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the magazine of electronic servicing

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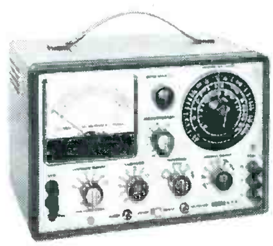

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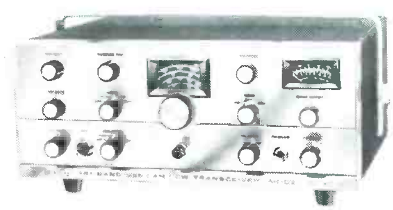

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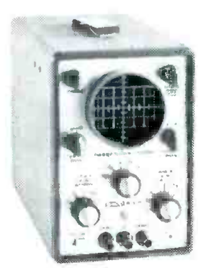

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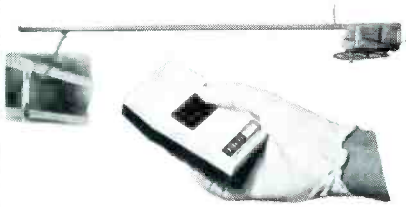

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1945-1965: TWENTY YEARS OF LEADERSHIP IN CREATIVE ELECTRONICS

Circle 1 on literature card

audio servicing from A to Z

Circuits and how to troubleshoot them.

by David I. King

As stereophonic FM radios, record players, tape recorders, and massive solid-state home entertainment centers become increasingly popular, it is apparent that public interest in audio products is rapidly growing. Today, systems of types which once were owned by only the most sophisticated audiophile are becoming common in many homes.

To capitalize on the opportunity that servicing audio systems presents, the service technician needs only: the equipment that is normally used for servicing radio and TV audio circuits (which includes an audio signal generator), a basic understanding of audio theory (ranging from the oldest to the most modern circuits), and a knowledge of troubleshooting techniques which will produce rapid, efficient repairs.

General Service Techniques

There are many techniques commonly used to isolate trouble in audio circuits. One of the most common methods is the "hum" or "click" test, which is accomplished by touching a finger or a screwdriver to the grid of the output stage. A loud "click" or "hum" from the speaker indicates the stage is operating. The serviceman then moves to each preceding stage in succession until the dead stage is found.

While this method is excellent for rapid service of table-model radios, it could prove disastrous if tried on the preamp of a powerful stereo amplifier using large speakers—the expensive woofers might be damaged by the transients and hum. When servicing transistor circuits, the low input impedance makes it difficult to induce significant hum in medium- and high-level stages. Too, in a crowded printed circuit the possibility of shorting the transistor base to the collector with a screwdriver makes the "click" test inadvisable for transistor servicing.

With the high power and wide bandwidth common in modern high-quality vacuum-tube and solid-state audio equipment, certain precautions must be taken while servicing. Replacement of the speaker with a terminating resistor will not only protect the speaker (and the technician's ears) from loud transients accidentally introduced while troubleshooting, it will make frequency-response checks of the amplifier more accurate by eliminating phase shift caused by changes in loudspeaker impedance. For proper operation, the terminating resistor must be large enough to dissipate all the audio power produced by the amplifier, and it must match the output impedance. Most audio test equipment was designed originally for checking vacuum-tube equipment; special precautions must be taken to insure that, for example, signal-generator output voltage is not too high for low-level transistor circuits. Unlike vacuum tubes, transistors can be destroyed by small overloads. To prevent damage from AC voltages introduced by ground loops, all equipment attached to transistor circuits must be properly grounded.

Either signal tracing or signal injection can be used to find defective stages; both methods require the same equipment, but the techniques are opposite. Signal tracing involves the use of a signal generator feeding the input of an audio amplifier. An oscilloscope is then used to trace the signal from the input toward the output until the defective stage is found. In contrast, signal injection involves the use of an oscilloscope tied to the output of the amplifier. Signal-generator output is injected first at the final stage; then, it is injected at preceding stages until the defective stage is found.

Although either type alone is quite useful, a combination of sine- and square-wave tests will give visible scope indications of most forms of distortion. Sine-wave checks will detect nonlinearity causing harmonic distortion, whereas square-

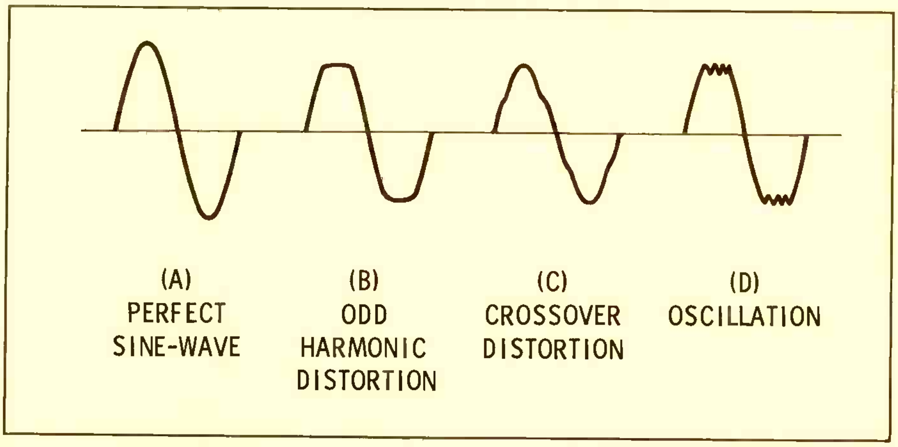

Fig. 1. Amplifier sine-wave outputs show various types of harmonic distortion.

wave checks will display phase shift causing frequency distortion.

Fig. 1 shows a normal sine wave compared to sine waves that have undergone various forms of distortion. In Fig. 2, a perfect square wave is compared to square waves that have been altered by phase shift. Circuit design will determine normal sine- and square-wave response of an amplifier. For example, while it is normal for a low-priced portable radio to display some harmonic distortion and degradation of a 1000-cps square wave, any sine-wave distortion for 20 to 20,000 cps or phase shift of square waves from 300 to 2000 cps would be an immediate indication of malfunction in a high-quality system.

If harmonic distortion is less than 10%, it is hard to detect with a normal sine-wave display. However, the test setup shown in Fig. 3 can be used to display as little as 1% harmonic distortion. With this arrangement, phase shift can be detected also.

The line in Fig. 3A will tilt to the left or right depending upon whether the output of the amplifier is in phase or 180° out of phase with the input. Care must be taken to insure that the scope introduces no distortion. Initially bypass the attenuator and amplifier to be certain that with the amplifier out of the circuit the line is straight and there is no phase shift. To prevent phase shift within the test setup, the attenuator and terminating resistor must be purely resistive—carbon or *noninductive* wirewound resistors must be used.

Nonlinearity within the amplifier will cause a change in the vertical-deflection rate. The horizontal-sweep amplifier is fed directly by the sine-wave oscillator; hence, the horizontal-deflection rate will not be distorted and will exceed the vertical-deflection rate. The result is the deviations from a straight line shown in Figs. 3B and 3C.

If phase shift within the amplifier equalled 90°, the pattern produced would be circular; but phase shift seldom equals 90°, so the resulting pattern is elliptical. Phase shift (Fig. 3D) should not be noticeable except at the limits of the amplifier frequency-response characteristics. Any flattening of the elliptical trace is an indication of amplitude distortion. Kinks or curves within the ellipse indicate the presence of hum, noise, or oscillation.

All checks of amplifier frequency response must be made with tone controls set for flat response and all equalization (where used) switched out of the circuit. Otherwise the results of any test will be misleading.

After the stage causing trouble is found, checks are needed to isolate the defective component. An understanding of circuit function and characteristics is needed for troubleshooting individual stages. To cover the various audio circuits in use, the circuits have been classified as to the signal level at which they operate. The three divisions are: (1) Low-level circuits, which are the input stages; (2) medium-level circuits, which drive the final stages; and (3) high-level circuits, which supply power to the speaker. By analyzing common vacuum-tube circuits and comparing them to the newer transistor circuits, the serviceman can develop the basic knowledge of audio circuits that is essential for rapid troubleshooting.

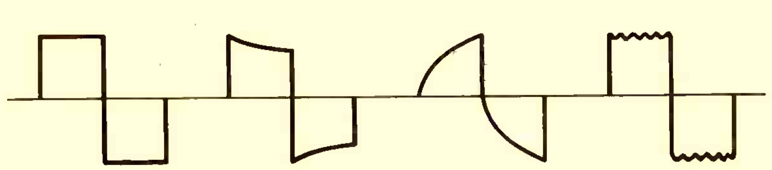

Fig. 2. Amplifier square-wave outputs show different types of phase distortion.

Low-Level Circuits

Fig. 4A shows a common-cathode amplifier. This circuit is often used as the preamplifier in high-quality audio circuits, because it has a high input impedance, high voltage gain, and low distortion. Input signal is developed across the 100K grid resistor (R1) and fed to the grid of V1. DC voltage drop across R2 develops negative grid bias by making the cathode positive with respect to the grid. R2 is sometimes unbypassed to introduce some degeneration which improves linearity. The output signal is developed across plate load resistor R3, then fed via C1 to the next stage. C2A and C2B together with R4 and R5 serve as a decoupling and voltage dropping network.

The circuit shown in Fig. 4B is primarily used as the first audio stage for AC-DC table radios. For small input signals this circuit is linear and has high gain. Bias is developed by electron emission from the cathode striking the control grid. A small negative voltage (.5 volts) results across the high-resistance (3.3 meg) grid resistor R1. In all other respects this circuit functions in exactly the same way as the circuit in Fig. 4A.

Grounded-grid amplifiers (Fig. 4C) are occasionally used instead of an input transformer to provide low input impedance and high output impedance. In the mobile radio circuit shown in Fig. 4C, variable resistor R1 is actually a carbon microphone; there is no need for an input transformer or separate carbon-microphone power supply. Often the signal is coupled by C1 and developed between grid and cathode by R1. In these cases R1 is a fixed resistor. As the cathode is normally positive with respect to the grid, bias circuitry is simplified. Instantaneous grid-to-cathode voltage still controls tube conduction, but the cathode voltage is varied instead of the grid voltage. The grid remains at ground potential. Also, there is no phase inversion; the amplified plate signal developed across load resistor R2 is in phase with the cathode signal. Again, C2 is the coupling capacitor to the next stage.

The transistor equivalent of the common-cathode amplifier, the common-emitter amplifier, is shown in Fig. 5A. This circuit is widely used in low-level transistor circuits because of its flexibility, stability, and high gain. If circuit values such as coupling-capacitor size are noted, the low impedance common to transistor circuits become apparent. Input impedance for a typical common-emitter circuit ranges from 20 to 5000 ohms. Transistors are operated primarily as power amplifiers; gain for these circuits is expressed in db as power gain. In contrast, gain for low-level vacuum-tube amplifiers is usually expressed in db as voltage gain.

C1 (Fig. 5A) couples the input signal to the base of X1; the base is forward biased −.1 volt by voltage divider R1-R2. Load resistor R4 develops the amplified and inverted output signal. C3, a 10-mfd electrolytic, then couples the output to the following stage. Protective biasing is provided by R3; C2 prevents degeneration.

Like its vacuum-tube counterpart, the grounded-grid amplifier, the common-base amplifier is used as a transformerless matching circuit. In Fig. 5B, the signal is coupled by C1 and developed across R1 to control base-emitter and, thus, collector-emitter current. C2 and C4 keep the base and emitter supply at AC ground; resistors R2 and R3 form a voltage divider to forward bias X1. The output signal, which is in phase with the input signal, is developed across R4 and coupled by C3 to the next stage.

Servicing Low-Level Circuits

All defects in amplifier circuits can be classed as one or more of the following: (1) low gain, (2) hum, (3) distortion, (4) noise, and (5) oscillation. Often these defects occur in a combination, such as hum and distortion or noise and oscillation.

Low-level vacuum-tube amplifiers are particularly susceptible to hum and noise. Hum may be externally introduced by ground loops or can be caused internally by heater-cathode leakage or poor power-supply filtering. One rapid method of tracing hum is to bypass points in the signal path to ground with a 10-mfd capacitor. Bypassing pin 7 (the grid) of V1A in Fig. 4A will eliminate the hum if its source precedes this stage. Should the hum be caused by defects within this stage, it will not decrease; if heater-cathode leakage in V1A is causing the hum, bypassing the grid will slightly *increase* hum output. Heater-cathode leakage should immediately be suspected when hum is found in a grounded-grid amplifier (Fig. 4C); the very low input impedance reduces the probability of externally induced hum.

The quickest test for open or dried-out filter electrolytics is to bridge them with a unit known to be good. Sometimes hum is introduced by leakage between sections of a multisection electrolytic; here, bridging will not cure the trouble.

Partial or complete loss of gain is usually caused by vacuum-tube defects. Voltage checks on the cathode, grid, and plate of V1A (Fig. 4A) should indicate a defective tube. With a plate-to-grid or plate-to-cathode short, the plate will be at a low voltage and cathode voltage will increase. A grid-to-cathode short will slightly increase cathode voltage (the grid will be at cathode potential) and decrease plate voltage. Open elements or complete loss of emission can be detected rapidly because the plate will be at B+ voltage.

Distortion is caused by operation outside the vacuum-tube's linear range. The most usual causes of nonlinearity are grid current, grid cutoff, or plate saturation. Excessive drive can cause all of these and must be remedied. If the input signal is normal, nonlinearity in the grid circuit is a result of improper bias. A gassy tube is a common cause of grid current. Also, a leaky interstage coupling capacitor will place a positive voltage on the grid and cause grid current.

Microphonic tubes, noisy controls, and poor connections are the most common causes of noise in vacuum-tube circuits. Watching for noise on the scope while tapping around the circuit with a pencil eraser will indicate most sources of noise.

Oscillation in an audio amplifier will not always be an audible howl. Sometimes the only audible evidence will be edginess and distortion; an oscilloscope will provide the most reliable detection—see Fig. 1D. Since oscillation usually involves several stages, if negative feedback is used check the feedback network first. Remove any input signal to prevent overload, then disconnect the feedback circuit; in Fig. 4A it is tied to the junction of R2 and the cathode of V1A. If oscillation ceases, a component in the feedback path has changed value. Should oscillation continue, check for an open bypass capacitor or ungrounded shield. When all else fails, try extra shielding. An increase in power supply impedance caused by the opening of an electrolytic will allow motorboating (low-frequency oscillation) to occur; as with searching for hum, bridging with a good electrolytic will usually pinpoint the defective component.

Transistor circuits are not subject to many of the malfunctions that occur in vacuum-tube circuits. There is no filament voltage required, and low impedances prevent electrostatic pickup; so, hum is almost nonexistent. Microphonics cannot be generated by transistors so all noise is

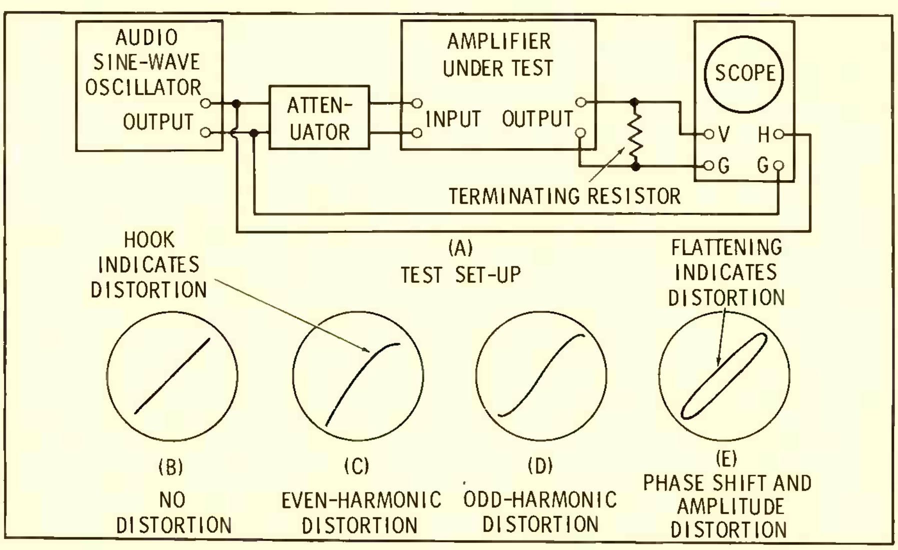

Fig. 3. Test setup will effectively show phase shift and amplitude distortion.

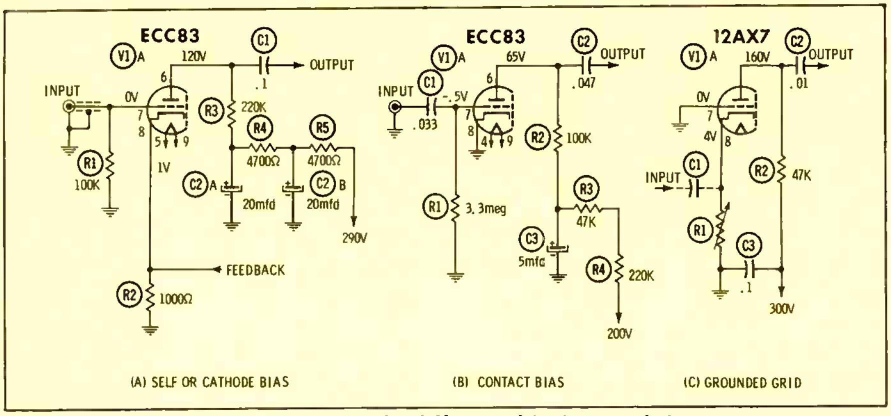

Fig. 4. Low-level tube circuits with different biasing and input arrangements.

limited to the surrounding circuitry.

Bias problems are the major cause of nonlinearity in transistor circuits. Leaky coupling capacitors will upset bias conditions and produce distortion. Good bantam electrolytics (which are commonly used for coupling) should have from 2 to 6 ua leakage—no more. Bias resistors should also be checked to insure that they have not changed value.

Motorboating in transistor circuits is a frequent trouble, especially in low-quality circuits. Defective electrolytics and weak batteries, where used, are the most common causes of motorboating. Bridging filter capacitors is a rapid way of finding the trouble; make sure the capacitor used for bridging is large enough. Since negative feedback is commonly used in transistor circuits, components associated with the feedback path can, if they change value, cause oscillation.

Low gain in transistor circuits is usually caused by defective coupling networks. Shorted interstage transformers, open coupling capacitors, and open collector load resistors can all cause low gain or complete loss of output. Shorted or open transistors are not as common, but these defects do occur. For example, in Fig. 5A, with the emitter open, the junction of the emitter and R3 would drop to 0 volts, and collector voltage would rise to the supply voltage (−12 volts). An open base, collector, or emitter will each produce almost the same symptoms, although there will be a slight emitter-base current with an open collector. A collector-to-emitter short will cause excessive emitter current and low collector voltage; collector and emitter voltages will be equal, but the base voltage will be normal. All three voltages (collector, base, and emitter) will be almost equal with a collector-to-base short; again, emitter current will be high. Base-to-emitter shorts are harder to detect, since the normal difference between base and emitter voltage is only .1 or .2 volt; usually, the transistor will be cut off and collector voltage will equal supply voltage. A base-to-emitter short can be found by connecting a VOM between base and emitter and checking for the absence of bias voltage with the low-meter scale.

To determine rapidly if a transistor has an emitter-to-collector short, carefully short the base to the emitter. If the transistor is good, removing forward bias will cut it off, and collector voltage should equal source voltage.

A potentiometer between the power supply and ground can be used to forward bias the base of a transistor. Carefully set the wiper arm for .1 to .2 volt of forward bias with respect to the emitter; connect the wiper arm to the base. As forward bias is slowly increased by the potentiometer, collector voltage should decrease; if not, the transistor is *open.*

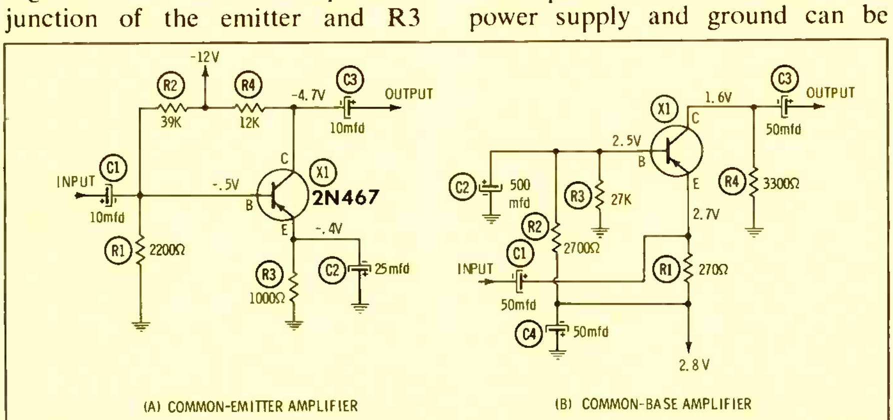

Fig. 5. Signal is coupled to emitter or base of low-level transistor circuits.

Medium-Level Circuits

The primary use for the cathode follower in Fig. 6A is as an impedance-matching circuit. Cathode followers are often used to provide a low-impedance output for cables to other equipment; occasionally they are also used as drivers for class AB output stages.

The cathode *follows* the grid signal. Since the signal developed across the cathode resistor is degenerative, it can never exceed the grid signal. Voltage gain in a cathode follower can never exceed one; however, owing to the high input and low output impedance, the cathode follower can produce power gain.

V1A's (Fig. 6A) grid signal is coupled in via C1 and developed across R1 and R3. DC through V1 produces a voltage drop across R2 for negative grid bias. The output signal is in phase with the input; it is coupled from the cathode of V1 by C2 to the load resistor, R4, and output jack, V1.

Fig. 6B shows a split-load paraphase amplifier. Note the similarity to the cathode follower (Fig. 6A); however, another output is taken from the plate. This circuit has a voltage gain of less than one for both outputs. Coupling capacitor C1 passes input signal to the grid of V1; bias is developed by R2. C3 couples the cathode signal appearing across R2 and R3 to the output stage. The plate signal developed by load resistor R4 is coupled to the output stage by C2. Outputs from C2 and C3 are of equal amplitude and 180° out of phase to provide drive for a class A push-pull output stage.

A cathode-coupled paraphase amplifier is shown in Fig. 6C; note that the bottom section is the grounded-grid amplifier previously discussed. DC coupling from the previous stage is often used in this circuit. V1A's grid (and cathode, due to R2) follow the input signal. The grid of V1B is held at AC ground by C1; but V1B's cathode follows the signal on R2, which in turn follows the signal of V1A's grid. The plate signal of V1A is 180° out of phase with the input signal, and the plate signal of V1B is in phase with the input signal. By proper selection of components, two signals of equal amplitude and 180° out of phase are coupled to the output stage.

Fig. 6D shows a floating paraphase amplifier. This circuit is composed of two cascaded common-cathode amplifiers with an output taken from each stage. Since phase inversion occurs in each stage, the output at the second stage is 180° out of phase with the output of the first stage. The input signal is coupled by C1 to V1A's grid; the inverted and amplified output is fed by C2 to one side of the output stage. Simultaneously, R2, R7, and C3 couple V1A's output to the grid of V1B. Plate signal from V1B is fed through two paths: via C4 to the output stage, and via R6, R7, and C3 back to the grid. Negative feedback is used to counteract the effects of aging tubes and slight changes in component values.

The transistor equivalent of the cathode follower, the emitter follower, is shown in Fig. 7A. Although this circuit has the lowest power gain of all three transistor amplifier configurations (common-emitter, common-base, and emitter-follower), it is quite popular as a coupling circuit. An emitter follower's high input impedance matches the common emitter's output impedance; while it's low output impedance matches the common emitter's input impedance.

Also, because it produces current gain, the emitter follower is often used to drive a single-ended class A output stage. Forward bias for X1 is provided through R4, R1, and R2. Current flow through the transistor is controlled by the base signal, which has been coupled from the preceding stage by C1. The output signal is developed across R3 and direct coupled to the following stage.

