained on the VTVM. It should also be borne in mind that the average VTVM does not respond accurately to non-sinusoidal waveforms, whereas the scope gives a complete picture (depending of course, on its own accuracy) of whatever is put into it. The scope will thus detect distortion in the output of the signal generator as well as distortion introduced by the amplifier under test.

The scope can also be used for square-wave testing, of course, which is a terrific shortcut in audio amplifier checking, since it covers amplitude, frequency and phase all at one time over a fairly wide range.

# UHF Converters

(*Continued from page 45*)

ratio for incoming UHF signals may be much poorer (than in UHF converters or tuners). UHF oscillator frequency drift has been observed to be greater, due to lack of suitable drift-compensating units.

There are two strip sections in each UHF strip. One section is made up of the antenna input circuit, a crystal mixer with its tuned circuit, and a 1st IF grid coil. The other strip section contains coils for the 1st IF plate, converter grid and oscillator. (The stages referred to are the VHF receiver's RF amplifier, converter and oscillator, respectively.) An oscillator harmonic generator crystal and its accompanying bias network is also present.

The oscillator crystal generates a fundamental frequency, a harmonic of which is used as the oscillator signal. The UHF signal is fed into the balanced antenna input coil and transformer-coupled into the mixer tuned circuit, where it is mixed with the oscillator signal, causing an IF signal to be produced. This 1st IF signal falls into the section of the spectrum that lies between the low and high VHF bands.

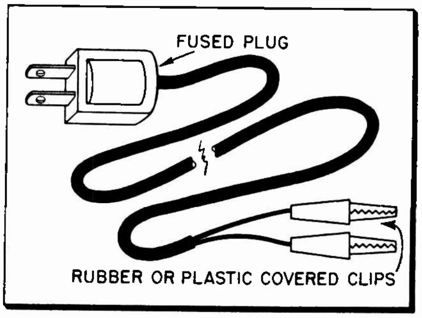
The 1st IF is coupled to the VHF receiver's RF amplifier, and then processed like a conventional VHF signal.

UHF strip circuits have been considerably improved of late, but the circuits employed are, at the time of writing, not available. One strip manufacturer dispenses with a dual conversion system, and converts the UHF signal directly into a 40 MC video IF signal. By switching in suitable tuned circuits, he is enabled to use the VHF oscillator and mixer to amplify the UHF signals.

# Shop Shortcuts

### Universal Test Cord

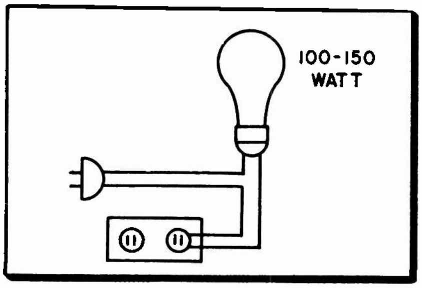
One of the most useful tools around any repair shop is a test cord for the AC supply line. This test cord has fused plug on one end which carries two tubular fuses of 2 to 6 amp. capacity, depending on the equipment to be under test. On the other end it has small alligator clips almost completely covered by rubber




grips to protect the technician from shock and to keep the clips separated when they are used on terminals which are close to each other. This sort of cord can be used as a universal test cord for TV sets, particularly in the case of older sets such as GE, Philco, Emerson, which for some years had an AC interlock receptacle differing from what has now become standard for the industry.—*Arthur Bertram, 247 West 13th St., New York, N. Y.*

### Test Lamp Setup

Useful in testing for shorts in radios and other devices, but particularly needed when checking for shorted




power-supply components, this fuse protector lights up brightly on shorts, dully if device is OK. *J. L. Brody, Ab's Radio, Chapel Hill, N. C.*

### Tool Keeper

Although you may have "a place for everything" in the way of tools at your service bench, it is very seldom that you keep "everything in its place" when you're busy turning out the work. The result is that when you want a particular tool, you have to stop and turn everything over in an attempt to find it. I have solved this problem by putting the most-often-used ones in a pan or tray where I have them handy for every job. I use a wide bread pan, which works out very nicely. For the contents, I suggest: long nose pliers, cutters, solder, soldering tool, dual blade screw-driver (Philips & Standard), small set-screw driver, 1/4" socket, 3/8" socket and flashlight.—*Ralph E. Hahn, 2450 Waukegan Rd., Glenview, Ill.*

### Dial Stringing

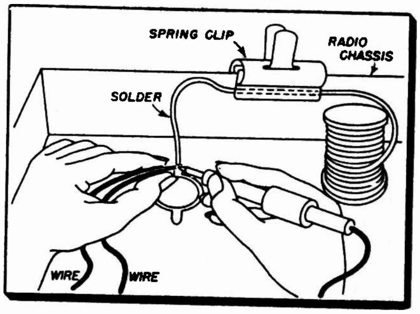
I use an old shoe-button hook to pick up cable and slide it onto reels. For string, I use 24 lb. hard braided nylon fishing line, which I find most satisfactory. Some wax on a large pulley will help hold two cables in place while stringing. To get a good fit, I first string the cable on the shafts of the slide pulleys (will stay in place there better, too) and when I'm finished, I slip it over the pulleys themselves. This makes the cable tight and eliminates "push-pull" dialing. Rubber bands on knob shafts keep string from slipping.—*Beryl Bass, Bass Radio, Lamoni, Iowa.*

### Intermittent Noises

Don't bother to examine the TV set or radio in cases where the customer says that walking across the floor causes noise in the receiver. The trouble is in the house wiring, and may be due to grounded electrical feed wires, or lack of a ground for the entire lighting circuit. In some cases it is possible to eliminate the "noise" condition by moving the receiver to another location.

### Servicers "Third Hand"

Often on midget radios, it is impossible to make the usual mechanical joint first, before soldering, due to short leads or very tight quarters.




The drawing shows how I use a spring clip as a third hand to hold the solder in exactly the right position.—*J. Amorose, Amorose Radio, Route 4, Hungary Rd., Richmond, Va.*

### Phono Groove-Skipping

Before making any adjustments on a phono record changer where the complaint concerns the arm "sliding" across the microgroove record, use a small pocket level to determine whether or not the turntable is tilted. Sometimes it is necessary to raise the rear of the turntable slightly to eliminate "sliding," though, theoretically, it should be perfectly level.—*Ed. Note: Obviously you should do this before removing the changer from console or table cabinet, in the customer's home.*



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