Fig. 7B shows the transistor version of the split-load paraphase amplifier. This circuit, like its vacuum-tube counterpart, is used to drive a class A push-pull output stage. The push-pull output here drives a single-ended load. To help explain circuit action, the output stage has been included in the diagram. Input signal is coupled by C1 to the base of X1; R1 and R2 provide forward bias. C3 couples the emitter signal, which follows the input signal, to the base of X3. Collector signal from X1, which is 180° out of phase with the input signal, is coupled by C2 to the base of X2. Since X2 is used in an emitter-follower configuration, the signal voltage appearing at the collector of X3 causes degeneration in X2. Feedback through C4 to the junction of R4 and R5 increases the signal applied to the base of X2 and decreases the signal applied to the base of X3. The circuit constants are chosen so that a balanced output signal results.

The third medium-level transistor circuit, in Fig. 7C, uses a class-A driver and a transformer to provide two outputs for push-pull operation. Because of its simplicity and high efficiency, this is the most common driver circuit. Operation is basically identical to that in Fig. 5A. Conduction of X1 controls current through the T1 primary; signal variations are coupled to the secondary windings. R4 provides a means of controlling the amount of high-frequency signal shunted to ground by C3; thus, it provides tone control.

Servicing Medium-Level Circuits

Troubleshooting medium-level circuits involves the same basic principles used for low-level circuits, but, since these circuits have different functions, new techniques must be added.

Due to the great amount of degeneration within the cathode follower, malfunctions are not common. Aging tubes and small component value changes will have little effect on this circuit. Only major tube defects (open elements, internal shorts, and complete loss of emission) or component failures (open resistors or shorted capacitors) create trouble in this circuit.

Phase inverters should be subjected to both sine- and square-wave tests to insure that both outputs are of equal amplitude and have equal phase shift. Vacuum-tube aging is the usual cause of unbalance; changes in capacitors and resistors cause unequal phase shift. The cathodes of the phase inverter in Fig. 6C operate above ground, which makes this circuit susceptible to heater-cathode leakage. The circuit in Fig. 6D tends to become unbalanced as the tube ages.

Critical forward bias for X1 in

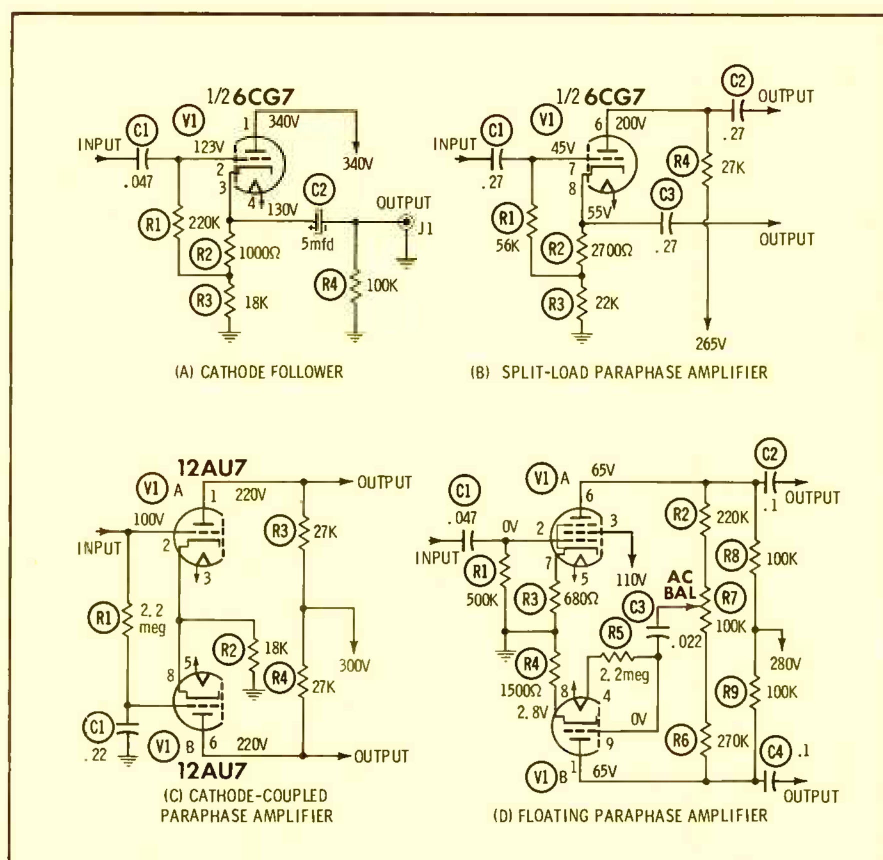

Fig. 6. Medium-level vacuum-tube circuits prepare signal for the output stage.

Fig. 7A makes the operation of the emitter follower more touchy than that of the cathode follower. Unbalanced output from T1 in the driver circuit of Fig. 7C can be caused by shorted turns in the secondary. Troubleshooting procedures for the emitter follower and the driver circuit are identical to those for low-level circuits.

Because of the circuit arrangment, scoping for unbalance in the paraphase amplifier of Fig. 7B can be difficult; here if unbalance is noted, individual component tests will be needed to find the trouble.

High-Level Circuits

The most common output circuit used in AC-DC radios, low-priced phonographs, and television sets is shown in Fig. 8A. Use of a beam-power pentode gives the circuit relatively high efficiency, high power output, and high power sensitivity (which minimizes the number of preceding stages). With only 125 volts on the plate, this circuit can provide more than 2 watts output. Signal to the grid of V1 is coupled by C1; R1 is the grid resistor, and R2 provides cathode bias. The cathode is kept at AC ground by C2, and C3 suppresses transients produced by T1. V1 controls current flow through T1, which couples plate current variations to the speaker.

In Fig. 8B, the output stage is essentially the same as in Fig. 8A, but the cathode of V1 is used as the 135-volt supply point. R1, R2, and R3 bias the grid, since the cathode is 135 volts above ground; C3 holds the cathode at AC ground. The output tube and the tubes supplied with 135 volts form a voltage divider.

Where higher power and greater fidelity is required, push-pull output circuits are used. Even harmonics and hum are cancelled in the push-pull arrangement, and the operating cycle is divided between both tubes. Hence, the push-pull circuit shown in Fig. 8C will operate in class A or class AB to provide high power with far greater fidelity than can be realized with single-ended output circuits.

Because the two sections are identical in operation, only the top section of the push-pull stage will be described. Input signal is coupled by C1 and developed across R1 and R4 to ground. From the bias supply −14 volts is applied to the DC BALANCE control; the bias for V1 is determined by the position of R2's wiper-arm. These circuits often use negative feedback, and phase shift at high frequencies can cause unstable operation; for this reason, parasitic suppressor R6 is inserted in series with the control grid of V1. Current flow through the T1 primary is controlled by V1 and V2. The secondary of T1 transforms the low impedance of the loudspeaker to the load impedance required by the tubes.

While vacuum-tube circuits have evolved into more-or-less standardized designs, it seems that today the flexibility of the transistor is being used to create as many design variations as possible. Compare, for example, the two single-ended output circuits in Fig. 9.

In Fig. 9A, the input signal coupled to the secondary of T1 is connected to X1's base. R1, R2, R3, and R4 control forward bias to X1. As surrounding temperature increases, negative-temperature-coefficient resistor R4 decreases in resistance, and forward bias decreases. C1 and C2 reduce high-frequency response. The inverted signal at X1 collector is coupled by C1 back to the base, providing negative feedback, and C2 shunts high-frequency transients to ground. Both impedance matching for the 3-ohm speaker, and output transistor protection from shorts are provided by using output transformer T2.

Direct coupling is used in Fig. 9B for maximum simplicity and economy. Components associated with the emitter-follower driving X1 are selected to set proper bias at the base of X1. Part of the output from X1 collector is fed back to the preceding stages as DC stabilization and negative feedback—this arrangement prevents thermal runaway and reduces distortion. Inductor L1 aids impedance matching to the 35-ohm speaker.

OTL (output-transformerless) transistor circuits are one of the most important innovations in audio circuitry. Weight and space requirements for high-power output circuits are reduced, and elimination of the output transformer improves speaker damping.

To obtain maximum power in the

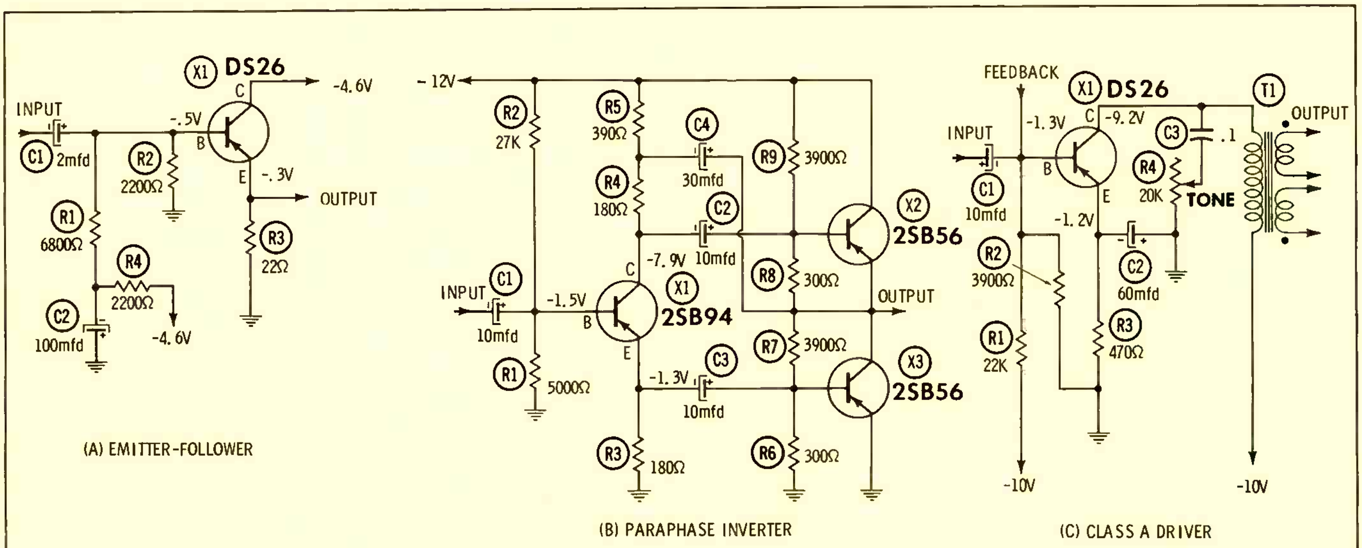

Fig. 7. Transistors in medium-level circuits use direct, RC, or transformer coupling to drive the power-output stage.

OTL circuit of Fig. 10A, the transistors are stacked in series. For one half of the input cycle, the top section (transistors X1 and X2) controls current flow from the −32 volt supply through the speaker to ground; for the alternate half-cycle, the lower section (X3 and X4) controls current flow from the +32 volt supply through the speaker to ground.

Since circuit action in the top and bottom sections is identical, only the top section will be explained. The signal from the driver is coupled by T1 and applied through R1 and R5 between the emitter and base of X1. Series resistors from −32 volts to ground provide forward bias for X1 at the junction of R1 and R2 and forward bias for X2 at the junction of R3 and R4. R5 is a stabilization resistor to prevent thermal runaway. Although the load (speaker) is in series with X1's emitter circuit, it is not tied between the emitter and base. Actually the load for X1 is grounded-base amplifier X2 (X2's base is tied to AC ground by C1). As the −32 volt power supply is considered to have no AC impedance, the speaker is effectively in series with the collector of X2. X1 and X2 form a compound circuit in which a common-emitter amplifier is directly coupled to a grounded-base amplifier with the speaker as a load.

There is no vacuum-tube equivalent for the circuit in Fig. 10B. The complementary-symmetry amplifier uses the opposing conduction characteristics of NPN and PNP transistors to produce a single-ended push-pull amplifier that requires no phase inverter. Forward bias and input signal are directly coupled to the base of NPN transistor X2; the same input signal is coupled through R1 to the base of PNP transistor X1. Power-supply voltage is connected by R4 and R2 to the base of X1 for forward bias. With no input signal, both transistors are conducting slightly, and C3 charges to the voltage at the junction of R5 and R6. As the input signal goes positive, the base of X1—a PNP transistor—is reverse biased, and electron flow from the −9 volt supply ceases. Simultaneously the base of X2—a NPN transistor—is being forward biased, and electron flow through X2 increases as C3 discharges through R6, X2, and the speaker. When the input signal goes negative, X2 stops conducting. Electron flow through X1 (which is now forward-biased) charges C3 and returns through the speaker to the supply. To reduce crossover distortion and DC imbalance, negative feedback is taken from the junction of R5 and R6 and fed through R3 to the preceding stage.

In Fig. 10C the circuit is similar to vacuum-tube push-pull output circuits; however, a center-tapped speaker voice-coil replaces the output transformer. T1 couples the signal from the driver to the bases of X2 and X3. Voltage developed across the forward-biased PN junction of X1, a diode-connected transistor, is used to forward bias X2 and X3. If surrounding temperature increases, the voltage across X1 will decrease, and forward bias to X2 and X3 will drop. R2 provides more stabilization to prevent thermal runaway. Distortion is reduced by negative feedback from the collectors via C2, R3, C3, and R4. Transients developed across the speaker are suppressed by C1.

Servicing High-Level Circuits

Single-ended output stages are quite susceptible to distortion, hum, and parasitic oscillation. Distortion is usually caused by a gassy tube or a leaky coupling capacitor. In Fig. 8B, the cathode is positive with respect to the filament, and the possibility of heater-cathode leakage and shorts is increased. Often, beam-power output circuits are operated so that the screen grid is more positive than the plate during part of the operating cycle; this sometimes causes Barkhausen oscillations. Bypassing the screen grid as is done in Fig. 8B will usually prevent distortion and RF interference created by these oscillations.

Push-pull output stages (Fig. 8C) create distortion when they become unbalanced. Static balance of push-pull stages is accomplished by inserting a milliammeter in each cathode lead and adjusting bias until the currents are equal. At times, it may be necessary to select tubes to balance cathode currents. To check rapidly for oscillation around the feedback loop, disconnect the feedback path; cathode current will decrease if the circuit is oscillating.

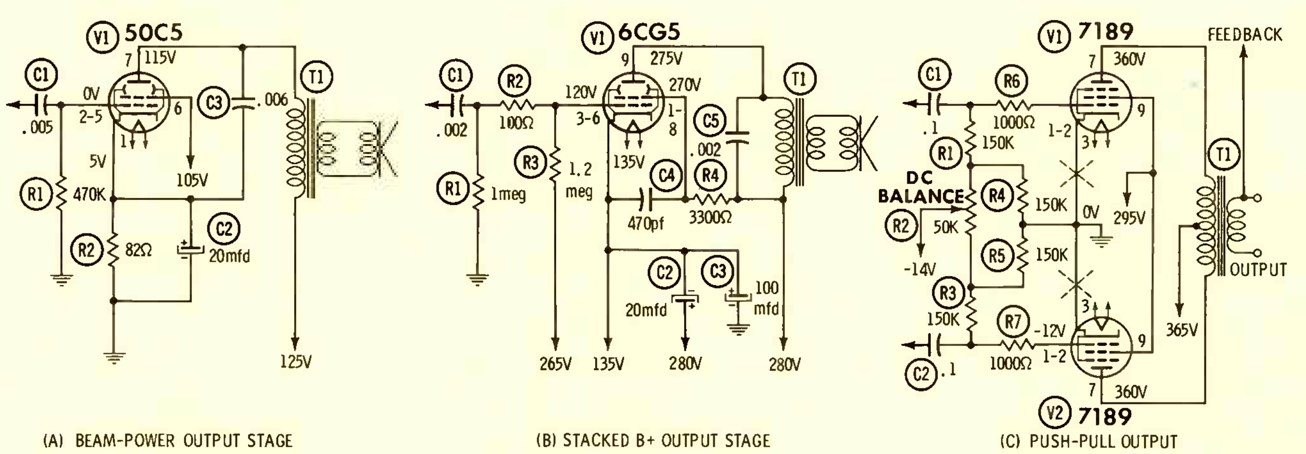

Fig. 8. Tube high-level output stages provide sufficient power to drive loudspeaker—output transformer matches impedances.

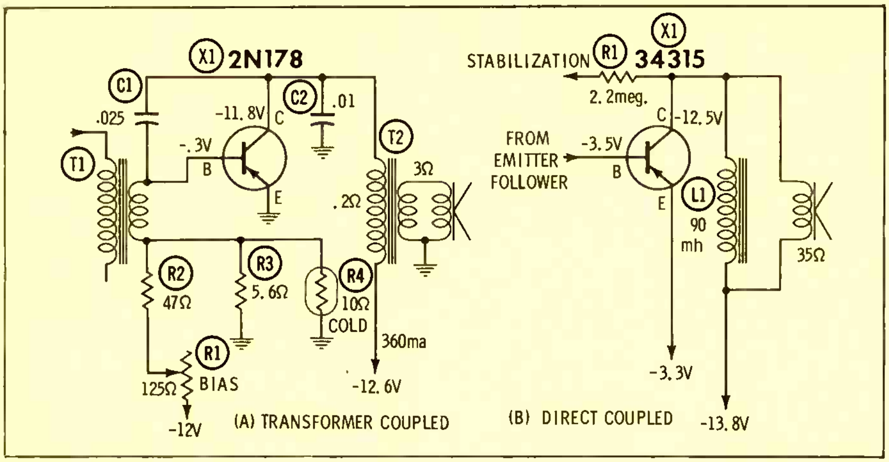

Fig. 9. Single transistor operates in class A for power to drive loudspeaker.

These push-pull stages will operate —with higher distortion and lower output—with only one side of the circuit functioning. Don't be surprised if the circuit works with one tube dead.

Transistor single-ended output circuits are critical as to bias adjustments for linear operation. Here, voltages are low, and much more information can be gained by using current checks to determine if the amount of current flow is normal. Excessive emitter current indicates that forward bias is too high or the transistor is shorted.

Insufficient emitter current indicates that forward bias is too low or the transistor is open. Components other than transistors are the most common cause of malfunctions; however, the failure of an associated component often damages the transistor. Always be certain that the primary cause of transistor failure has been found. When servicing direct-coupled output circuits such as the one in Fig. 9B, make sure that the cause of trouble is not in the preceding stages.

Since, for maximum efficiency, transistor push-pull output stages are operated class B, proper biasing to prevent crossover distortion is important. This crossover distortion, as is shown in Fig. 1C, occurs if one half of a push-pull amplifier begins to cut off before the other half starts to conduct. Because the percentage of distortion is higher, crossover distortion is much more prominent at low output levels. If R4 in Fig. 9A were to increase in value, or the voltage across X1 in Fig. 10C were to decrease, forward bias would decrease, and crossover distortion would occur. Because the transistors of the complementary-symmetry amplifier (Fig. 10B) are different types, it is difficult to match them. Care must be taken to insure a replacement complements the other transistor's characteristics. Oscillation at a low frequency (which can be mistaken from motorboating) will occur in the circuit of Fig. 10C if one half of the speaker voice coil opens. The feedback path consists of C1, the collector-base negative feedback network of the open side, and the T1 secondary. The same symptom can occur at a higher frequency if X2 or X3 opens. Here, as in single-ended transistor outputs, static current checks may, at times, be more useful than voltage checks; both should be used to get all possible clues as to the cause of trouble.

Conclusion

Although a few different techniques are necessary for servicing the latest transistorized audio circuits, the same basic procedures used for all electronic troubleshooting still apply. A basic understanding of audio circuit theory and test equipment application will enable a service technician to troubleshoot the most difficult audio troubles. ▲

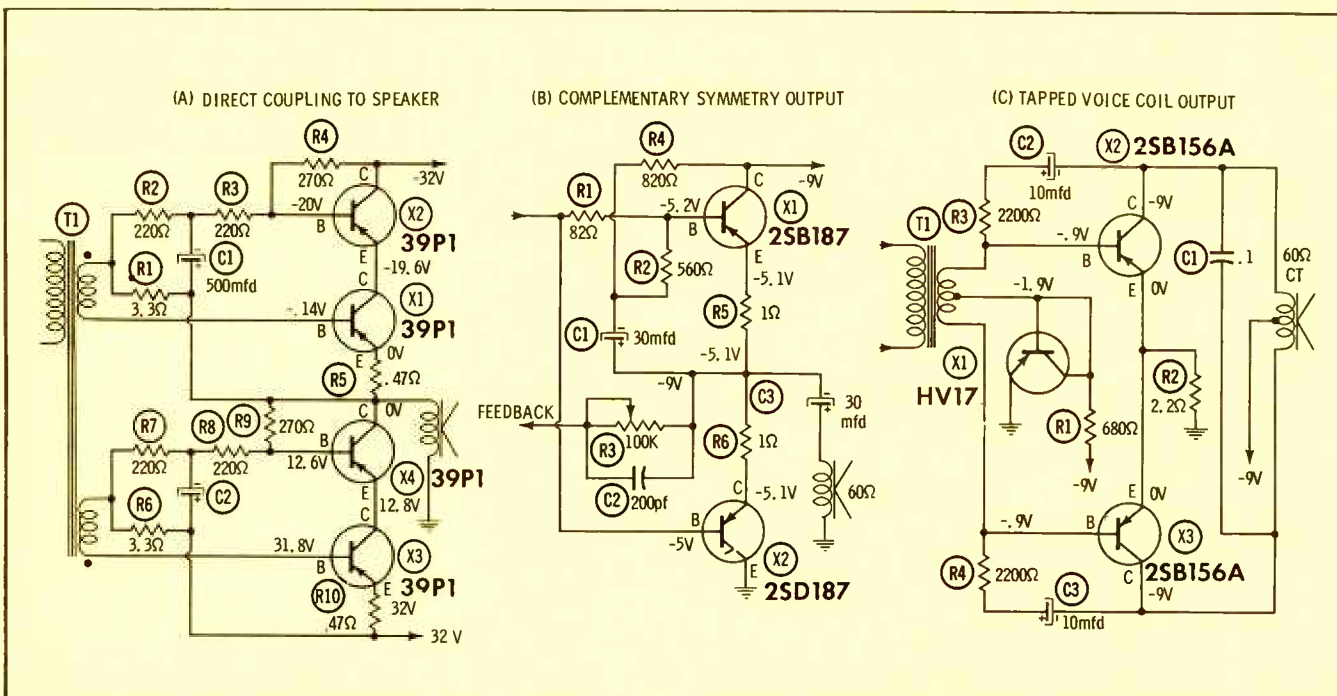

Fig. 10. Transistor OTL stages couple power to the speaker directly or use a capacitor; no output transformer is needed.

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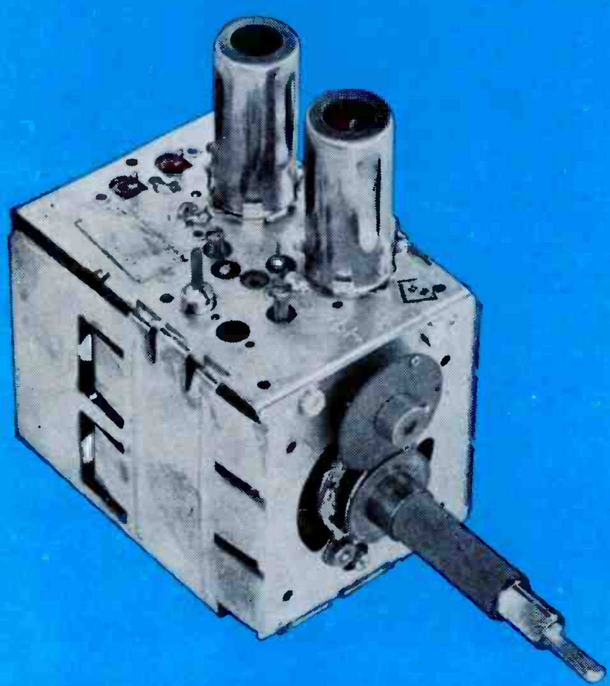

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PHOTOFACT

the magazine of electronic servicing

VOLUME 15, No. 8 *AUGUST, 1965*

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ABOUT THE COVER

The interior of the anechoic room at RCA's Indianapolis plant sets the theme of this month's issue. Speaker tests, such as the one simulated in the cover scene, are but one aspect of the ever-growing field of audio technology.

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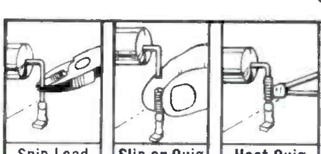

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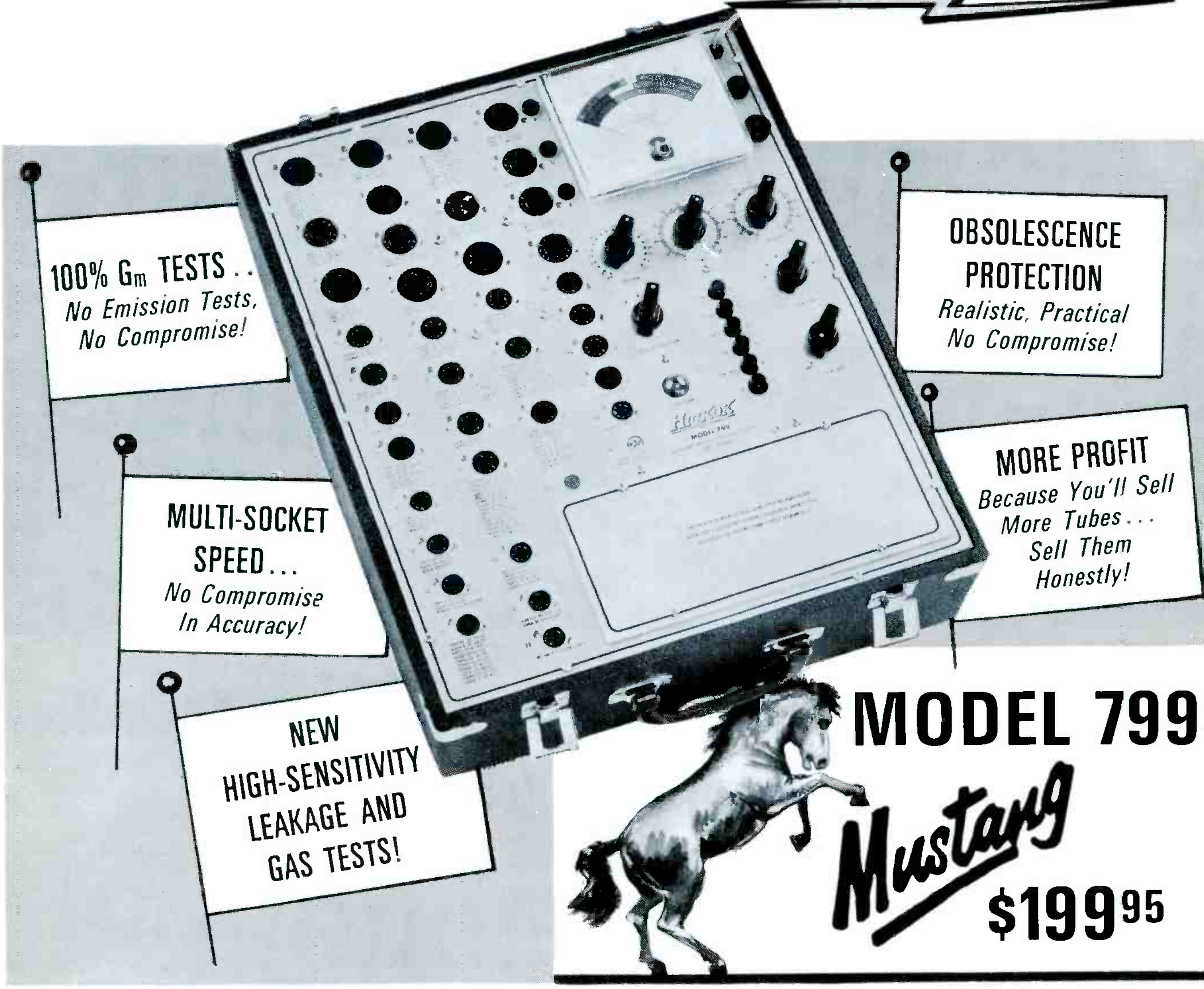

From the laboratories of the world's leading tube tester manufacturer comes the model 799 "Mustang"—a completely new tube tester.

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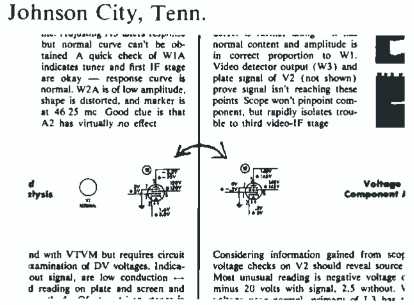
Letters to the Editor

Dear Editor:

In the April 1965 issue, I believe the tube-voltage schematics in SYMFACT Symptoms 3 and 4 should be exchanged. Also, the open connection you say is at terminal 2 of L2 should actually be at terminal 3 or 4. Correct me if I'm wrong. I enjoy SYMFACT, and it's very helpful. Sometimes, however, these errors (though not many) make me dig in to see what's wrong.

ROSS SHIPLEY

Johnson City, Tenn.



I wish we could say we drop in those errors to keep you on your toes, Ross; unfortunately, they slip in despite our best efforts to keep them out. Your discoveries are correct, and the figure herewith shows one way to mark your SYMFACT *sheet and call attention to the switch of schematics. The other error is easily marked; the heading should read* "Open Connection, Pin 3 of L2."—*Ed.*

Dear Editor:

I am interested in writing articles for PF REPORTER. What kind of training does this require? Do you demand special qualifications of your authors? I have been servicing electronics equipment for almost ten years, and feel as if I could pass along quite a bit of information that would be useful to other technicians—especially beginners. Can I write about anything I want to? Or do your articles have to be on specific subjects?

WOOD B. REITER

Somewhere, U.S.A.

This is typical of several letters we've received recently. Qualifications for a PF REPORTER *author include a thorough knowledge of electronic principles, experience in applying these principles and in troubleshooting, and the ability to put your experiences on paper in accurate, readable English. Most of the articles in* PF REPORTER *are staff-written and edited. Those that are prepared outside our staff are usually done on assignment only, and we recommend that you send us an outline of any proposed article before you work up a manuscript. This might save you time and effort because we can frequently give concrete suggestions concerning how to proceed with a particular subject. A letter stating your background and experience will get you a copy of our mechanical-requirements sheet. A sample manuscript would also allow us to offer suggestions on your writing.—Ed.* ▲

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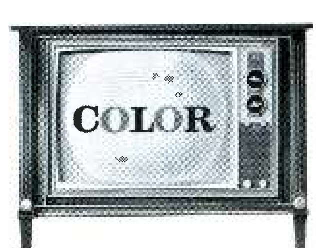

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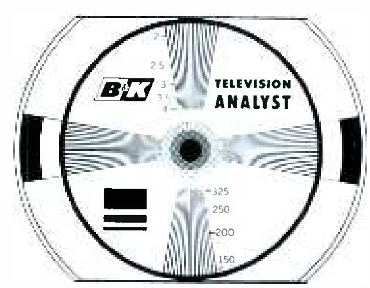

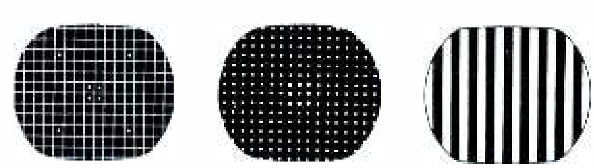

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The Electronic Scanner

news of the servicing industry

Winners of "500" Contest

Three PHOTOFACT 500 Mile Race Contest winners who received deluxe trips to the race in Indianapolis have been announced by Howard W. Sams & Co., Inc.

Winners were Harold Law (right) and Floyd Burch (left), both of Electronic Parts Company, of Denver, Colorado, and

Joe Taylor, (center) Tri-State Electronics, Greenville, Mississippi. These three top salesmen were named from 3000 entries in the national sales contest.

In a four-day trip to Indianapolis, the three winners and their wives participated in a series of race-week festivities that included the "500" festival parade, a VIP tour of the Speedway, and numerous parties and social events.

Broadcasting and Communications

The 30th Annual Report of the Federal Communications Commission gives some idea of growth in the regulated branches of electronics.

Big news of course is Comsat (Communications Satellite Corporation) whose initial $200-million stock issue was snapped up quickly at $20 per share. Half was subscribed by communications carriers and half by the public. Their Early Bird satellite is in use, and by press time Comsat should have filed rate tariffs.

American Broadcasting Co. has already thrown a curve to Comsat and to AT & T; ABC proposes orbiting their own relay satellite for network programs, bypassing both Comsat's spaceborne relay station and AT & T's microwave and long-line facilities. FCC will decide whether or not to authorize this new idea.

Only one aired pay-TV test is in progress—in Hartford, Conn., and no applications are pending. WHCT, Channel 18, Hartford, has about 5000 subscribers and transmits about 30 hours of toll telecasts each week (plus regular free programs). Subscription service over cable, which isn't regulated by FCC, took a beating in California, but the upset has been overridden by a Federal Court Judge who ruled the new restriction unconstitutional. Unless an appeal is granted, pay TV may get a foothold there on the cable system installed expressly for the purpose.

There are 350 television channels now reserved for educational TV (ETV or ITV). At least 14 cities have two ETV channel allocations. About 80 ETV stations are now on the air, not counting translators. Airborne ETV (MPATI) is still underway in the Midwest, although their request for more channels (74, 78, 80, and 82) is still under consideration. MPATI presently uses channesl 72 and 76.

Total commercial television stations authorized are 668, with only 582 of them in operation. Add 1913 translators to this (1415 in operation), and you find nearly 2000 operating and 584 (mostly translators) to come.

Every state has at least one commercial FM station. There are more than 1180 on the air, with 190 more authorized. About 400 of the stations carry subsidiary background music.

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All kits contain the fastest moving parts and information pinpointing the models they're meant for. There are no carryovers from previous years.

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United Delco

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Nearly 300 are broadcasting multiplex stereo programs. Educational FM stations number 243, with another 14 due on the air this summer. There are 3976 AM stations on the air, with 85 more that are authorized but silent for one reason or another.

Safety and Special Radio Services have made spectacular growths. Here are some statistics of transmitters authorized:

Amateur	298,338
Aviation	172,663
Citizen's Band	2,197,302
Industrial Group	1,161,505
Land Transportation	396,211
Marine	195,670
Public Safety	509,800
TOTAL	4,931,489

On the not-so-sunny side, FCC pointed out that they received 27,135 complaints of TVI, 3,725 of BCI, and 7,381 others. Of this 38,241, they investigated 18,922, and received the help of 799 interference committees. They found 480 unlicensed stations and 47 cases of indecent language. There were 2772 violation notices issued to ship stations, 2596 to broadcast stations, 3915 to non-broadcast services, and an undisclosed number of amateurs. There was a net of 8401 new First- and Second-Class Radiotelephone Licenses granted, bringing the total to 145,767 (about 55% of them First's). First- and Second-Class Radiotelegraph Licenses number 15,390.

FCC has had a busy year. And this year will be busy for the licensed 160,000 technicians whose job it will be to maintain those 4,900,000 Safety & Special Services transmitters and the 7476 broadcast stations, not to mention installing the other 901 stations that are authorized.

Staging A Comeback

An old-timer in the television industry, a brand that withdrew from the field a few years ago, is returning. **Hoffman Electronics Corporation,** which produced more than a million sets prior to withdrawal from the television industry in 1960, will be offering color television receivers and solid-state stereophonic phonographs to the public this Fall. The West Coast manufacturer will market its new products to the public through franchised dealers. Color receivers will be utilizing the shallow-depth, rectangular picture tube.

New Building

Antennacraft Co. is now in operation in their newly completed modern factory building located just outside of Burlington, Iowa, on highway 34. It is a steel and concrete structure that

doubles the floor space of the former location. A matching building, now under construction, will again double their floor space.

Color CRT's and Yokes

Color television picture tubes have been receiving a lot of attention lately among the manufacturers of sets. It seems no one can agree if there are too many or too few and of which size you're asking about.

Major companies building color CRT's are RCA, Rauland (Zenith), National Video, Sylvania, Philco, General Electric, and soon Westinghouse. Some produce only for themselves, some only for others, some do both, all depending on what size you're asking about.

RCA, largest source of 21" round color tubes, has gone through several phases of rationing this popular commodity, sometimes amid cries of "overcharging." From a policy of "none to anyone," RCA has progressed through "limited quantities to others" to a "no-limit" supply. Recently, however, the word came out that RCA would again supply primarily its own needs and only limited quantities would be available to others. During the earlier "freeze," other tube makers started building 21" color CTR's but not sufficiently to supply everyone.

On the heels of this announcement was the news that RCA's new 19" rectangular 90° color tube would be available to manufacturers in "sample commercial quantities." This new tube contains a "rare-earth" (Europium and Yttrium) red phosphor of the type pioneered by Sylvania, and also includes improved blue and green sulphide phosphors. These improvements, which result in mainly brighter color pictures, are being incorporated in all RCA color CRT's; the new line is tagged "Hi-Lite." The Sylvania 19" tube, introduced earlier also contains rare-earth phosphors.

General Electric, meanwhile, has started producing what they call "an improved version" of the shadow-mask type—in a 12" size This new three-gun tube incorporates the raster-brightening rare-earth phosphors already mentioned. G-E has tested the new tube in a variety of screen sizes, but production will be limited during 1965.

Sylvania plans to double its color-tube production this year, Admiral is tooling up for pilot production, Philco's plans for their own tubes are far along, and Westinghouse is working on developing their own color CRT's.

Most major set manufacturers are now on the 25" bandwagon, and the tubes for these may develop into a supply problem, since RCA is allocating only beyond their own needs. Rauland (Zenith) and Sylvania are both producing tubes in this size, but it is doubtful they can fill the demand without some of RCA's output. Motorola, meanwhile is rolling along smoothly with their own supplier (National Video) of 23" rectangular color tubes, which they pioneered.

With color picture tubes in such short supply, it seems the replacement market may find itself working primarily with "rebuilt" color CRT's. These are generally tubes that have been regunned, since the phosphor-depositing process is expensive and complicated—approaching new-tube costs.

While color CRT's are in the limelight, over on the sidelines some observers are predicting a scramble for other color parts—particularly yokes, as was pointed out recently in **Television Digest.** Three manufacturers are the main source of yokes for color sets: Advance Ross Electronics, F. W. Sickles Div. of General Instruments, and of course RCA. In a not-too-veiled hint, RCA told color-set manufacturers that good purchasing procedure "includes the development of secondary sources of supply." This includes all types of parts, obviously, but copper scarcities have caused a "run" on suppliers of yokes, who can't seem to get enough raw material to meet the demand. The yoke builders, and their suppliers of copper wire, indicate that set manufacturers are ordering "an unreasonable and unrealistic" quantity of yokes—more, in fact, than they can use.

From all this controversy, however, one thing the service technician and dealer can be sure of: Color television is no longer the "baby" of RCA and the industry; it's big business!

CATV School

Twenty-three CATV operators from all over the country became the 150th class to complete the one-week CATV course offered by the CATV Division of **Jerrold Electronics Corp.** The course covered CATV system design, maintenance, and troubleshooting. Emphasized were Jerrold transistor systems, microwave, and test equipment. Jerrold has been holding classes for the past 13 years. More classes are to be held soon. ▲

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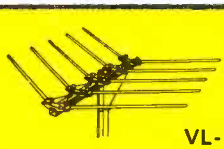

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5 driven elements
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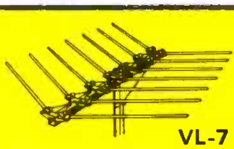

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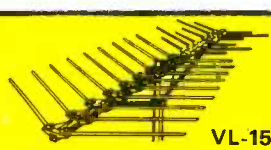

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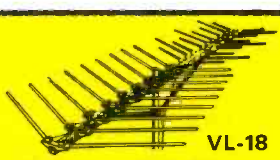

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Circle 14 on literature card

What you should know about TV lead-in before you buy!

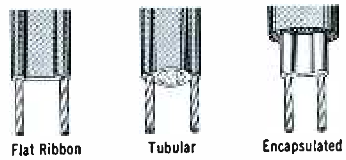
By Roland Miracle
Engineer, Electronics Division
Belden Manufacturing Company
Richmond, Indiana

There are four basic types of cable for TV lead-in on the market today—flat ribbon, tubular, encapsulated, and coaxial. The advantages and disadvantages of each type should be understood before making an installation.

Here, Roland Miracle, electronics engineer at Belden Manufacturing Company's Richmond plant, answers questions regarding the suitability of the 300-ohm twin-lead types and coaxial cable.

Q. *What is the best TV lead-in for most applications?*

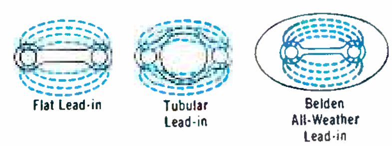
A. The choice is not simply between coaxial cable and twin-lead. This is because there is a great deal of difference between old style 300-ohm line and encapsulated 300-ohm line. Ordinary ribbon lines will give troublesome and inconsistent performance in color or UHF installations.



Q. *What are the differences In 300-ohm line?*

A. Flat ribbon and tubular 300-ohm line perform well at UHF frequencies *only* when they are free from all traces of surface deposits. When these lines encounter dirt, rain, snow, salt, smog, fog or industrial deposits, problems arise. Impedance drops abruptly, and attenuation soars. Ghost pictures result.

Encapsulated 300-ohm line features a low loss cellular polyethylene protective jacket which keeps all surface deposits out of the critical conductor area—regardless of weather conditions. This type of lead-in is made by Belden under the name of "Belden All-Weather Permohm* Lead-In" and is highly recommended for UHF and color installations.



Q. *When and where are coaxial cable installations best?*

A. Coaxial cable systems are preferred where strong interference signals are present. This will usually be an urban location near a hospital, an industrial complex, or other such locations where extreme interference is radiated.

Q. *Are the transmission characteristics of coaxial cable superior to 300-ohm twin-lead?*

A. No! The attenuation of TV signals through coaxial cable is *much* greater than through 300-ohm twin-lead. This higher loss reduces the signal delivered to the TV receiver and makes booster amplifiers necessary at VHF frequencies in all but high strength areas. Coaxial cable systems also require two matching transformers—one at the set and one at the antenna—because all coaxial cables are unbalanced lines and normally have a 75-ohm impedance. TV antennas and receivers are normally designed to use balanced lines having 300-ohm impedance.

Q. *How does the attenuation of Permohm compare with coaxial lead-in?*

A. The chart in the next column compares the values of Belden Permohm (No. 8285) with a typical coaxial line (RG-59U) under similar conditions. Note, how even when enclosed in metal pipe, the encapsulated line delivers a stronger signal than an equal length of coaxial cable under the same circumstances. The difference is even more apparent at UHF frequencies.

Circle 15 on literature card

300 MICROVOLT ANTENNA SIGNAL

Channel 6	
RG-59U	201
8285 in air	261
8285 in pipe	210
Channel 13	
RG-59U	153
8285 in air	231
8285 in pipe	172
Channel 20	
RG-59U	99
8285 in air	195
8285 in pipe	123
Channel 83	
RG-59U	69
8285 in air	162
8285 in pipe	100

Q. *What about cost?*

A. A coaxial cable installation is much more expensive. The cost of a typical 75-ft. coaxial lead-in installation is about $20.00 compared to $7.00 for the best *encapsulated* 300-ohm lead-in. This extra cost results from the higher cost of the coaxial cable plus the extra cost of the two matching transformers. Also, coaxial cable requires carefully made electrical connections which are time consuming and costly.

Q. *Does Belden make all types?*

A. Yes. Belden offers the most complete line of TV lead-in, including coaxial cable. However, because of the many superior transmission characteristics of Permohm 300-ohm line, it continues to be the best lead-in for 90% of all TV installations. Ask your distributor about Belden Permohm.

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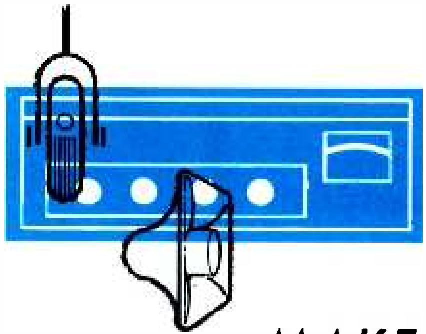

MAKE MONEY IN RENTALS SALES LEASES

A path to profits in audio systems.

by Thomas R. Haskett

Lots of people—merchants, educators, political candidates, etc.—need to reach the public through sound and public-address systems. Providing the equipment for these requirements can be a profitable addition to a service business. There are three general ways that audio gear is handled by a service shop: short-term rental, long-term lease, and outright sale.

Rental

It's likely that if a client is going to use your equipment for only a few days he will be renting. it. Enterprises that are likely prospects for sound and public-address (PA) equipment rental include any activity of a temporary nature. For instance, church bazaars and bingo parties, company picnics and beach parties, jazz festivals, band concerts in the park, and religious revivals all are naturals for rental arrangements.

At a small company picnic where it is necessary only to provide music and a microphone for speeches and announcements, the client normally will request only that you deliver the equipment to the site, hook it up, assure him that it's working, and then pick it up when he's finished with it. If the equipment is relatively uncomplicated, he will probably provide an operator. Your responsibility is merely to furnish working gear.

The situation is different, however, at a large political rally or an important commercial venture (such as an outdoor symphony concert). Here the client is not merely concerned that the equipment works; he wants his PA coverage to be handled properly. Thus, he will be glad to pay for the services of a technician to set up the gear and operate it to provide the best possible coverage of the event.

Leasing

When a client desires the use of sound equipment for more than about a week, the arrangement is generally referred to as a lease. Most leases involve rather extended periods of time (months or years), but there is no rigid rule except that the longer the customer desires the equipment, the lower the lease rate is. A client may, for example, wish to install a background-music and paging system in a restaurant that he has leased and is operating. Since he doesn't own the restaurant, he may not want to buy the sound equipment.

It goes without saying that when you rent equipment it must be kept in working condition. It is unlikely that an amplifier will develop trouble during a three-day period of use, although it's a good idea to have spare units on hand for immediate replacement in case trouble does arise. When it comes to a lease lasting several months, the spare equipment becomes mandatory, because part of your lease contract will include a provision that you service and maintain the equipment and insure continuity of service.

Sales

When an audio shop rents and leases PA gear, it is natural that some customers will come to the shop when they are thinking of purchasing such equipment. Some dealers use the lease-purchase plan, which allows the client to apply a portion of his lease fees toward the eventual purchase of the item. If a new amplifier is purchased, it carries a manufacturer's guarantee; however, if the same amplifier is leased with an option to purchase, the guarantee may expire before the client actually buys the unit, and it's your duty to make this point clear to him. On-hand used equipment, which is leased and later purchased, carries no guarantee unless you choose to guarantee it yourself. Some shops offer rebuilt and reconditioned amplifiers with a 30-day guarantee. This often encourages a sale, but yet isn't burdensome or expensive for the dealer.

Still other shops sell the equipment and a maintenance contract along with it. You should point out to the customer that in a commercial venture he may be losing money if his equipment fails and he can't get it repaired in a hurry. Your job will then be to check it out periodically and anticipate trouble, as well as to be on call for emergencies.

Equipment Involved

To engage in audio rental, lease, and sales, you must maintain a certain amount of equipment on hand —ready to go at a moment's notice. For outdoor work, you'll need several horn-type radiators and their associated drivers. Matching transformers designed for use with 70-volt lines are necessary, and of course you'll need several rolls of speaker cable. You may find that indoor jobs can be done with horn speakers. However, if you are going to engage in musical concerts, sealed enclosures of the high-fidelity type are a much better investment, as they have a broader frequency response.

Two types of amplifiers are useful in sound and PA work. The first, and older, is the integrated amplifier with two or three built-in microphone preamplifiers. You can obtain this type in power outputs from 12 to 150 watts, with 30 or 40 watts being the most useful size. These units include a phono input for a crystal or ceramic (high-level) phono cartridge; they have constant-voltage output and 4-, 8-, and 16-ohm taps.

The other type of amplifier consists of a mixer-preamplifier and a power amplifier. The preamplifier may have from three to six microphone inputs, a tape input, and a magnetic-phono input. A cathode-follower output stage provides about 2 volts RMS, and the unit sometimes is equipped with a VU meter. Along with the mixer-preamplifier, you'll need a power amplifier designed to work with the mixer. The amplifier generally has a single input, which requires about 1 or 2 volts RMS to drive it, and the various constant-voltage and low-impedance outputs for speakers.

The advantages of the preamplifier-amplifier arrangement are that the inputs are more flexible and as many power amplifiers as desired can be added. For instance, when installing the sound system for a jazz festival, it's not unusual to have six or eight microphones in use at various times. In such cases, two mixer-preamplifiers would be used, with their outputs connected in parallel across a buss feeding several parallel-connected power amplifiers. Each PA then drives its own bank of speakers. This parallel arrangement offers the additional advantage of redundancy: If any single amplifier failed in service, the rest of the system would continue to function, and if necessary, you could use the remaining power amplifiers to drive the extra speakers (at a slight reduction in volume).

When the client desires music on location, some shops still rent or lease phonographs or turntables for use with PA amplifiers. But the cartridge-tape recorder is more practical, especially where nontechnical personnel must operate the system. You can buy prerecorded tapes and wind them on cartridges, or you can dub your own tapes from discs. Sometimes the customer will want a sales message recorded for use at a display; in this case a repeating cartridge is used.

Cartridge-type players are available for vehicular use, and this is another possibility for your service. Any type of truck or automobile which can be fitted with rooftop carriers and horn speakers can be used as a mobile sound truck. All that is required is the addition of a transistor amplifier and a cartridge-tape player, powered by the car battery. Such a vehicle is useful in political campaigns, sales promotion drives, and many other similar events. Movies are sometimes promoted prior to their local opening by such a truck displaying posters and playing a cartridge which contains a radio spot announcement or a portion of the sound track of the movie.

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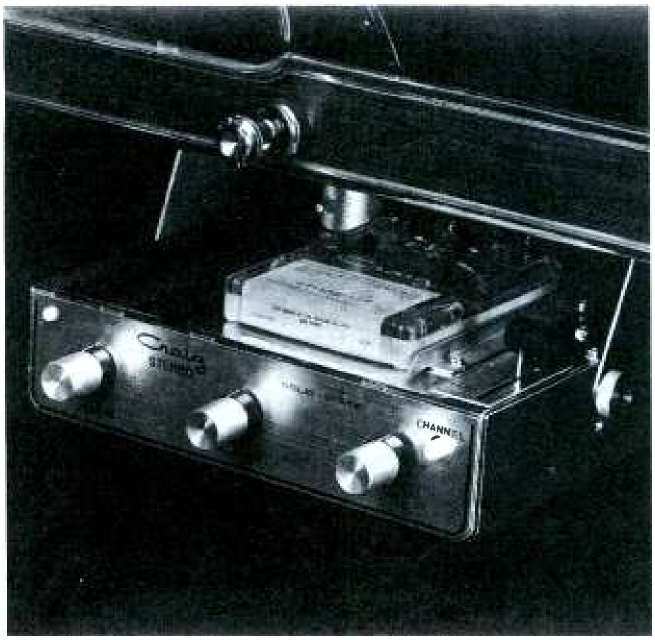

Cartridge-tape recorders are available for automobile use.

Company picnics are a good prospect for audio gear rentals.

STEREO with Transistors

Solid-state amplifiers are now the word.

by Leo G. Sands

Solid state hi-fi is not new. Almost a decade ago, a 20-watt all-transistor hi-fi amplifier was placed on the market. It could be operated from AC or a 12-volt battery; it would even operate at reduced power from a 6-volt dry-cell battery. However, it wasn't a commercial success because some audiophiles contended that its performance was not equal to that which could be obtained with tube sets. It was also prone to output-transformer failures.

But, that is "ancient history," and much progress has been made since those early days. The output transformer has been eliminated, and many audio experts now claim that "transistor sound" is better than that produced by tubes. The availability of suitable transistors is no longer a problem, and transistor costs are much lower.

There are two basic types of so-called solid-state stereo receivers (which are also called tuner-amplifiers, since the FM tuner and the stereo audio amplifiers are packaged together in a single unit), hybrid and fully solid state. One such hybrid, for example, uses a 6HA5/EC900 tetrode tube as an RF amplifier, a 6CW4 nuvistor tube as the mixer, and another 6CW4 as the local oscillator. The rest of the receiver employs diodes and transistors throughout. No tubes at all are used in the fully solid-state receivers.

The hi-fi enthusiast, like the typical automobile owner, often wants the latest and the best. Conventional tube-type equipment, regardless of how good it is, is "old hat" in the minds of many, as evidenced by the ever growing demand for solid-state equipment.

The service technician is now faced with the reality of having to service solid-state stereo equipment. This service can be quite easy provided the right test equipment is available and sensible precautions, applicable to all transistor equipment, are employed.

Since very few prospective customers need stereo equipment operable from a 12-volt battery, design engineers are not restricted by voltage limitations. Even so, the operating voltages are considerably

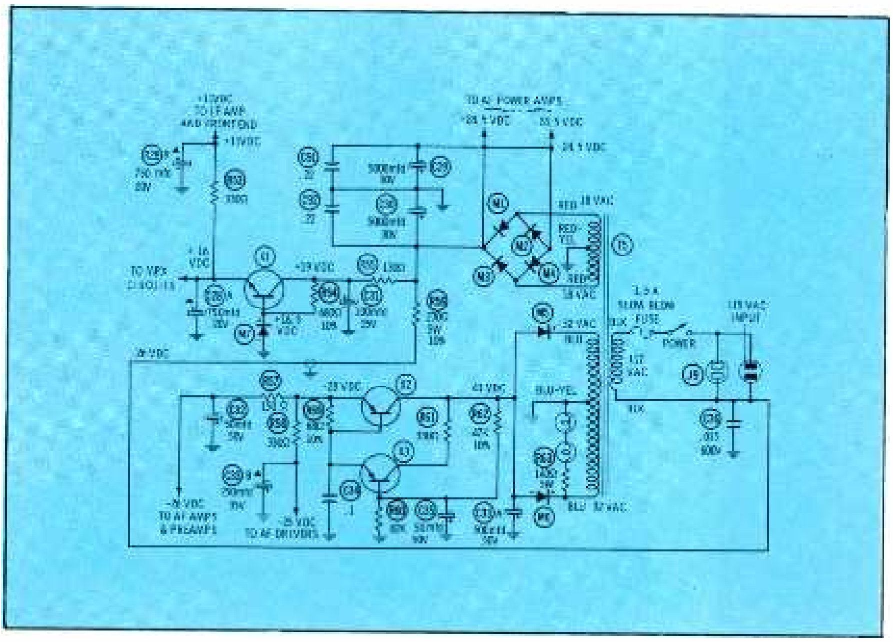

Fig. 1. Diagram of power supply used in a fully solid-state stereo receiver.

lower than those required for tubes.

The highest voltage above chassis ground in a typical all-transistor unit is −43 volts. Since there are no DC voltages greater than 43 volts across any component, capacitor breakdown problems are minimized. Furthermore, because of the high efficiency of transistors, compared to tubes, very little heat is generated.

All-Solid-State Stereo

The power-supply section for a completely solid-state unit is shown in Fig. 1. It consists of two power supplies sharing the same power-transformer core. Unregulated DC at +24.5 volts and −24.5 volts for the audio power amplifiers is obtained from a full-wave bridge rectifier. The transformer center tap is grounded in order to obtain voltages of equal but opposite polarity with respect to ground. Note that only half of the total bridge-rectifier output voltage is applied individually to filter capacitors C29 and C30.

Regulated +16 volts DC is fed from transistor X1 to the multiplex circuit, the IF amplifiers, and the front end of the receiver. The transistor regulator is referenced to zener diode M7.

A full-wave, center-tap rectifier (M5 and M6) applies 43 volts DC to the direct-coupled series transistor regulators (X2 and X3) which maintain a constant output voltage of −28 volts. This voltage is reduced slightly by decoupling networks prior to application to the preamplifier and audio amplifier stages.

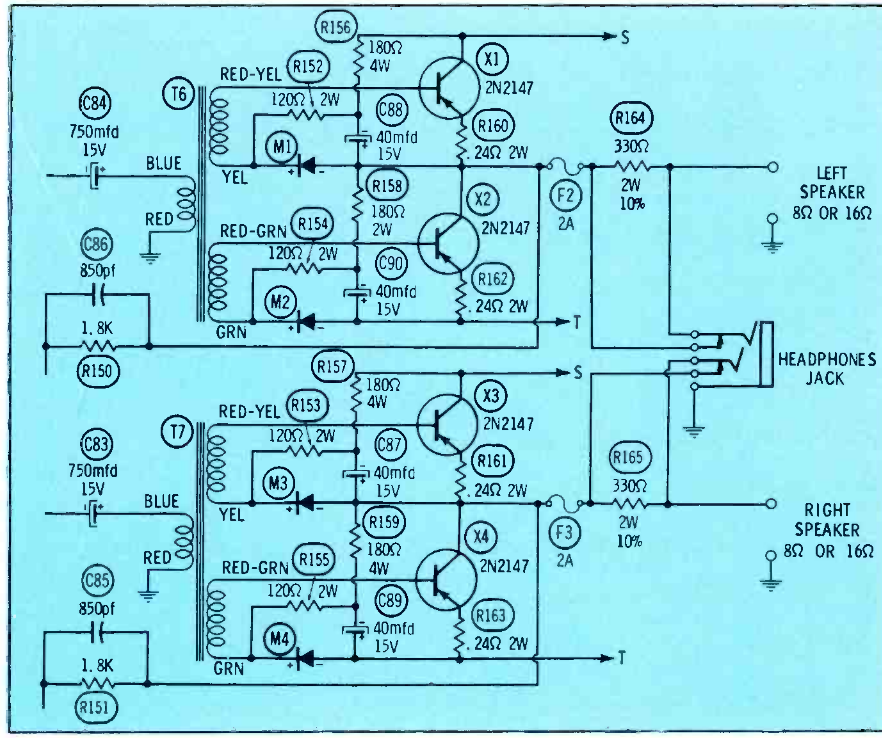

Fig. 2. Power output circuit uses four 2N2147 transistors, but no transformer.

Employing voltage regulators and separate rectifiers insures that heavy instantaneous current surges in the output stages have no effect on the operation of rest of the circuits.

Each audio channel employs a pair of 2N2147 power transistors in the output stages, as shown in Fig. 2. The two channels combined are capable of delivering 112 watts of IHF music power to 4-ohm speaker systems, or 75 watts to 8-ohm speakers. Who says transistors can't compete with tubes?

Notice in this circuit there is no output transformer, which has been somewhat of a bottleneck in hi-fi systems until recently. Since the speakers are not isolated from the DC circuits each speaker network is fused to prevent damage due to inadvertent shorting of the speaker leads. A stereo headphone jack is provided which cuts off the speakers when the headphones are used.

The audio amplifier ahead of the output stages employs 18 transistors and provides ample gain: 3-millivolt sensitivity for magnetic phono cartridges and 180-millivolt sensitivity for tape and auxilliary inputs. Frequency response is ±1 db from 5 to 10,000 cps at 25 watts output per channel, power band-

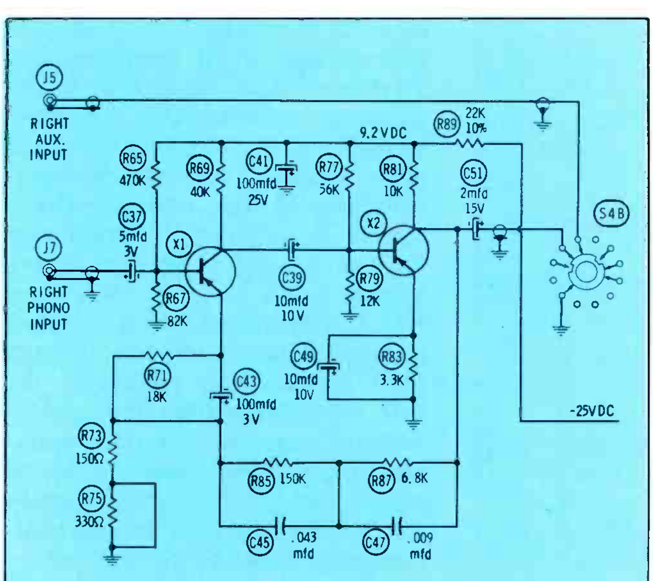

Fig. 3. Preamplifier uses electrolytics for impedance match.

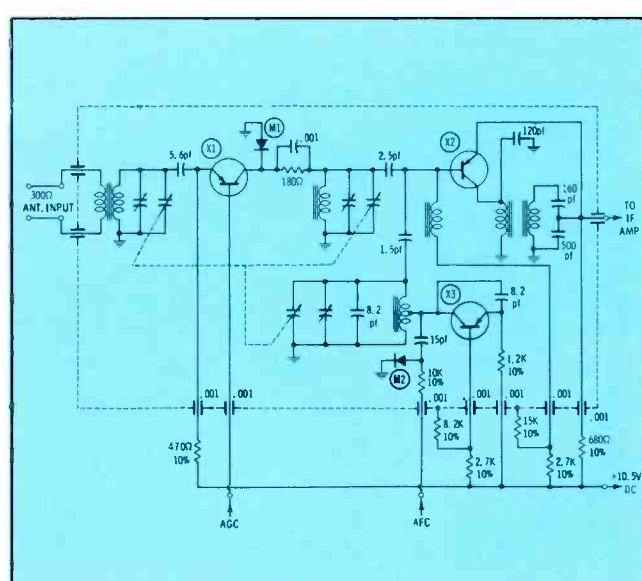

Fig. 4. Solid-state RF section uses three PNP transistors.

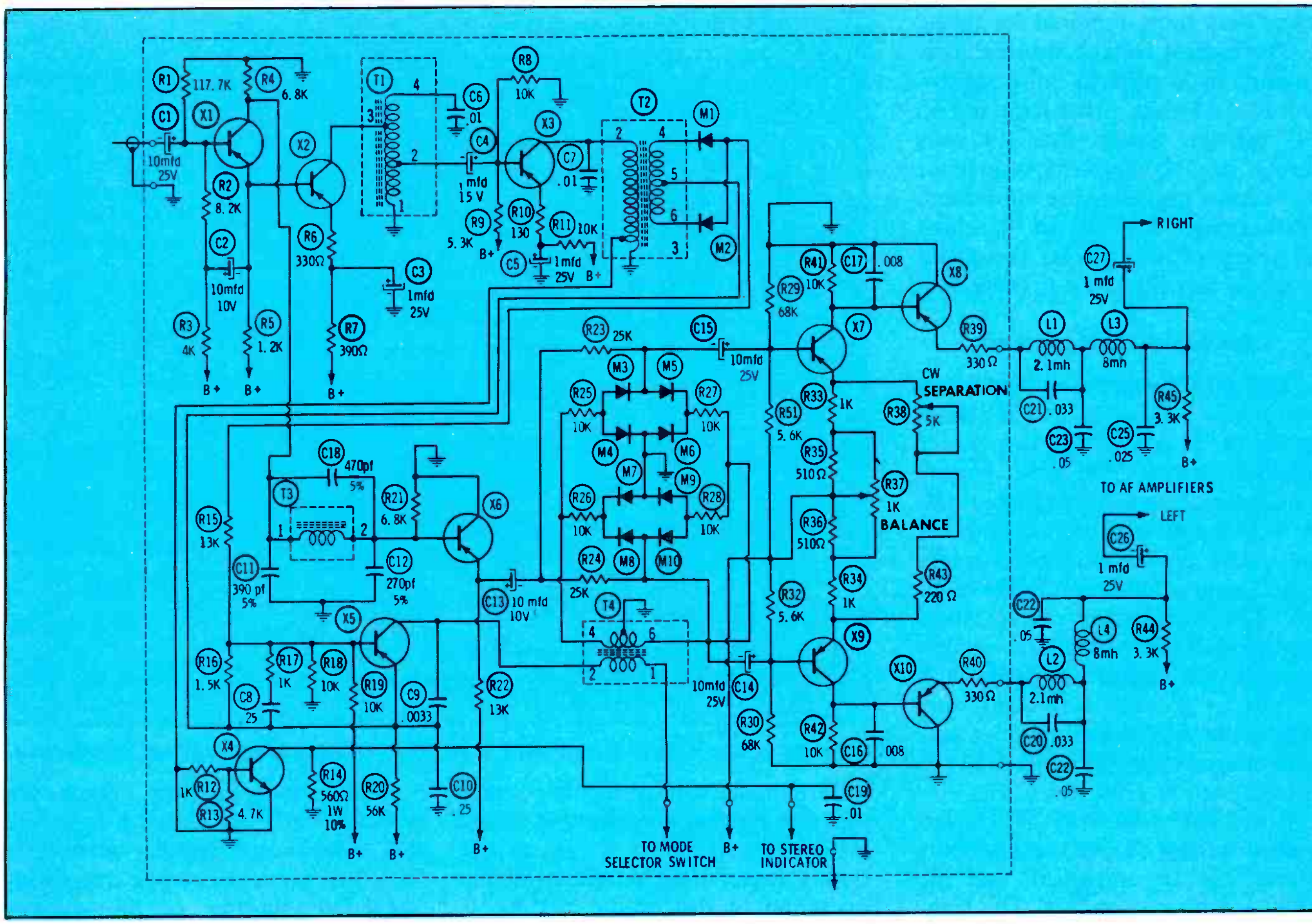

Fig. 5. Multiplex decoder uses a total of ten transistors and ten signal diodes.

width is 8-60,000 cps, and distortion is as low as or lower than that of most good quality tube amplifiers.

The stereo preamplifier uses a total of four transistors (two for each channel). Notice that the phono input is coupled to the base of X1 through a 5-mfd electrolytic capacitor to match the low input impedance of the transistor. The circuit of the right-channel preamplifier is given in Fig. 3.

The front end, as shown in Fig. 4, employs three transistors and two diodes in the RF, mixer, and local oscillator stages. Front-end overloading, even on strong local signals, is prevented by AGC and a shunt diode in the RF amplifier. Sensitivity, nevertheless, is 1.2 microvolts for 20 db quieting and 2.7 microvolts for full limiting and 40 db quieting.

The mixer drives a 4-stage IF amplifier, which in turn feeds a broadband ratio detector. The composite stereo signal from the detector is applied to a printed circuit board which contains the multiplex circuits. This multiplex (FM stereo) unit consists of 10 transistors and 10 diodes, as shown in Fig. 7. The sampling (time-sharing) technique is used for deriving the individual audio signals. The 19-kc pilot signal (part of the composite stereo signal) is amplified by transistors X1 and X2 and is doubled in frequency to 38 kc at the output of X3. This synchronized 38-kc signal is applied to diodes M3 through M10 and used in recovering the L-R information from the double-sideband, suppressed-carrier multiplex signal. The separated stereo signals are fed through transistors X7, X8, X9, and X10 through compensating networks to the corresponding audio amplifier channels.

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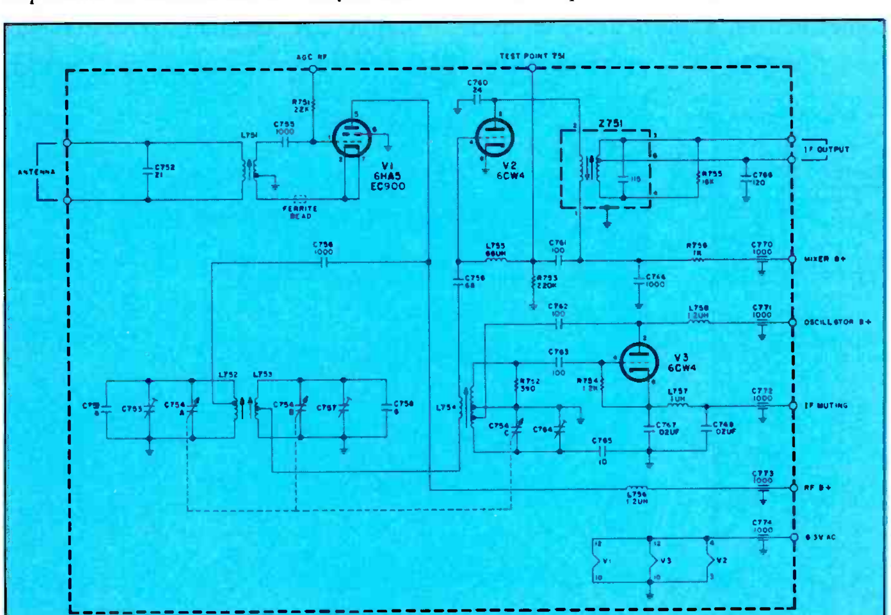
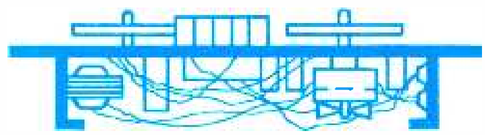


Fig. 6. This hybrid receiver employs tubes only in the FM front-end circuits.

Dirt removal from tape and phono mechanisms.

keep it clean!



by Steve P. Dow

Cleaning tape-recorder and phono mechanisms is an important part of audio-equipment maintenance. As use of a machine increases, regular cleaning becomes all the more essential. Environment has much to do with the amount of dust and grime that accumulates; recorders with fans attached to motors draw in dust with the cooling air. Because dust and heat harden bearing lubrication in time, the motor torque needed to pull automatic record changers through their cycles and run tape recorders at stable speeds is lost. Dirty idlers and belts soon lose their traction and slip causing erratic operation. The critical tension involved in friction clutches is drastically altered as pads become saturated with dirt. Failure of brakes to control fast-moving spools of tape causes breakage and spills.

Tools and Materials

Cotton swabs, available at any drugstore, are good for cleaning mechanisms, and a small wooden typewriter brush is handy for getting dirt out of small grooved pulleys and gears. (Don't use a plastic brush because solvents will melt it.) A supply of clean lint-free rags should also be kept on hand. Standard solvents for tape and phono work are carbon tetrachloride, acetone, wood alcohol, and benzene. Carbon tet is an excellent degreaser and a good rubber solvent. Acetone is a plastic and cement solvent and loosens sealing compounds used to lock mechanical preset adjustments; it also breaks down hard deposits of tape-oxide grime that collects on guides and tape lifters. Wood alcohol is a mild solvent and can be applied to sensitive plastic parts that are attacked by carbon tet and acetone. Benzene is a rubber cleaner and traction surface reactivator.

Use caution with any solvent when cleaning plastic parts; most plastics are soluble in certain solvents. Whenever there is doubt about whether a solvent will melt a plastic, a simple test can be made by dipping a swab into the solvent and holding it against some unexposed area of the part until it dries. If the cotton adheres to the part, the solvent can damage it. Benzene, wood alcohol, and acetone are inflammable—don't keep a large supply on the bench! Work from a two-ounce bottle, and use an applicator; never pour a solvent onto a part or into a mechanism. Rags that have been used with solvents should be kept in a metal container. Whenever using acetone, or carbon tet avoid breathing the vapors. Keep a small fan on the bench to blow the fumes away from your face, and, if possible, keep a window open for adequate ventilation.

Idler Drive Maintenance

Idlers couple motor shafts to flywheels and turntables. Slippage is caused when traction surfaces become hard and shiny after long periods of use; idlers with scarred surfaces or bumps must be replaced. Traction surfaces can be restored by rubbing them with benzene; work the benzene in well with a cloth until all the glaze is gone. A clear idler has a rich carbon-black color. Note the number of spacer washers above and below an idler when removing it; these are used for positioning and changing the height, and could cause trouble if improperly replaced.

Stepped shafts on motors provide the speed selection on most changers and idler-driven recorders; clean these with carbon tet to remove rubber deposits and oil. Never clean motor shafts with the motor running. Threads from the swab or cloth may drap around the narrow sections causing them to bend and introducing flutter and speed problems. Shafts with coiled-spring diameter sections must be cleaned with care so the spring position won't be altered.

Cleaning Belt-Drive Mechanisms

Belts used in recorders are of three types: rubber, rubber-backed fabric, and coil spring. Rubber belts are self tensioning and are made in four forms—grooved, square, and round (commonly called "O" rings). Oil and grease is picked up in minute quantities and absorbed by belts; this makes them soft and causes slippage. Belts can be degreased and cleaned by immersing them in benzene for a few seconds, then wiping them off with a cloth. Tacky, stretched, or cracked belts must be replaced. When a belt is cleaned or replaced, the pulley should be checked to make sure that no rubber deposit is left. Rubber-belt slippage causes small particles of rubber to peel off and adhere to the pulley; the replacement belt then has a tendency to vibrate or grab. Carbon tet cleans and degreases metal pulleys; nylon pulleys should be cleaned with benzene.

Fabric belts are used in machines as slipping clutch devices; they are

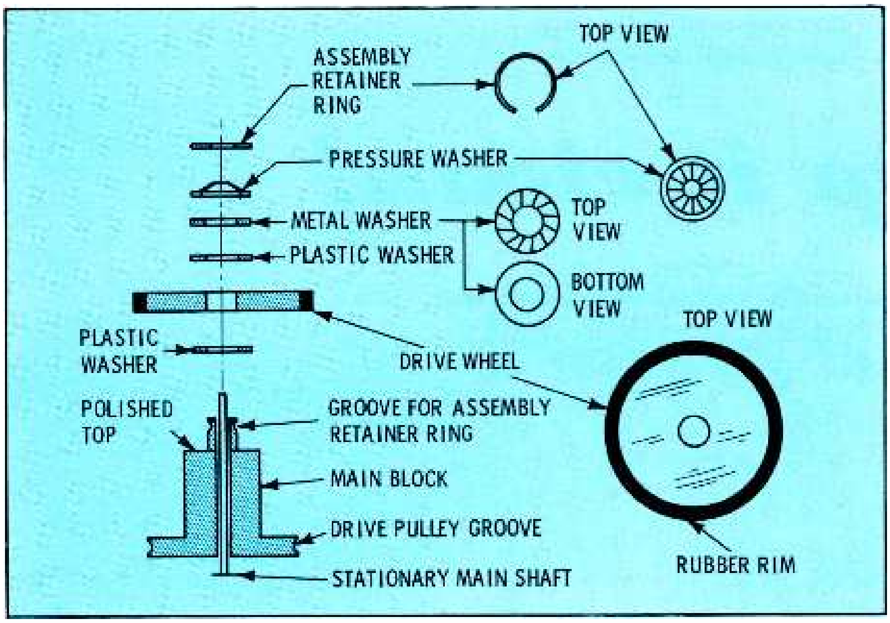


Fig. 1. Blown-up view showing parts of a typical surge-clutch assembly.

not elastic and require tensioning. By changing belt tension, the torque on a driven pulley can be altered. When rubber-backed fabric belts wear out, the rubber impregnates the fabric and slip qualities are lost. It's hard to clean fabric belts because the solvent dissolves the backing; without backing the fabric frays and the belt comes apart. When replacing fabric belts, be sure the pulleys and tension rollers are free of oil and dirt. If they are not, the new belt will soon fail.

Coil-spring belts are quite trouble free but do require cleaning to remove grease and oil. The spring should be dipped in carbon tet and allowed to dry.

Cleaning Brake Mechanisms

Recorder brakes must stop the tape smoothly without spilling or tearing. Dirt and grease cause brakes to work erratically or fail completely. Cork is often used for recorder brakes because it provides smooth braking with little tendency to grab. Apply benzene carefully when cleaning cork brake surfaces so that the glue holding the pad won't be loosened. Some recorders use rubber drums and plastic shoes. Others use rubber shoes with tensioning devices to make braking smooth. Use benzene on metal brake drums; wood alcohol should be used on plastic drums and shoes. When rubber is used in a braking system, clean it with wood alcohol. If the alcohol doesn't restore the surface, use a bit of benzene; apply just enough so that it evaporates in a second. Don't rub it in. Too much benzene will make the brakes grab.

Cord brakes are lengths of cord strung around drums attached to the feed and takeup spindles. The cords are fixed at one end, and the other end goes to spring-tension levers attached to the function-selector system. Metal cord drums are cleaned with benzene and plastic ones with alcohol. Solvents can weaken the cords; wipe them with a rag moistened in water.

Felt brake shoes absorb dirt and become hard. If no replacement pads are available, pry the old pad off and soak it in acetone. Squeeze it dry after a few minutes and then soak it in carbon tet. (The acetone removes the old cement, and the carbon tet removes the grease and dirt.) When the pad is dry, reglue it with a good plastic cement. Don't use a rubber adhesive.

Servicing Clutches

Clutches are key parts of single-motor tape recorders; they drive the takeup reel and apply back tension

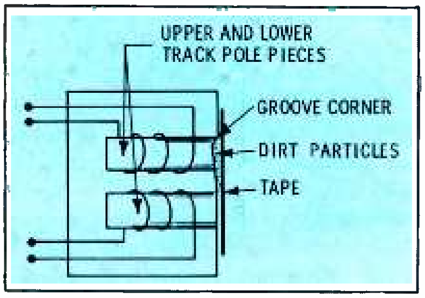


Fig. 2. Grime collection on undercut groove holds tape away from the gap.

to the feed reel. In some recorders clutches limit the surge force applied to the tape during winding and rewinding operations. Friction between two plates of a clutch depends upon the nature of the coupling surfaces, and torque transmitted through a clutch depends upon the force pushing the plates together. If the plates of a clutch get dirty or greasy, tape tension will be changed, and the tape reels will pull too hard or stop altogether.

Felt rings are used extensively in recorder clutches. They are glued to metal plates and rotate against flat metal, nylon, or plastic tables. Clean the metal or nylon clutch plates with benzene. Use wood alcohol on plastic plates. Soak the felt rings in acetone to remove all traces of the old cement; then soak them in carbon tet to remove oil and dirt deposits. When drying the rings don't twist or pull them to remove excess liquid; press them between two pieces of blotting paper. Twisting or pulling wet felt stretches it out of shape. Reglue the ring with a good plastic cement and allow it to set before reinstalling the clutch.

Surge-limiting clutches seldom seize; instead, oil gets inside and makes them slip. This causes tape to slow down near the end of reels during winding and rewinding. Surge clutches must be cleaned with care and reassembled in exactly the same way that they came apart. Clean plastic contact disks, found in some surge clutches, with wood alcohol. Fig. 1 shows the assembly of a typical surge clutch.

Tape-Head Maintenance

Tapes are lubricated during manufacture to reduce friction. New tape has loose particles of oxide that come off and combine with the lubricant to form sticky deposits on the recorder heads and guides. These deposits greatly increase abrasion between the tape and the surface over which it passes. Deposits on the heads keep the tape away from the gap and cause loss of high frequency response. Quarter-track recorders are more prone to trouble from dirty heads than half- or full-track machines. Dirt on a quarter-track head that causes a 10db loss in playback level can prevent the machine from recording

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ShopTalk

by Allan F. Kinckiner

AGC Filter and Distribution Faults

Case histories of how some tough dogs were overcome.

In servicing TV sets, the technician encounters a great variety of resistor-capacitor filter networks used between the AGC source and the tubes controlled by AGC. Typical circuits for this application are shown in Fig. 1. In each circuit, resistors R1 and R2 serve two purposes: They serve as supply routes for the AGC voltage and also help filter out video signals from the AGC lines. The capacitors contribute to the filtering action and also serve as signal-return paths for the input loads of the IF and RF stages.

The RC time constants for any filter capacitor, both charge time and discharge time, must be considered. Charge time is obtained by multiplying C in mfd times R in megohms, where R is the total resistance between the AGC source and the capacitor. Discharge time is also obtained by multiplying C times R, but R is now the effective resistance between C and ground. Notice what an interesting effect this has on the RC discharge time constant on the RF filter in circuit F.

Another factor involved in the circuits is the magnitude and type of signal present at the AGC source. When AGC is derived from simple AGC, the source has a relatively small signal of detected video. With peak AGC, the video signal at the source is slightly larger. The two sources supplying supplemented AGC are out of phase, although both develop negative voltage; this out-of-phase combining makes for a relatively clean source of AGC. When the source is keyed AGC, it not only has a greater amount of video signal, it has high-level horizontal pulses that must be filtered out.

Circuit G has a noteworthy oddity. As used in a mid-fifties Andrea, the resistor and capacitor shown in dashed lines cleaned up the horizontal keying pulse at the source, the plate of a keyed-AGC stage. Some recent RCA receivers with keyed AGC use a similar arrangement; the networks reduce harmonic hash that might be present on the keying pulse. The circuit shown in Fig. 1H is used in many models by Westinghouse, and in a few models by many different set makers. It also has a cleaner voltage at the AGC source.

Values of the resistors and capacitors in the filter networks are determined by a great number of variables. In general, the RC time constant should be large enough to filter out efficiently the lowest-frequency signals on the AGC lines, but the time constant must also be small enough to permit the DC charge on the capacitor to adjust to changing DC levels at the source without excessive time delay—the speed with which DC on the capacitor follows DC at the AGC source determines the ability of a receiver to maintain a reasonably constant signal at the video detector despite fluctuating or fading of received signals. However, if the RC time constant is too short, the network is inefficient at filtering the lowest-frequency signals present at the AGC source. If these low-frequency signals, particularly the vertical-sync pulse trains, are impressed on the IF and RF stages, they cause, at worst, vertical-sync instability or, at least, raster shading.

Larger network RC time constants result in better pictures without raster shading and also improved vertical locking. But fading or fluctuating signals at the antenna will present contrast fluctuation at the picture tube; a prime example of this condition is the "airplane flutter" common to some early-model receivers.

It is interesting that if the charging time constant and the discharging time constant are nearly equal the picture flutter is worse than if there is considerable difference in the two time constants. For example, in early receivers using the network in Fig. 1A, the charging time constant of the IF AGC was R1 (1.5 meg) times C1 (.22 mfd), or .3 sec. The discharging time constant equalled C1 times the sum of R1 plus the resistance looking into the AGC source. Since the resistance of the source was only five thousand ohms, the discharge-time constant was practically equal to the charging time constant. With this network

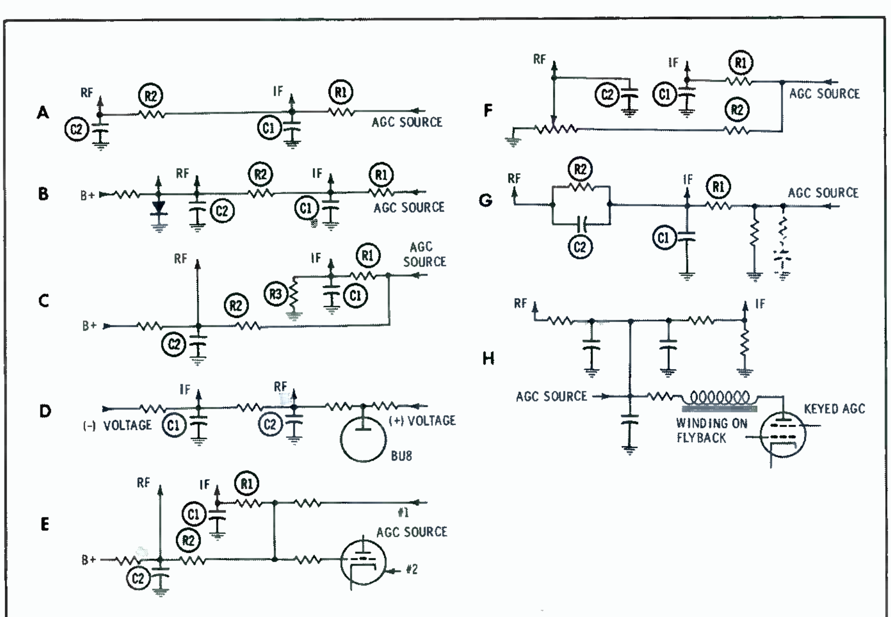


Fig. 1. Schematics of common AGC filter and voltage-distribution circuits.

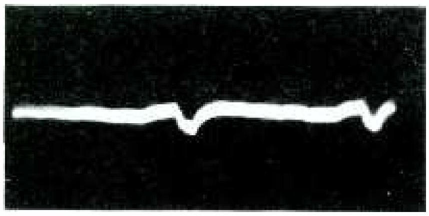


Fig. 2. One-and-one-half-volt unwanted signal on IF AGC line in Motorola set.

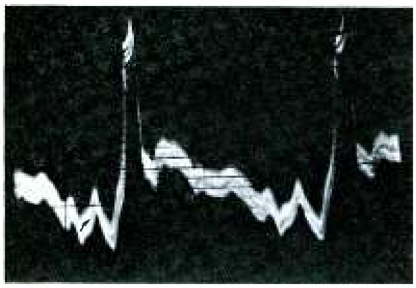


Fig. 3. One-volt unwanted signal was found on AGC line of Bendix receiver.

in a simple AGC circuit, annoying airplane flutter was invariably present. When the same network was used in a peak AGC circuit, the source resistance was increased to 1 meg. Under this condition the charge time remained the same as before, but the discharge time became .55 sec. With the discharge time greater than the charge time, the picture flutter was greatly reduced. In the circuit of Fig. 1C, R1 is 1.8 meg, C1 is 1 mfd, the charge time constant is 1.8 sec, and the discharge time is only .15 sec (since R3 is only .15 meg). With this circuit, used in many late-model Admirals, contrast flutter is negligible even in the face of fading signals.

It must be clarified that the time constant applying to an individual RC combination is not necessarily the time constant characteristic of the AGC. The latter is a result of combining the time constants of all RC combinations in the circuit and is a measure of the speed with which overall sensitivity will respond to changes in received-signal level. Nonetheless, the preceding explanations should be helpful in understanding the effects of defective AGC filtering.

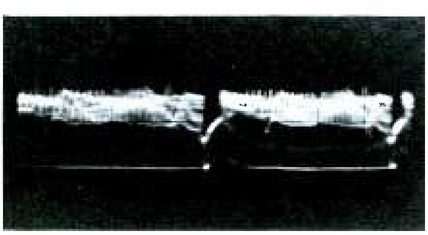


Fig. 4. Video-detector signal in Bendix; note distorted vertical back porch.

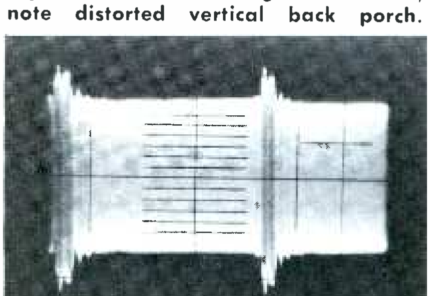


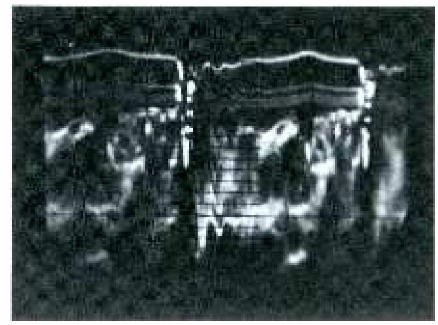
Fig. 5. Hash signal on AGC line during white-out due to open filter capacitor.

Filter Troubles

Filtering of the AGC voltage will be impaired if any of the numbered resistors in the Fig. 1 circuits changes value severely, but the major cause of poor filtering is defects in the numbered capacitors. The effect of an open or low-capacitance defect naturally varies from case to case, depending on four factors: 1. type of AGC involved, 2. gain of IF stages, 3. location of open filter (on IF or RF line), and 4. amount of residual or other capacitance bypassing the open filter. In addition to symptoms on the screen, the open capacitor also causes distortion in sync and video waveforms and permits the presence of unwanted signals on the AGC line. In fact, some milder effects of filter troubles are more recognizable on scope traces than by the marginal trouble produced in the picture.

Critical vertical locking is probably the mildest trouble that can result from an open AGC filter. In one Motorola TS-292, the critical locking was accompanied by occasional vertical jitter. Scoping the AGC line—after almost everything else had been checked—revealed the signal shown in Fig. 2. This model uses a circuit similar to Fig. 1A, and the offending capacitor corresponds to C1 in that circuit. A Bendix with the same symptoms plus intermittent top hooking was found to have an intermittently open filter in the same location. This set uses the same Fig. 1A circuit with simple AGC, but the unwanted signal on the AGC line appeared as in Fig. 3. The big discrepancy between Fig. 2 and Fig. 3 is probably due to the isolation networks used at the return ends of the IF-transformer secondaries. The Bendix set also had distortion on the detected video signal as in Fig. 4; no corresponding distortion was noted on the Motorola video-detector signal. The

A



B

Fig. 6. Horizontal bars only appeared at top of picture in Westinghouse set.

distorted back porch of the vertical sync, apparent in Fig. 4, is one of several distortions found there in almost every case of open AGC filters.

Intermittent white-out on one Sylvania 518 was also traced to an open AGC filter. When the picture whited out, the scope indicated the signal disappeared at the video detector; this definitely localized the trouble to the IF and RF sections. The circuit fault was so touchy that

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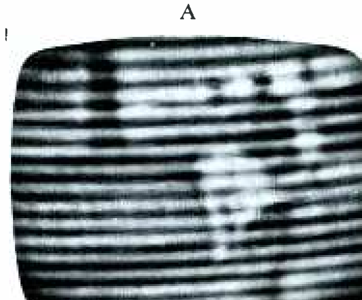
A



B

Fig. 7. More severe bar conditions appearing in some RCA TV receivers.

Testing

by Robert G. Middleton

Fourth in a series of square-wave-testing articles, this installment in our "Advanced Service Techniques" department takes up the analysis of RC combinations by square-wave testing procedures. Following an introductory article on the square wave itself (April 1965 PF REPORTER—"Advanced Techniques for Future Servicing"), the first three testing articles covered resistance, inductance, and capacitance. In articles that follow, you will learn how to use the knowledge gained from these first articles to analyze three-terminal networks that contain combinations of all three—resistance, inductance, and capacitance. When the only visible portion of a component pack is a set of three leads, these special tests are one of the few ways you can identify what's inside or what may be defective inside.

The techniques outlined can be carried out properly only with a triggered scope of the variety described in the March 1965 PF REPORTER article "Learning About Triggered-Sweep Scopes." Few service shops have such an instrument available; they are found mostly in television broadcast stations, electronic and research labs, and of course a few truly forward-thinking shops. If you can find any way to gain the use of such a scope, for even a few hours each month, take advantage of the opportunity to familiarize yourself with its operation and to practice the testing techniques we're outlining in this series. The time will come when much of your servicing work will require a scope like this; a lot of your present troubleshooting could be greatly simplified by a high-quality triggered scope on a rollabout cart in your shop. Future articles, in addition to showing you how to test component combinations of the ordinary and microcircuit variety, will teach you to use a triggered-sweep scope for regular troubleshooting in television and stereo receivers, where the ability of a fast-rise triggered scope to reproduce faithfully every "squiggle" in a waveform can speed your circuit analysis tremendously.—*The Editor.*

We have seen how various types of resistors, capacitors, and inductors respond to square-wave voltages. If the applied square wave has a long rise time, a wire-wound resistor responds in the same manner as a composition resistor. On the other hand, if the applied square wave has a short rise time, the reproduced wave shows the presence of inductance in a wire-wound resistor. Again, if the applied square wave has a long rise time, a high-capacitance potentiometer responds in the same way as a low-capacitance potentiometer; but if the applied square wave has a short rise time, the reproduced wave shows the presence of objectionable capacitance in a high-capacitance potentiometer.

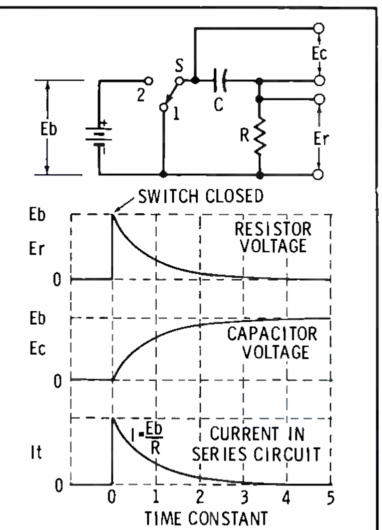


Fig. 1. RC circuit with charge waveforms across capacitor and resistor.

We have also seen that when a square wave with a long rise time is applied, a paper capacitor will respond as a mica capacitor. However, when a square wave with a short rise time is applied, the reproduced wave shows the presence of inductance in a paper capacitor. In general, the larger the paper capacitor is, the more inductance is found by a square-wave test. Furthermore, test leads were seen to have appreciable inductance and capacitance in short-rise-time tests. Hence, it is necessary to keep test leads short when making a square-wave test of any component.

RC Circuit Response

It is helpful to develop an understanding of square-wave testing by analyzing circuits which have "perfect" components. We will limit our tests at this time to circuits which comprise composition resistors and mica (or ceramic) capacitors. In turn, the reproduced square waves will show the response of simple *circuits,* in which the resistors and capacitors are "perfect" from a practical viewpoint. Accordingly, the shape of the reproduced square wave will obey simple theory, unless a capacitor or resistor is defective. We shall also see how departures in waveshape indicate which component is defective, and what the particular defect may be.

Before going any further, it's a good idea to review RC circuit theory. In Fig. 1, S is initially at contact 1. C is completely discharged, and there is no voltage

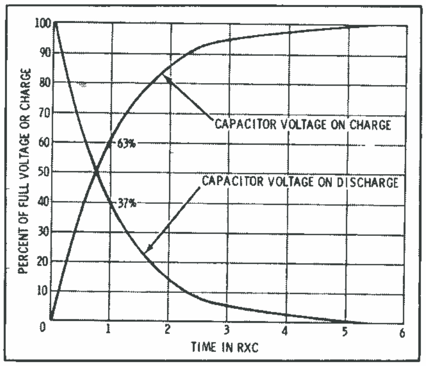


Fig. 2. Graph shows charge and discharge percentage vs time constant.

across R. S is then switched to contact 2; as the graph shows, current instantly increases to maximum value and is limited only by resistance R. As Fig. 2 shows, in one time constant (TC)—which is equal to resistance, in ohms, multiplied by capacitance, in farads — C will charge to 63.2% of voltage Eb. Consequently the voltage across R will decrease from EB (at 1TC) to 36.8% of Eb. Ec will increase and Er will decrease until, at 5 TC, Ec will for all practical purposes equal Eb.

The battery and switch form a very simple square-wave generator. To further explain RC circuit action let's use a conventional square-wave generator as is done in Fig. 3. Here the square wave switches symmetrically above and below zero voltage. Square-wave frequency has been selected for a value that allows C to charge to peak voltage during T (each half of the square-wave period). In other words, T equals 5 TC.

Voltage across C (Fig. 3) has a very rounded leading edge; in fact, the leading edge resembles that of a sine wave. If the voltage across C were used, the circuit would be called an *integrator*—to integrate means to unite. Since the capacitor

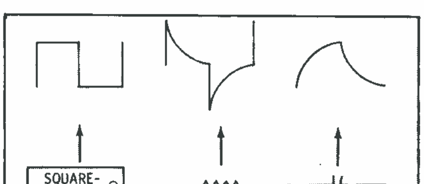


Fig. 3. Waveforms across resistor and capacitor with square wave applied.

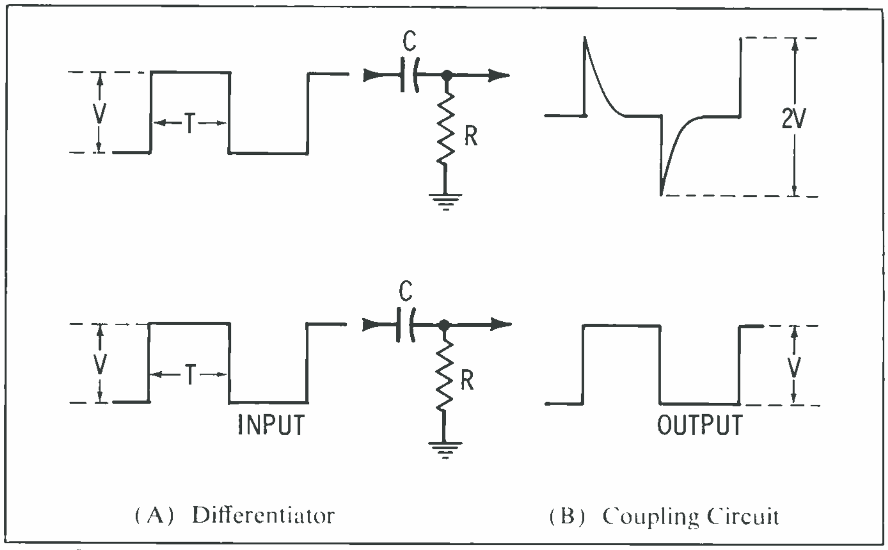


Fig. 4. Time-constant versus duration of waveform determines circuit function.

offers little impedance to the high-frequency elements of the square wave, they appear across R. Because C's impedance increases as frequency decreases, the low-frequency elements appear across C. As TC becomes longer with respect to T, the output of the integrator becomes closer to pure DC; the parts are summed. If the input waveform is AC, the alternate halves will cancel and there will be zero DC voltage remaining across C; but if the input is DC or has a DC component, C will charge to the DC voltage.

Because the highest-frequency elements appear across R the waveform has a very sharp leading edge. When the resistor voltage is considered as the output, differentiation—which means to break up into small parts—of the waveform takes place. In contrast to the integrator, the square wave is broken into a series of frequencies with maximum amplitude developed at the highest frequency elements. As Fig. 4A shows, the resulting waveform is a spike with the leading-edge rise time determined by the highest frequency, and the lagging edge determined by the circuit TC. Note the fact that the peak-to-peak voltage across R is twice the peak-to-peak square-wave voltage. Yet as was shown in Fig. 3, Kirchoff's law holds true; at any instant the sum of the voltages around this network equals zero.

Differentiation will not take place if the circuit TC is more than 10 times as long as T, because C will not have time to assume any significant charge. Instead, this circuit can be used as a coupling circuit as Fig. 4B shows. Often compromises have to be made in circuit design, and some differentiation of low-frequency square waves occurs as is shown in Fig. 5.

Rise Time of Applied Square Wave

The preceding facts are comparatively well known. However, it is worthwhile to review these basic principles to reassure the beginner who is tackling square-wave testing for the first time. Next, we must ask how the *output voltage* from a differentiating circuit may depend upon the *rise time* of the applied square wave. We shall find that there are situations in which the applied square wave may be considered "perfect" (as in Fig. 3), but that there are other situations in which the output amplitude is lowered. If we do not understand how the output amplitude is related to the rise time in various practical situations, we will arrive at false conclusions.

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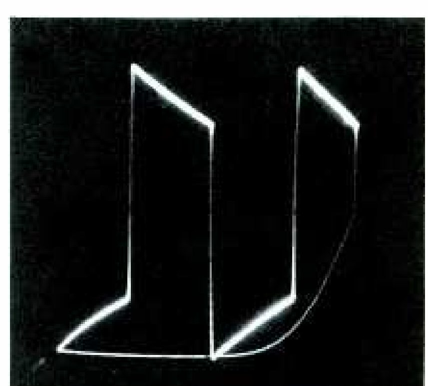

Fig. 5. Differentiation limits the low-frequency response of coupling network.

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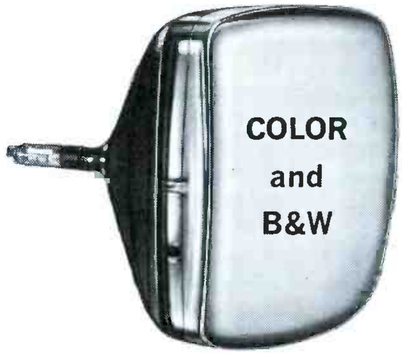

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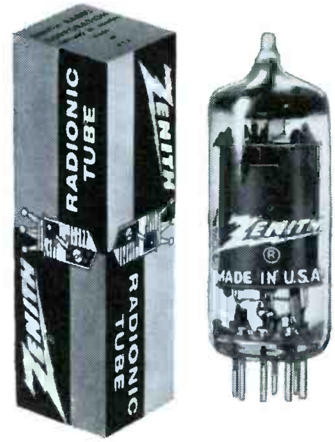

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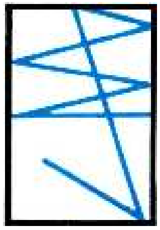

ACOUSTICS can be measured

Quantitative ways to judge room "response".

by Don Davis

The two components of a sound system that normally remain untested are the speaker system and the acoustical properties of the environment. To fully engineer a sound system, the characteristics of the space where it will be used must be considered, and the system adjusted to give the best possible performance in that space. The characteristics of sound in a confined space are called *acoustics*.

What to Measure

There are four basic conditions that need to be measured and subjected to reasonable control if good listening conditions are to be achieved. These are (1) quietness, (2) proper reverberation, (3) useful and adequate loudness, and (4) proper distribution.

Quietness

You need to know two things about the noise present: its sound-pressure level (SPL) and its distribution by frequency. Once these two factors are determined you can make an accurate engineering judgment regarding the potential of the noise for creating interference and the best solutions to apply in each situation.

At the Indianapolis Motor Speedway, a sound level of 125 db was present 85 feet or more from the track as a field of 33 cars raced by the grandstands. The majority of this energy was concentrated below 500 cps. This knowledge allowed us to concentrate our effort at reinforcement to the end of the spectrum where results were possible.

Noise level can vary from impossible, which would require a solution involving the quieting of the noise source itself, to ideal, which allows great freedom in planning a full-range low-distortion music reinforcement system.

Fig. 1. Sound-level meter with mic.

Proper Reverberation

Sounds must "hang on" long enough to allow music to sound natural, and yet not long enough to allow one word to blur the next word during normal speech. It is often desirable to have low frequencies reverberate longer than high frequencies in the same space.

Here again two factors need to be measured: how long it takes sound to decay in the room and how the decay time varies at different frequencies. It is good practice to measure the decay time at each 1/3-octave interval from 50 cps to 10,000 cps.

Reverberation times range from in excess of 18 seconds down to less than .4 second. The 18-second auditorium was accompanied by 38 echoes per sound. It was impossible to communicate prior to the survey, but subsequent improvements—based on the survey information—completely changed this situation.

Loudness

Loudness must be adequate and useful if the audience is to hear. A louder sound does not necessarily mean a clearer sound. Echos increase the total amount of sound but often at the expense of intelligibility. Far too many sound systems simply add to the ambient noise level with more-than-adequate but less-than-useful loudness. Failure to achieve useful loudness can be attributed to (1) nonuniform frequency response, (2) high distortion of the signal, (3) improper polar response characteristics, (4) incorrect high- and low-cutoff frequencies, or (5) improper equalization.

The recently developed pulse test measures the ratio of direct sound to reflected sound present at a point. With this test, any location can be measured and rated as to useful and adequate loudness. The test gives a clear picture of the relative amplitudes (in db) and the relative time differences (in milli-seconds). Also it clearly reveals when direct sound has failed to reach the seat or has failed to override ambient noise that is present at this location.

Proper Distribution

The entire audience needs to hear clearly. Good listening in one seat must not be at the expense of marginal listening elsewhere. The graphic level recorder, random noise generator, and tunable 1/3-octave filter have made it possible to quickly and economically "search" the entire audience area for changes in acoustic level. There is no excuse left for individuals in an audience to discover that their particular seat in an auditorium is located in a "dead spot."

Specific Measurements

The basic environmental and system parameters that can be measured during an acoustical survey are:

1. The ambient noise level (in db) of the environment at 1/3-octave intervals from 50 cps to 10,000 cps.
2. The reverberation times of the environment (in number of seconds for 60 db of decay) taken at 1/3 octave intervals from 50 cps to 10,000 cps.
3. The distribution of sound, verified by a complete "level search" of the listening area at 1/3-octave band intervals throughout the spectrum incorporated in the system design.

In addition, the following measurements should be made at each listener's seat:

1. Frequency response.
2. Total harmonic distortion at each octave interval.
3. The relative direct-to-reflected-sound differences of amplitude (in db) and time (in milliseconds).

Microphones

The basic instrument in any acoustical measuring system is a reliable, accurately calibrated microphone. Unfortunately, no one type of microphone possesses all the desired qualities, so the usual compromise is to use a calibrated ceramic microphone of the type shown on the sound-level meter in Fig. 1. They are more costly than their commercial sound counterparts, but are rugged in regard to temperature variations, moisture, and moderately rough treatment.

The usual measuring chain has as an alternate condenser microphone system for when (1) extended frequency response is needed, (2) high sound-pressure levels are encountered and or (3) extremely smooth frequency response is required.

Sound-Level Meter

The sound-level meter into which microphones operate is essentially a very sensitive audio-frequency voltmeter with a calibrated attenuator. It also includes the necessary isolation stages to drive recording devices and analyzers.

Fig 2. Band-rejection filter analyzer.

The sound-level meter contains within its own circuits a small amount of analyzing ability in its "weighting networks." The presence of sound pressure primarily low in frequency can be detected by going to the "A" scale and observing a drop in the meter reading.

For example, in a DC-7, the meter reading was over 90 db on the "C" scale. This normally indicates a noise level that would interfere with speech. Passengers had no difficulty conversing, however. On further investigation of the "A" and "B" scale readings, it immediately became apparent that most of the sound pressure indicated on the meter was concentrated at the frequency of the low-pitched throb of the four engines.

The decibel scale is the most convenient for expressing ratios between two sound pressures. Hearing responds logarithmically to stimuli. In measuring work, it is possible to run into SPL changes on the order of ten million (10^7) to one. Since the decibel is merely a ratio indication until given a reference, there has been established a standard reference pressure called 0 db which is .0002 dyne per cm^2.

The inverse-square law states that the strength of a field decreases in proportion to the square of the distance from its source. As applied to acoustics, this means that the reading on a sound-level meter will decrease 6 db when the distance from the source is doubled, or it will increase 6 db when the distance is halved. Reflections especially on indoor systems, can change this considerably, but the foregoing serves as a rough planning guide to avoid inadequate coverage of a widespread audience. If this *power* of an amplifier driving a speaker is doubled, the sound-level meter will show a 3-db increase. Conversely, if the power is halved, the meter reading will drop 3 db. A knowledge of what to expect in advance, along with some understanding of reasonable readings, leads to a much more intelligent interpretation of the data.

Although the sound-level meter gives an accurate reading in decibels, it does not indicate directly how this pressure is distributed by frequency. For example, an audio oscillator putting out a 1000-tone over a speaker system could be adjusted to give a sound-level meter reading of 80 db. The entire 80 db would be concentrated at 1000 cps. If a random-noise source were substituted for the oscillator and adjusted so the sound-level meter again read 80 db, the amount of 1000-cps energy would be considerably less. The 80 db of energy in the random noise would be distributed over all the frequencies present in the noise source.

Fig. 3. Octave-band noise analyzer.

Wave Analyzer

Because few of the noises dealt with in acoustical measuring work are single-frequency in nature, a way is needed to determine how they are distributed over the frequency spectrum. A wave analyzer, connected to the output of the sound-level meter, indicates in detail the frequency distribution of any signal.

The three basic types of wave analyzers are (1) constant bandwidth, (2) band-rejection filter, and (3) constant-percentage bandwith. Filters for four bandwiths are used with the constant-percentage-bandwidth type of wave analyzer: the octave filter, ½-octave filter, 1/3-octave filter, and narrowhead (7%) filter.

The band-rejection filter analyzer (Fig. 2) also known as a distortion and noise meter, is the type most commonly seen on the test benches of commercial sound technicians. Although it is used widely to test electronic components for distortion, hum, and noise, it can also measure acoustical distortion.

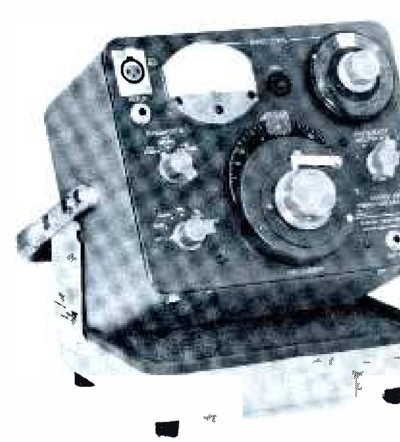

Fig. 4. Sound and vibration analyzer.

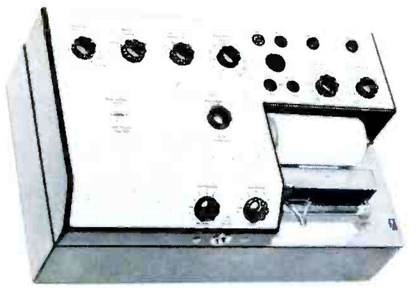

Fig. 5. A graphic level recorder.

The constant-percentage bandwidth analyzers are the most useful of all the types available for acoustical tests and measurements. The least detailed is the octave-band noise analyzer (Fig. 3). The unit shown breaks down the audio spectrum (approximately 20 to 20,000 cps) into 10 contiguous bands.

The most desirable instrument is a sound and vibration analyzer which combines the 1/3-octave band and 1/10-octave (7%) wave analyzer. A typical unit is shown in Fig. 4. In the 1/3-octave mode it provides 41 contiguous bands, and in its 1/10-octave mode, 135 contiguous bands. This instrument is essentially a continuously tunable audio voltmeter of extremely uniform frequency response and high sensitivity.

Once the frequency of a signal is known, the wavelength can be calculated since the speed of sound in air (at 68°F) is 1127 feet per second. The formula is: W=1127 divided by f, where W is the wavelength in feet and f is the frequency in cps.

By the foregoing formula, the wavelength of a 1000 cps tone is 1.127 ft, 100 cps is 11.27 ft, and 30 cps is 37.56 ft.

Graphic Level Recorder

Because of the tremendous amount of data desired for a thorough survey and because of the speed required, some form of automatic recorder is highly desirable if accuracy is to be maintained. In the case of reverberation-time measurements, automatic recording is mandatory. Servo-operated AC recording voltmeters suitable for acoustic work are called graphic level recorders. Fig. 5 illustrates one such recorder. A different unit can be mechanically interlinked with either an analyzer or a beat-frequency oscillator (BFO) for completely automatic chart tracing.

Charts are available for recorders to match the spacing of the dial calibrations of the various analyzers and oscillators. Special time-base charts are also available for reverberation-time measurements as well as level searches.

The graphic level recorder can be operated in either a forward or a reverse direction, thus allowing a resonance in a space to be approached from either direction frequencywise. This makes it possible to detect the contribution of a resonance to the readings after the resonance passes its fundamental frequency but before it decays.

Oscilloscope

Amplitude, frequency, and time can be measured with more than adequate accuracy for acoustical work using the combination of a sound-level meter, a wave analyzer, and a graphic level recorder. With the addition of a calibrated oscilloscope, signal waveforms can be seen that are of too short a duration to be written down accurately by a graphic level recorder.

Such an oscilloscope should be of the x-y input variety, with a sensitivity of 1 mv/cm and sweep times from 5 sec/cm to 1 usec/cm. Both amplitude and time-base calibrations are most useful when they are stepped in a 5, 2, 1 configuration such as 5 sec/cm, 2 sec/cm, 1 sec/cm, .5 sec/cm, .2 sec/cm, .1 sec/cm, etc. A P2 phosphor is the most suitable for general audio and acoustical use, especially for photo-

• *Please turn to page 44*

Notes on Test Equipment

analysis of test instruments . . . operation . . . applications

by Major Henricks and David I. King

Capacitance Analyzer

A handy addition to the test bench is the capacitor tester, of which several types are being manufactured. One type which, instead of measuring power factor for electrolytics, measures effective capacitance is the B & K Model 801 Capacitor Analyst. (Fig. 1).

Tests for shorts, opens, and leakage (except in electrolytics) may be made in circuit. Tests for capacitance value and leakage (for electrolytics) must be made out of circuit; that is, one capacitor lead must be disconnected. The capacitance-value test will measure the value of capacitors from 25 pf to 100 mfd for nonelectrolytics and up to 2000 mfd for electrolytic units. The two leakage ranges (3 volts and 100 volts) assure adequate testing for both high-voltage types and low-voltage types (such as those used in transistor radios).

A simplified schematic of the circuit used to measure the effective capacitance of electrolytics is shown in Fig. 2. Without CX (the unknown capacitor), equal currents flow through both legs of the bridge; that is, the current through X1 and R1 is equal to the current through X2 and R2. Since the two diodes (X1 and X2) are alike and resistors R1 and R2 are equal in value, the potential difference between points A and B is zero. When CX is added to the circuit, it will charge through X2 during one half-cycle of the supply voltage. During the next half-cycle, CX appears as an equivalent battery connected in parallel with R2. Some of the charge is lost during the second half-cycle when the diodes are back biased. The amount of discharge depends on the resistance across the capacitor, which is made up of R2 and the leakage resistance of CX. If the capacitor contains a high amount of internal leakage, more of the charge will leak off. The amount of charge left will then appear in series opposing to the new charging half-cycle, and the potential at point B will be lower than normal.

Since a potential difference now exists between points A and B, the meter will indicate a current flow between the two points. Since the amount of potential difference between points A and B depends on the amount of charge that CX will hold, the meter can be calibrated in effective capacitance. If CX contains a high series resistance, the amount of charge will be lower and the meter will read less. If CX contains a high amount of leakage (low leakage resistance) the charge will not hold and the meter will still read less. In both cases the charging ability is reflected in the meter reading. Since this is the same as actually changing the value of capacitance connected across R2, the meter can be calibrated in microfarads.

For further information circle 130 on literature card

B & K Model 801 Specifications

Functions:
Tests for shorts, opens, leakage; measures capacitance value.

Capacitance Range:
25 pf to 100 mfd for nonelectrolytic, special *effective capacitance* scale for electrolytics. Eight ranges for capacitance measurement.

Leakages Ranges:
3 volts and 100 volts.

Other Ranges:
One open position, one short position, and one calibrate position.

Power Requirements:
117 volts AC, 60 cps, 14 watts.

Size (HWD):
5¾" x 12¾" x 7¼"

Weight:
8 lb.

Price:
$99.95

Fig. 1. Bridge-type analyst reads effective capacitance for electrolytics.

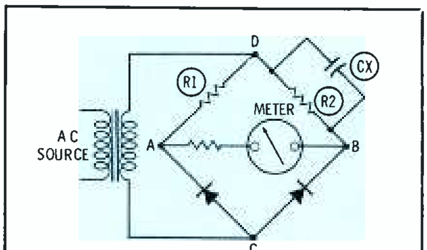

Fig. 2. Simplification of circuit which indicates effective capacitance value.

Wideband DC Scope

As color television becomes more popular, service technicians are becoming familiar with more sophisticated test equipment such as wideband oscilloscopes. To capitalize on the demand for more modern and complex devices, test-equipment manufacturers have recently begun to introduce wideband DC scopes with response characteristics which were originally common only in lab units.

There are many advantages to using a wideband DC scope. Although parallax error on the scope face limits accuracy, a DC scope can be used as a VTVM to determine DC voltage levels; this is particularly advantageous for servicing circuits where both the peak-to-peak waveform voltage and DC voltage level are critical for proper circuit operation. Also, the fact that a wideband scope is useful to 5 mc and above makes it possible to signal trace a number of RF and IF circuits without having to use a modulated signal and demodulator probe. The low-frequency response of a DC scope is invaluable for servicing high-quality audio equipment. Too, DC response is sometimes needed to service industrial equipment. As an added advantage, DC coupling eliminates the annoying bounce which occurs when the input probe is attached to a circuit point that is at a DC potential.

The EICO 435 (Fig. 3) is a very portable wideband DC oscilloscope. In fact, it is not much larger or heavier than some VTVM's. Yet this unit seems to be quite sturdy and reliable. Since the top of the chassis is very open, convection cooling dissipates the heat generated by the tubes and resistors. Open, neat construction insures adequate cooling for all parts and prevents hot spots which can cause DC drift and rapid component deterioration. The cabinet is made of lightweight aluminum, and perforations in the top, bottom, and sides provide ventilation.

In a unit like this, space is at a

EICO Model 435 Specifications

Vertical Channel:

Sensitivity—Direct terminal, .018 volt rms per cm; *response*—+1, –3 db from DC to 4.5 mc; *input impedance*—1 megohm shunted by 35 pf.

Horizontal Channel:

Sensitivity—Direct terminal, .7 volt rms per cm; *response*—+1, –3 db from 1 cps to 500 kc; *input impedance*—cathode follower input, 4 megohms shunted by 40 pf.

Sweep Generator:

Range—10 cps to 100 kc in four ranges, continuously adjustable. TV horizontal (7875 cps) and vertical (30 cps) test frequencies for fast checks on TV sets. *Synchronization*—four positions: internal +, internal, –, external, and 60 cps.

Features:

AC-DC signal operation, retrace blanking, internal calibrator, Z-axis input, sawtooth output, edge-lit CRT screen.

Power Requirements:

117 volts AC, 60 cps 110 watts.

Size (HWD):

8½" x 5¾" x 15½"

Weight:

15 lbs

Price:

$99.95 kit.
$149.95 factory assembled.

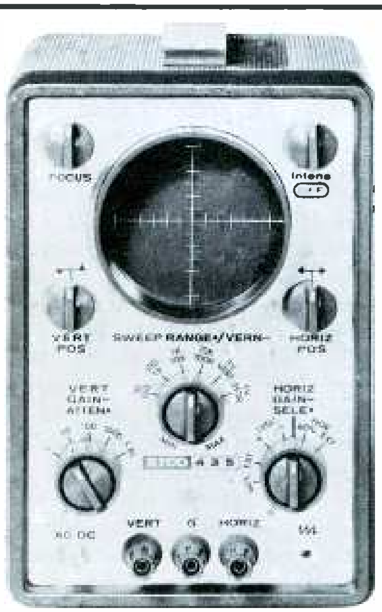

Fig. 3. Operating controls are fully accessible despite small scope size.

premium, but the controls most often used have been placed for easy use. The CRT controls—FOCUS, INTENS, VERT POS, and HORIZ POS — have been equally spaced around the 3" CRT, and a screwdriver adjustment to correct astigmatism is accessible through a hole in the left side of the cabinet. At the bottom left, vertical-amplifier gain is controlled by the concentric VERT GAIN-ATTEN switch and pot; below is an AC-DC switch that allows a choice of vertical amplifier operation. Selection of horizontal function and gain is accomplished with the HORIZ GAIN-SELE control. A sawtooth output from the horizontal cathode follower is available from a tip jack. Directly below the CRT is the SWEEP RANGE/VERN- control. Six range positions, 10-100, 100-1K, 1K-10K, 10K-100K, TV VERT (30 cps), and TV HOR (7875 cps), are included, and the concentric pot provides vernier control of sweep frequency from 10 cps to 100 KC. Across the bottom, 3 combination banana jack/binding posts, VERT, G (ground), and HORIZ, supply inputs for the vertical amplifiers and—depending on the position of the horizontal selector—the horizontal amplifier or external sync. On the back of the cabinet there is a tip jack which connects to the CRT grid for intensity modulation. Below this jack is a rheostat to control illumination of the edge-lit plexiglass CRT screen.

The block diagram in Fig. 4 can be divided into three main divisions: the vertical amplifier, the horizontal sweep generator, and the horizontal amplifier.

Vertical amplifier input is fed through the frequency-compensated vertical attenuator to the grid of V1A (Fig 5). Note the similarity of this circuit to a cathode-coupled paraphase amplifier. However the outputs of this circuit—although they are 180° out of phase—are not of equal amplitude. With R5 set for maximum resistance, there is very little signal output from V2's plate. As R5's resistance is decreased, the signal output from V2A increases until with

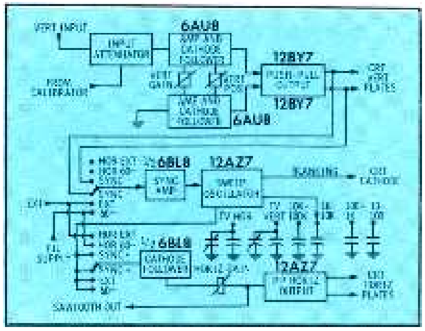

Fig. 4. Block diagram shows reliable design based upon simple circuitry.

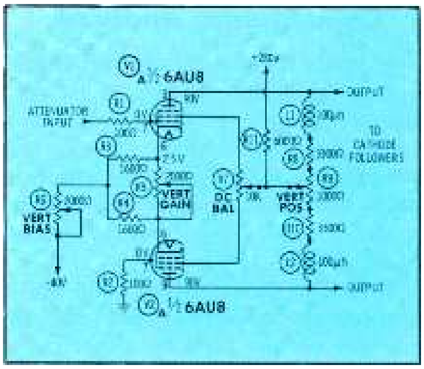

Fig. 5. Amplifier balances DC drift and rejects common-mode interference.

minimum resistance between the cathodes of V1A and V2A, the output on V2A is 80% of that form V1A. The output from V1A also increases as R5's resistance decreases because R4 then parallels R3, thus decreasing degeneration. Since V2A's grid is grounded, only the signal of V1A's grid will unbalance this circuit. V1A and V2A form a differential amplifier which rejects common-mode signals such as noise, hum, and DC drift caused by power-supply variations.

The outputs of V1A and V2A are fed to cathode followers V1B and V2B respectively; this simplifies DC coupling and extends high-frequency response by presenting low impedance inputs to the push-pull output stage. Because the cathodes of the two

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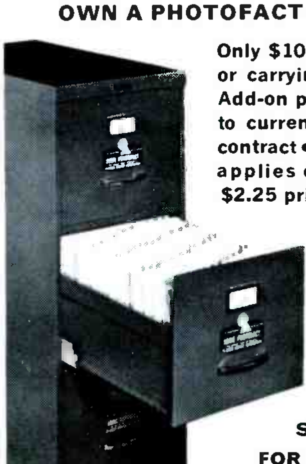

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12BY7 output tubes are connected and a relatively large cathode resistor is used, the output stage functions as a paraphrase amplifier and feeds a push-pull signal to the CRT vertical-deflection plates. Common-mode signals arriving at the grids are of equal amplitude and in phase; hence, they are cancelled.

Despite its simplicity, the 12AZ7 cathode-coupled sweep multivibrator produces a linear sweep throughout its range. Also, retrace time is very short; using our lab scope we found that retrace time ranges from 400 μs at 10 cps sweep rate to 1 μs at 100 kc. A biased diode and coupling capacitor are used to select and feed the proper blanking voltage to the CRT cathode. The 6BL8 pentode section is used as a limiter amplifier to trigger the sweep oscillator.

Horizontal amplifier design is quite straightforward. The 6BL8 triode section is used as a cathode follower; its output is coupled by a 50-mfd capacitor to the horizontal output amp and the sawtooth-output jack. One 12AZ7 is connected as a paraphase amplifier to develop push-pull output voltages for the horizontal-deflection plates of the CRT.

Both +360 and −40 volts are fed from the low-voltage power supply to allow DC operation of the vertical amplifier; the circuit uses an EX81 full-wave rectifier. A source of −1600 volts for the CRT cathode is produced by the high-voltage power supply which uses a 1V2 half-wave rectifier. AC from the power transformer is fed through a 150K dropping resistor to a 1N713 zener diode; a divider across the diode provides a 200 mv peak-to-peak square wave for calibration.

We connected our laboratory square-wave generator to the 435 and ran it over its entire range; the square waves displayed by the 435 showed little droop or overshoot. At 1 mc, the highest frequency available from our generator, the scope still could sync with no visible jitter or pulling. Using internal sync the scope will lock on with less than 1 cm peak-to-peak pulse displayed. Square-wave tests also showed that with AC operation low-frequency droop did not exceed 10% until the square-wave frequency went below 10 cps. We also displayed the output of a 5.35 mc marker generator; although it took 1.5 cm display for internal sync, the waveform was clear with little pulling.

Where a very portable scope which offers the advantages of wideband DC operation is required, the EICO 435 will do the job. ▲

For further information, circle 131 on literature card.

Circle 22 on literature card

Acoustics

(Continued from page 36)

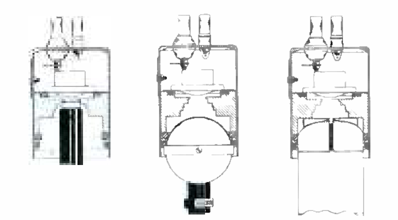

Fig. 6. One type sound-level calibrator.

graphic purposes. The oscilloscope must have a variable trigger with an adjustable threshold for amplitude sensitivity. An illuminated graticule is required which has a minimum viewing area of 8 x 10 cm, calibrated vertically and horizontally with five minor divisions per centimeter.

Sound-Level Calibrator

In order to calibrate the entire chain of instruments some form of reliable and accurate acoustical signal is required. Fig. 6 shows one type of sound-level calibrator and its accompanying audio source.

Once a chain of acoustical measuring instruments has been set up, a known acoustical signal must be applied to bring all readings into agreement. The calibrator applies such a signal to the microphone of the sound-level meter so that the latter can be calibrated. This signal also appears at the output of the meter and can be used to calibrate the wave analyzer, graphic level recorder, oscilloscope, and tape recorder.

Microphone sensitivity is usually checked with a 120-db signal at 400 cps. (Data are supplied with the calibrator so that a wide range of frequencies at reduced levels can be used for calibration.) However, a microphone can usually be considered functioning properly if it sounds normal when listened to and meets its sensitivity figure of 400 cps. The sound-level calibrator can be used with microphones varying in size and shape.

Conclusion

Other, more specialized acoustic-measuring instruments are available to the sound technician. Special techniques, notably the time-pulse system, offer more acoustical information than ever before. When you're faced with a tough audience-coverage problem, therefore, don't hesitate to put these instruments and techniques to work for you. The result will be a truly professional job. ▲

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SK-3009	pnp type, Audio Output Stages of Auto Radios
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Circle 53 on literature card

Money in Rentals

(Continued from page 25)

At many outdoor events, 100-milliwatt transceivers (operating on CB frequencies) are useful adjuncts to outdoor events. At a bicycle race, for instance, the sponsoring organization could station spotters at strategic places around the track, and these spotters could then report the happenings back to the location of the PA microphone. Transceivers are also useful in wiring buildings; it then isn't necessary to tie up a telephone or string your own communication lines.

If you are going into sound and PA work, it would be worth your while to make arrangements with some manufacturers so that you can use and sell their amplifiers, speakers, etc. It's a good idea to have a display of their products in your shop, preferably one that can be demonstrated upon demand. Some shops try to buy one of each new item that hits the market.

Fees

Naturally, your charges will depend on the amount of equipment used, how long it is used, and whether or not you must furnish a technician to operate it. Your charges must be adequate to cover paying the technician, the use of the truck to deliver and pick up the gear, and the cost of purchase and maintenance of the equipment. You will also want insurance—liability insurance to protect yourself from a lawsuit resulting from an accident caused by your company, and some form of protective insurance to protect yourself against loss of equipment installed on the client's premises.

Conclusion

Whether or not you should expand your present business to inclųde an audio rental, lease, and sales department depends on many things. First of all, is there a demand for such services in your particular location? Secondly, do you have or can you hire a serviceman qualified to install and repair this equipment? If the answer to both of these questions is yes, your bank account can rise considerably from the income of this new venture. ▲

Circle 25 on literature card

Circle 26 on literature card

 (Continued from page 28)

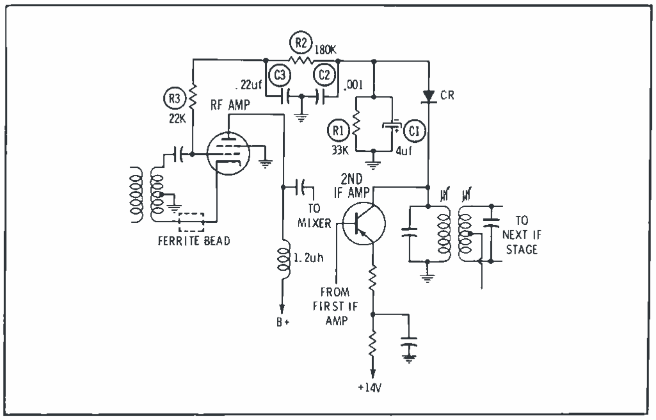


Fig. 7. RF amplifier is AGC controlled by signal from IF.

The filter consisting of C11, C12, C18, and T3 attenuates the 67-kc SCA signal to prevent interference when it is present on the carrier.

Hybrid Receivers

Most hybrid sets also are designed for operation from a 115-volt AC source. One winding on the power transformer furnishes 6.3 volts AC for the heaters of the three tubes and the dial lights. Other windings and their associated rectifiers supply regulated DC at up to −34 volts, unregulated DC at −36 volts and +36 volts, and +152 volts DC (for the plates of the tubes used in the front end). The FM tuner section, which employs all the tubes used in this receiver, is shown in Fig. 6.

AGC voltage for the RF amplifier tubes is obtained by rectifying the IF signal at the collector of the second IF amplifier transistor as shown in the simplified diagram, Fig. 7. The collector is at DC ground potential except for the small DC voltage drop in the primary of the IF transformer. The IF signal present here causes a DC voltage to be developed across R1 and C1. This voltage is then fed through an RC filter and isolating resistor R3 to the control grid of the RF amplifier tetrode. The amount of applied DC voltage is proportional to IF signal level, and its variations are delayed by C1—a 4-mfd capacitor.

The multiplex circuit, shown in Fig. 8, employs six transistors, two independent diodes, and a packaged ring demodulator (CR403) containing four diodes. There are two separate audio control amplifiers, one for each stereo channel.

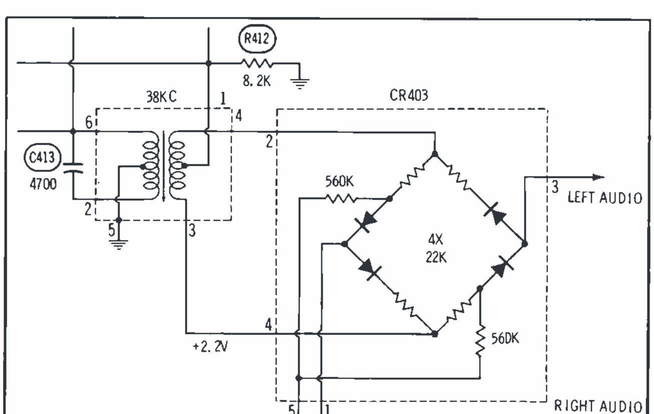


Fig. 8. Signal is detected by packaged-ring demodulator.

The two stereo units described here typify the basic concepts used by equipment designers. One set uses diodes and transistors throughout, the other uses tubes, but only in the VHF circuits in the front end. In both, very little heat is generated compared to all-tube designs.

Servicing Solid-State

Servicing solid state stereo is not much different from servicing tube-type equipment, except that the voltages are lower. To service FM/MPX stereo, a sweep generator and an oscilloscope are required for aligning the IF stages. A VOM and a VTVM are required for measuring DC and signal voltages, and an FM/MPX stereo signal generator is required for adjusting and checking the multiplex circuit. An in-circuit transistor checker facilitates testing of transistors without having to remove them from their circuits. Some receivers employ wired-in transistors; others use plug-in types.

In addition to complete receivers (tuner-amplifiers), separate solid-state stereo amplifiers are also available. Most FM/MPX stereo equipment is available in factory-wired form. However, some manufacturers offer kits and wired equipment.

Antennas

Along with increased business for the service shop because of the growing number of transistor stereo sets, there will be a sharp rise in FM antenna sales. While the better stereo sets are unusually sensitive, a good antenna system will provide more satisfactory performance. Full limiting is required for stereo reproduction. A good antenna system provides a strong signal at the tuner input and minimizes distortion that might otherwise be caused by multipath propagation.

Conclusion

We have given you a brief description of what's inside solid-state stereo receivers. Let's face it, solid-state receivers are here to stay! If you aren't prepared to service these units, you'll be missing an abundance of added work. The serviceman who can repair transistor sets is the one who is going to be in business longer and make more money. ▲

Keep it Clean

(Continued from page 30)

entirely on that track. A badly worn head requires cleaning more often than a new one; Fig. 2 shows what happens when grime accumulates on a head that has a groove worn in it. The dirt pushes the tape out of the groove, and any slight vertical drift moves it away from the pole piece.

Pressure pads on tape heads soon accumulate dirt and harden. Stiff pads cannot hold the tape to the contour of the head. Dirty guide-posts increase the friction during winding and rewinding. In some cases the increased drag may stall the machine.

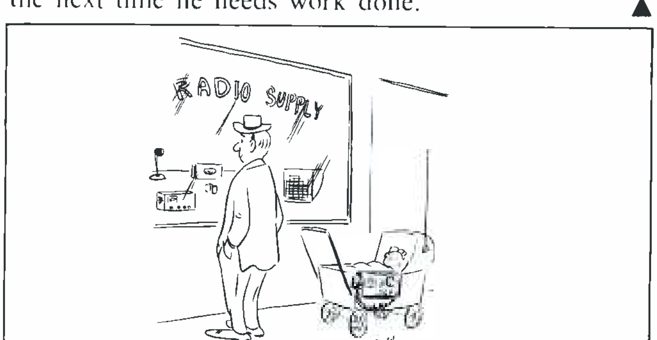
Clean the tape heads with wood alcohol; don't use stronger solvents, because they may damage spacers or other plastic parts in the face of the head. Use acetone to remove hard deposits of dirt from tape filters and guideposts. It may be necessary to use a small brush to get all the dirt out. Be careful not to splatter the acetone on plastic or painted surfaces. Stiff pressure pads should be replaced, but if none are available soak the pad in acetone and carbon tet. Reglue the pad with plastic cement, and position it so that the tape is pressed squarely against the head. Clean the pinch roller with wood alcohol to remove oxide particles. If the roller is glazed, wipe it with benzene to restore the surface. Remove all traces of rubber from the capstan with carbon tet.

Finishing the Job

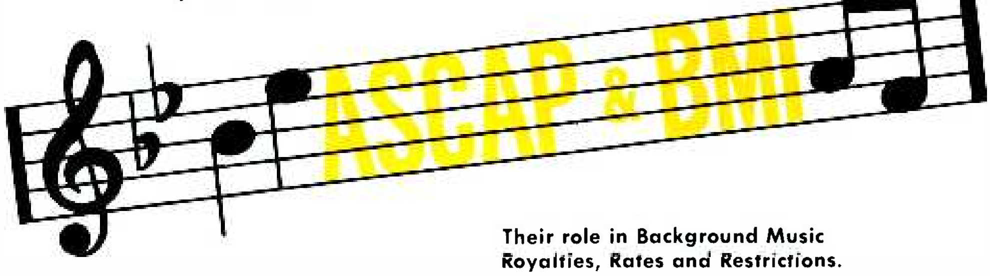
When a customer picks up his tape recorder or record player at your shop, the outside appearance of the machine counts more than all the careful craftsmanship that went into the repair job. Clean knobs and polished plastic trim plates stand out and are likely to be remembered when the machine needs service again.

Clean the imitiation leather or plastic fabric covering with a small amount of liquid detergent on a damp rag. Use a brush dipped in soapy water to get dirt out of grooves in knobs and trim plates. Paper-covered cases must be cleaned with care; rubbing too hard may remove the pattern. Plastic faces over tape-counter dials are cleaned with a soft rag. Magic-eye tubes grow dim after long periods of use; replacing them adds a bit of sparkle to the job. Clean number drums on tape-footage counters with a cotton swab dipped in soapy water; don't rub too hard or the paint will come off the numbers. As a final touch, clean the line cord and wind it up neatly.

Attention to these final details is important. Because phonos and tape recorders require regular service, part of the job is making sure the customer returns to you the next time he needs work done. ▲



by Paul Norman



Their role in Background Music Royalties, Rates and Restrictions.

Songwriters write songs to make a living. Obviously, if you want a copy of the sheet music of a song, or a recording of that song, you must pay for it; part of the purchase price goes to the writer of the song. If you use the sheet music or the recording only for your personal enjoyment or that of your friends, no one minds—this is the purpose for which you've made your purchase. But suppose you decide to hire a band and have them play the music, or set up a phonograph and play the recording, and then charge admission so that the public may enjoy the music for a price. Under the U.S. copyright law, you must pay the composer a fee for this additional use. Why? Because you are using his music to make a profit.

As a matter of fact, a series of court decisions has established that it makes no difference whether the public must pay admission or not and it doesn't matter whether the music is played by a live orchestra or reproduced by means of recordings, radio, or television. If the music is furnished by the operator of a commercial establishment (a restaurant or store, for instance) for the enjoyment of his customers, who pay him money for his goods and or services, then that operator is said to be using the copyrighted material for profit. He owes the songwriter a fee. It makes no difference that the music may be incidental, as in the case of background music; obviously, the presence of music enhances the attractiveness of the restaurant or makes working conditions more pleasant for factory or office employees—or else the management wouldn't spend money to install the equipment and lease the music service. The music is being performed for profit, and the courts have held that the user must pay the composer. (There is an exception for jukeboxes, but that doesn't concern us here.)

Music Licensing

There are several thousand songwriters in the U.S. alone. There are also several hundred thousand commercial establishments which use music to entertain their patrons. Obviously, it would be impossible for each composer to deal directly with each restaurant, night club, factory, and other place that might use his music. To perform this task, music-licensing organizations have been formed. In 1914, composer Victor Herbert found to his dismay that a restaurant in New York City was using his music to entertain its patrons without paying him As a result of the lawsuit which he pressed, a ruling was obtained which bestowed the songwriter's right to a performance fee. Herbert was then faced with the problem of licensing such performance, and he joined with others to form ASCAP, the American Society of Composers, Authors, and Publishers.

During the 1940's, there was a dispute between ASCAP and the radio broadcasting industry, and ASCAP refused to license stations to broadcast their music. Broadcasters then formed their own licensing organization, Broadcast Music, Inc., more commonly known as BMI. The dispute has long since been settled, and since that time both organizations issue licenses to radio and TV stations, as well as nearly all other establishments which perform music for profit. There are, of course, other groups which represent copyright holders, but ASCAP and BMI handle the bulk of the U.S. industry.

When songwriters affiliate with ASCAP or BMI, they simply authorize the particular agency to represent them in licensing or franchising commercial establishments to perform their music publicly for profit. While there are exceptions, in nearly all cases the restaurant, broadcaster, or background-music supplier obtains a *blanket license* from the society. This entitles the operator to perform any or all of the society's music which is *cleared*, that is, for which the composer has granted performance permission. (Sometimes the composer of a Broadway musical or TV show will withhold permission until his show has opened, fearing premature exposure will destroy his music's freshness.)

If you use music without paying a fee and without a license, you are infringing the copyright. You are liable to a lawsuit and, if found guilty in court, you may be fined $250 for each unauthorized performance.

How Licensing is Accomplished

Night clubs using live musicians usually deal directly with a licensing society. Radio and TV stations and networks do the same, although the licenses are slightly different. Motion pictures are licensed through their producers, and recording companies have their own particular arrangements.

In the field of background music, the most common arrangement is for the supplier of the service to deal directly with a licensing body, paying such fees as may be required and then passing this expense *on* to his clients or subscribers. Thus relatively few restaurants, etc., must go to the trouble of negotiating with ASCAP or BMI for the right to use background music—unless the restaurant owner himself assembles and reproduces music from an unlicensed source, such as the corner record shop. In this somewhat rare case, the owner must obtain his own license. Note that records and tapes sold in stores to the public are licensed only for private use, *not for profit.*

There are also noncommercial licenses available for cases where music is used by nonprofit organizations such as churches, schools, and the like. These do not require the payment of fees.

Restrictions and Fees

The licensing organizations collect the fees from the users of the music. After deducting operating costs, they pass the money on to the composers and publishers. Money is apportioned to the various members on the basis of how frequently their music is performed.

When it comes to paying the license fees, it wouldn't be fair to charge the same rate for a small corner cafe as for a large hotel. Hence there are different rates for various commercial establishments, depending on such things as size of public area, seating capacity, number of speakers installed, type of establishment (industrial or entertainment), and whether or not admission is charged.

Generally the subscriber to background music is not permitted to make use of the music anywhere but on the premises specified in the license (or franchise or contract). He must make his books and records available (or else the supplier must) for inspection by the licensing society's representatives at any reasonable time, if necessary, to verify any agreements made under the license. From time to time, the subscriber or program supplier must furnish a sample log of musical selections transmitted to clients. The license may be terminated upon notice, which is often 30 days. There are various other minor technical restrictions.

If a franchise is granted for specific premises, such as a restaurant with a seating capacity of 50 persons, and the owner later remodels to seat 100, he must notify his music supplier and/or the licensing body.

Conclusion

The preceding information is necessarily generalized, but should serve as an introduction to the subject. If you are entering the background-music field as an installer or franchiser, you should write directly to the headquarters of ASCAP and BMI (see below) for specific information concerning your particular application. While both firms are headquartered in New York City, they have regional offices around the U.S. ▲

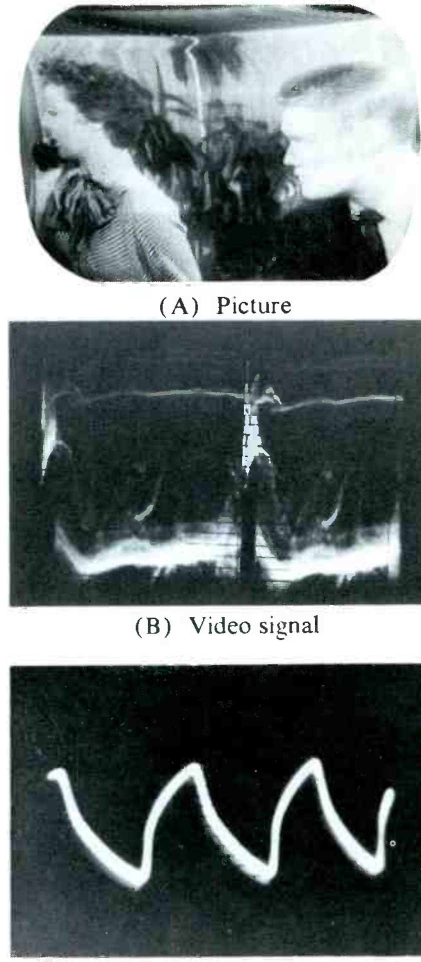
ASCAP: American Society of Composers, Authors, & Publishers
575 Madison Avenue
New York New York 10022

BMI: Broadcast Music, Inc.
589 Fifth Avenue
New York, New York 10017

AGC Filter

(Continued from page 32)

when voltage readings were attempted, the trouble would immediately clear up, and it was necessary to wait until it reappeared before further checks could be made. The shop scope was then used because with its low-cap probe it produced less circuit disturbance than an 11-meg VTVM. The signal in Fig. 5 was observed on the IF AGC line; the 2-mfd capacitor on the AGC line was open. This set uses keyed AGC and a filter circuit similar to Fig. 1C; the open filter corresponded to C1.



(A) Picture

(B) Video signal

(C) Signal on AGC line

Fig. 8. Hard-to-lock-in pix in Motorola was due to an open AGC filter.

Horizontal Line Interference

Horizontal-bar interference due to open AGC filters has been found in many makes and models using keyed AGC. This type of interference comes in many different variations. The condition shown in Fig. 6A occurred in a mid-fifties Westinghouse; the corresponding video signal is shown in Fig. 6B. Note that ringing in the trace and bars in the picture complement each other, being at the beginning of each vertical field and the top of the picture, respectively.

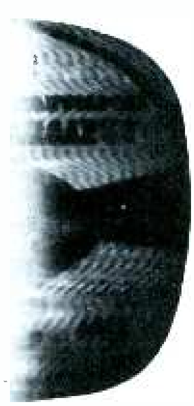
In some RCA's, KCS-68, 72, etc., the interference has been more severe. Two examples are the high-contrast condition with only 10 bars in Fig. 7A and the lower-contrast condition with about 16 bars in Fig. 7B.

More Effects

Add two more troubles stemming from open AGC filters to those already covered. The trouble (on a Motorola TS-426) pictured in Fig. 8A gave every indication of sync trouble; lockin was attainable only with the most critical adjusting of hold controls, and then held only a few seconds. Presence of the distortion at the vertical sync and blanking segments of the video signal (Fig. 8B) suggested AGC-filter trouble, and the waveform (Fig. 8) on the IF AGC line verified that the capacitor was faulty.

A most unusual effect of an open AGC filter occurred intermittently in an Admiral portable, Model 15G1. The condition shown in Fig. 9A presented itself after about 15 minutes of warmup; it would clear up and then reappear at random intervals. It was learned that tapping the chassis also corrected or created the trouble. It was decided to find out as much as possible with scope tracing before removing the case, to avoid accidently disturbing the defective component and making it that much harder to find.

The condition in Fig. 9A bears a resemblance to defective B— line filters discussed in previous Shop Talk articles. For this reason the easily accessible filter cans were scoped; their voltages were "hound's tooth" clean. Since there might have been other B— line filters than those in the cans, a scope check was made of the two B supplies (also accessible for scoping) feeding the tuner. Result — nothing. Finally a scope measurement at the feed-through connection for AGC to the tuner revealed the trouble—the 1½ volts of hash shown in Figs. 9B and 9C. Trace B was taken with a sweep frequency of 30 cps and a scope sensitivity of 10 volts per inch. Trace C shows the same signal with the



(A) Picture

(B) Hash on line

(C) Trace B, different settings

Fig. 9. Condition due to an open AGC filter on the RF line.

Fig. 10. Receiver adjusted for normal vertical blanking bar at midscreen.

sweep at one-half horizontal frequency and one volt per inch scope sensitivity.

Use the Vertical Blanking Bars

Inasmuch as defective AGC filters distort vertical sync signals, an indication of this defect can be obtained by looking at the vertical blanking bars. If the vertical-hold control is carefully adjusted so that the blanking bar can be seen, and brightness and contrast are also adjusted correctly, a normal bar will appear as in Fig. 10. Note that all portions of the blanking bar are darker than any picture content.

Fig. 11 shows the blanking bar in a set with an open AGC filter. In this case the equalizing pulses following the sync pulse dip into the

Fig. 11. Vertical blanking bar in set having an open AGC filter capacitor.

white levels of the video signal.

Conclusion

There are various indicators present in AGC-filter troubles: critical vertical sync, vertical shading, horizontal bars, the telltale distortions in video signals, distortions of the vertical-blanking bar, the presence of abnormal signals on AGC lines. Using these indicators—and perhaps others of his own—the service technician should be able to make troubleshooting and curing AGC-filter troubles one of the easier tasks in keeping TV watchers happy. ▲

 (Continued from page 34)

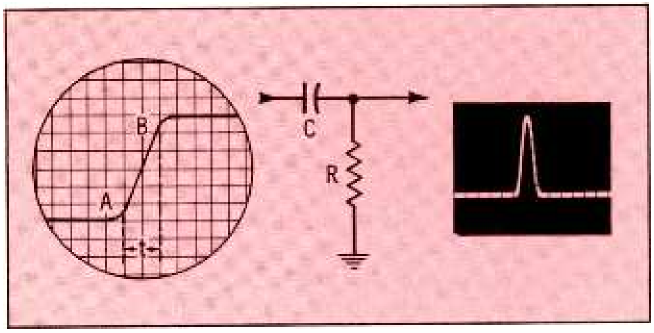


Fig. 6. Pulse amplitude is determined by both t and RC.

In Fig. 4A, the differentiating circuit produces an output pulse in which the leading edge has the *same* amplitude as the leading edge of the input square wave. In some practical situations, we will find this equality. On the other hand, consider the relations depicted in Fig. 6. Here, the amplitude of the output pulse is somewhat less than the square-wave amplitude. We will find by practical tests that as we make the time constant shorter, the amplitude of the output pulse becomes less; this results because the square wave does not have zero rise time. A square wave requires a certain time t to rise from A to B. In other words, we have a situation in which the square wave must be recognized as a trapezoidal wave.

Practical technicians do not concern themselves with the formula which relates t and RC in Fig. 6. Instead, they employ a handy rule-of-thumb, which states:

1. If RC is much greater than t, the pulse output has practically the same amplitude as the leading edge of the square wave.
2. If RC is about equal to t, the pulse output has approximately 53% of the amplitude of the leading edge of the square wave.
3. If RC is 30% or less of t, the pulse output will be approximately 30% or less of the amplitude of the leading edge of the square wave.

For example, if RC should be 10% of t, then the output pulse will have approximately 10% of the amplitude of the leading edge of the square wave. On the other hand, if RC should be 10 times t, then the output pulse will have approximately the same amplitude as the leading edge of the square wave. Note carefully that the rule-of-thumb we are discussing *has nothing whatsoever to do with the frequency of the square wave*. The rule-of-thumb concerns only the rise time of the square wave with respect to the amplitude of the output.

With these basic facts in mind, let's consider a practical application. Perhaps we suspect that C in Fig. 6 is open. A capacitor never becomes completely open, because there is a very small stray capacitance between its leads or terminals. If the capacitor is open, the time constant becomes very small. In turn, the amplitude of the output pulse becomes very small compared with the amplitude of the square-wave input. Observe the height of the output pulse. Then, short-circuit C temporarily. This feeds the input square wave directly to the scope. If the square-wave pattern jumps up to a much greater amplitude than the pulse, the suspicion that C is open is confirmed.

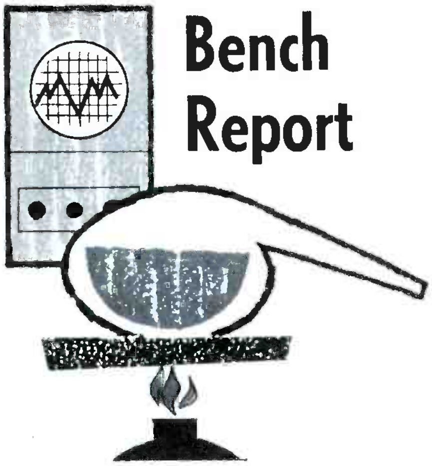
Next, let's consider another type of practical application. Suppose that you are at the incoming-inspection station and are checking a shipment of capacitors for satisfactory tolerance. We know that if RC is much smaller than t in Fig. 6, then *the height of the output pulse will be proportional to the value of C.* If you provide a test jig to plug capacitors into the differentiating circuit of Fig. 6, *the pulse height on the scope screen gives a relative measurement of capacitance.* In other words, after choosing a suitable value of R to work with, the scope can be calibrated to read capacitance directly. Compared with measurements on a capacitor bridge, this test method is very rapid, because there is no adjustment required to find a null.

Conclusion

Now that we have a basic understanding of how basic RC circuits respond to square waves, we are in a good position to proceed with square-wave tests of more elaborate RC "couplates" and complete stages of printed circuits. These considerations will be explained in the following article. You will find that it is seldom necessary to disconnect a capacitor or resistor to localize a defect in any printed circuit. Square-wave tests give more information than ordinary waveforms when we tackle complex RC circuitry because the frequency and rise time of the applied square wave can be varied to assist in evaluation of results. On the other hand, if we use the waveform which happens to be present in the circuit, we are "stuck" with this waveform's frequency and rise time.

We will find that the output amplitude from complex RC circuits varies with the square-wave rise time and that this voltage-vs-rise-time response has considerable meaning with respect to defective components. Thus, we will be working with input amplitude, output amplitude, output amplitude variation, input frequency and rise time, output waveshape, and critical test conditions. In many cases, we will be concerned with waveform details which correspond to values of individual components. ▲

PFR Bench Report



Transistor Tester

Many times, in troubleshooting transistor circuitry, the technician is not concerned with anything about the transistor except whether it is good or bad. This transistor tester provides just that information; it tells the operator to either replace the transistor or go on looking for the real trouble.

Provisions are made for the testing of transistors (low- and high-wattage) in or out of the circuit. For in-circuit testing, color-coded leads which plug into labeled jacks are included to clip onto the transistor terminals. For out-of-circuit testing, two sockets are mounted on the tester; simply plug in the transistor.

To test the transistor, connect the leads or plug the transistor into the proper socket. Start with the variable control set to zero. A tone should be heard from the speaker; if it is not, reverse the PNP-NPN switch (the transistor will not be damaged). Advance the control until the tone stops, then turn it back until the tone just starts, and flip the PNP-NPN switch to the opposite position, then back again. The tone should start immediately if the transistor is good.

The pilot lamp indicates the relative amount of emitter current, and the control is calibrated in relative base current. If the light glows with the control set to zero, the transistor has an emitter-to-collector short. Leaky transistors cause the tone to "beep."

The Model XT-1 dynamic transistor tester is available from **ESCO Manufacturing Company** distributors at $18.95. Test leads and instruction manual are included. ▲

CONSUMERS' CHOICE

Here's how.

	BRIGHTEST COLOR PICTURE	BEST OVERALL COLOR PERFORMANCE	CLEAREST COLOR PICTURE TO WATCH	BRIGHTEST BLACK AND WHITE PICTURES
Sylvania **color bright 85** picture tube	76.1%	66.6%	68.0%	77.7%
Picture Tube A	6.9	9.8	8.9	7.4
Picture Tube B	9.5	13.7	13.4	7.1
Picture Tube C	7.5	9.9	9.7	7.8

Test made under supervision of John J. Henderson and Associates, N. Y. Note: Not all people answered all questions–votes tabulated for 100% of answers to each.

In six major cities from coast to coast, 9,789 consumers compared the new *color bright 85* picture tube to ordinary non-rare-earth color tubes in three leading brands of TV sets. Sylvania's new tube, the first with rare-earth phosphors, was the overwhelming choice.

Here's why.

The vivid colors, derived from europium rare-earth compounds, are unexcelled for true color fidelity. In monochrome, the picture is noticeably brighter; there's better contrast too. And today this extraordinary tube is still the performance leader. Sylvania's new air-spun screening process gives *color bright 85* picture tubes the competitive difference in the sharpest images ever displayed.

The *color bright 85* tube is available to you now for today's growing color TV market. It is a product of Sylvania Electronic Tube Division, Electronic Components Group, Seneca Falls, N. Y.

SYLVANIA

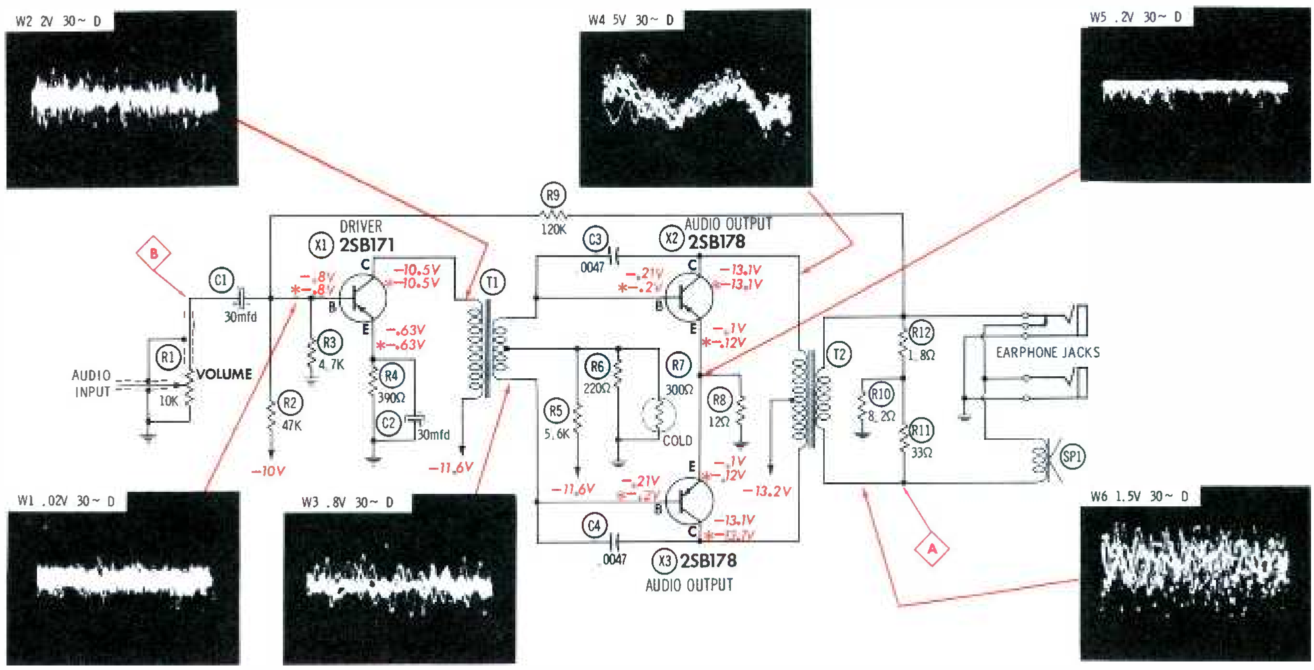
SUBSIDIARY OF
GENERAL TELEPHONE & ELECTRONICS GT&E

Circle 41 on literature card

PF REPORTER Symfact™

Audio Output

Push-Pull With Driver



DC VOLTAGES taken with VTVM, on inactive channel; antenna terminals shorted. *Indicates voltages taken with signal present—see "Operating Variation

WAVEFORMS taken with wideband scope; TV controls set to produce normal picture and sound. D (direct probe) usable at all points throughout circuit.

Normal Operation

Push-pull audio output circuit preceded by driver is quite typical of audio sections in transistor TV's. Circuit is also used in many transistor radios. Operation of output and driver stages shown here (from Panasonic Model Mitey 9U) is exactly same as ones found in FM radios. Audio signal is coupled to base of driver through C1; signal level is determined by setting of volume control. X1 base voltage is derived from base voltage-divider network (R2 and R3). Base voltage is same as drop across R3. With PNP transistors and negative supply supply voltage, resistor from base to ground is always smaller value than resistor from base to source. With positive source, or negative source and NPN transistor, reverse is true—smaller resistor is from base to source. Audio signal is amplified by X1 and coupled to bases of output transistors through driver transformer (T1). Amplitude loss in coupling through T1 is due to step-down transformer, necessary for low-impedance input of output transistors. Base voltage on output transistors again is determined by voltage divider network (R5, R6, and R7). Resistance of R7 is 300 ohms cold but decreases as set reaches operating temperature. Resistance change in R7 permits stable operation of transistors from time set is first turned on until set reaches maximum operating temperature. Emitter resistor R8 is to prevent thermal runaway of output transistors, isn't actually bias resistor, although small voltage is developed across it. T2 is step-down type similar to those used in tube-type receivers.

Operating Variations

X1 With or without signal present, DC voltages on all elements of driver transistor remain same. Waveform amplitude (peak-to-peak voltage) on base and collector is determined by setting of volume control. At maximum setting of control, (with normal program on local channel) audio signal at base increases to .07 volt; at collector to 10.

X2B, X3B With signal present and normal volume, base voltage on output transistors decreases slightly. Decrease is even greater (to −.15 volt) with volume control at maximum.

X2E, X3E Emitter voltage increases with signal, due to increased current in output stage. With volume control fully clockwise, voltage increases to −.3 volt.

X2C, X3C At normal volume, collector voltage remains constant with or without signal. However, with volume control set to maximum, increased collector current results in collector voltage decreasing to −12.8 volts.

WAVEFORMS Waveform amplitude throughout output stage is dependent upon content of audio signal and setting of volume control. At maximum volume W3 is 3 volts, W4 20 volts, W5 1 volt, and W6 is 1.5 volts.

Symptom 1

Audio Missing

No Hash or Noise Is Present

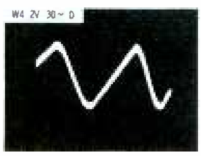
C1 Open

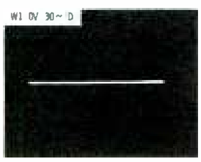
(Base Coupling Capacitor—30 mfd)

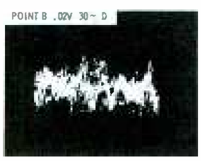
Symptom Analysis

Absolutely no sound is heard from speaker; not even hash or noise is present with receiver tuned to inactive channel; volume control has no effect. This suggests trouble in driver or output stages, because with defects in IF stages noise is usually audible.

Waveform Analysis







Audio signal is completely missing in W4, only 2-volt ripple on supply vcltage is present—evidenced by fact that waveform doesn't vary in amplitude as volume control is rotated. W1 eliminates driver and output stages, as signal is still missing at this point. Immediate area of trouble is pinpointed by scoping at point B. Audio signal is present here; thus open circuit exists somewhere between point B and base of driver transistor.

Voltage and Component Analysis

NO VOLTAGE CLUES

Open coupling capacitor from volume control to base of X1 has no effect on DC voltages—all remain normal with or without signal. Therefore, defect is impossible to locate with voltage measurements; however, trouble can be found quite easily and rapidly by scope or signal injection. Touching finger to soldering aid and making contact on X1 base produces buzz from speaker, indicating following stages are operating. Same procedure at high side of volume control results in no buzz; therefore open circuit is quickly isolated.

Best Bet: Scope or signal injection.

Symptom 2

Volume Reduced

Audio Not Garbled

R2 Increased in Value

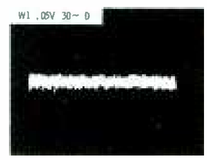
(Base Bias Resistor—47K)

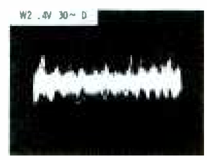
Symptom Analysis

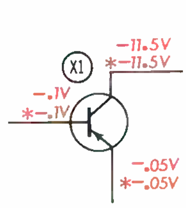
Output level from speaker is reduced; normal volume can be obtained, but volume control must be fully clockwise (maximum). Sound isn't "fuzzy" or garbled. Without signal, only background noise is audible; no buzz or hum is present. Audio output stages are suspected.

Waveform Analysis

Waveform (W3) on base of output transistor is reduced in amplitude—only .1 volt p-p (normal is .8 volt). This clears output stages as being responsible for trouble. All stages preceding driver are proven to be operating normally by fact that W1 is correct. Further isolation of defective area is obtained by viewing W2; amplitude is greatly reduced (it's only .4 volt p-p). Therefore, loss of amplification is occurring in driver stage.







Voltage and Component Analysis

Faulty stage can be isolated with meter; however, scope checks will locate defective stage much more readily. Only three waveform checks are necessary, whereas more measurements are required when checking with meter first. Once stage is determined with scope, voltage measurements on X1 readily point to trouble. Since base voltage is reduced to .1 volt, increase in value of R2 or decrease of R3 (less likely) is suspected. Emitter voltage is decreased and collector voltage increased because of reduced emitter and collector current.

Best Bet: Scope to isolate; then VTVM.

SYMPTOM 3

Volume Reduced

Audio Not Distorted

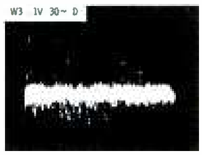
R4 Increased in Value

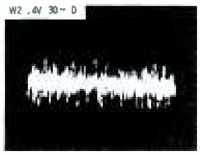
(Emitter Resistor—390 ohms)

Symptom Analysis

Sound output level is greatly reduced. At normal setting of volume control, sound is barely audible. Even with volume control at maximum, sound level is only normal or slightly less than normal. Audio is free from any type of distortion.

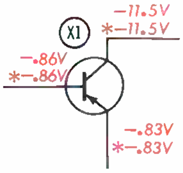
Waveform Analysis





Symptom suggests loss of gain in output or driver stage; thus, waveform check at base of output transistors (W3) is good place to begin troubleshooting. Signal level at this point is reduced to .1 volt, clearing output stage and suggesting next check should be in driver. W2 is also reduced—only .4 volt p-p. Tracing backward shows W1 is slightly increased; although not really indicative of trouble, it definitely isolates driver stage.

Voltage and Component Analysis



Based on information gained from scope analysis, voltage checks on elements of X1 should provide positive location of defective component—and they do. Emitter voltage is increased to −.83 volt and base voltage has also increased, but only slightly (.06 volt). Collector voltage is increased to −11.5 volts, suggesting decrease in collector current; however, emitter voltage indicates increased current. Analysis of voltage clues definitely points to increase in value of R4. Resistance measurement from emitter to ground isolates bad component.

Best Bet: Scope followed by voltage checks.

SYMPTOM 4

Volume Reduced

Audio Is Distinct

R8 Increased in Value

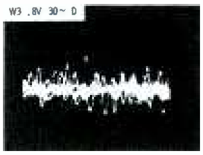
(Thermal-Runaway Resistor—12 ohms)

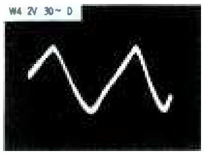
Symptom Analysis

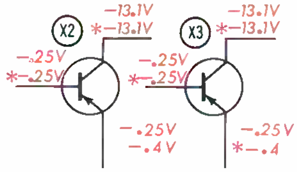
Sound heard from speaker is reduced, even with volume control at maximum. Audio is distinct—no buzz or hum is present. Picture and raster are normal; therefore, stages handling both audio and video are probably okay. Symptom is indicative of defect in audio output.

Waveform Analysis

Normal waveform (W3) on base of X3 and waveform on X2 base (not shown) prove previous stages are normal, and further substantiate that output circuit is responsible for trouble. Search for trouble is narrowed even further by W4; waveform is mostly 60-cps ripple which cancels in T2 primary. Emitter signal W5 is normal; scope proves only that loss of gain in output stage is reason for reduced volume, does not isolate defective component.







Voltage and Component Analysis

Following information gained from scope analysis and concentrating voltage checks on output stage proves helpful. Most drastic voltage change is on emitters of X2 and X3; reading has increased to −.4 volt, but collector voltage is unchanged. Thus, increase in value of R8, rather than increased current, is responsible for loss of gain. Base voltages did change slightly, but not enough to be of any significance. When emitter resistor has changed value, be sure to check output transistors, as they may have been damaged.

Best Bet: Scope followed by voltage measurements.

Symptom 5

Volume Insufficient

Audio Is Distortion Free

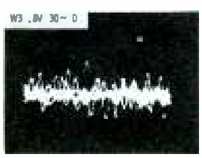
X2 Leaky

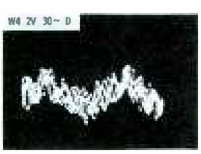
(Output Transistor—2SB178)

Symptom Analysis

With volume control at normal, sound volume from speaker is considerably less than adequate. Normal volume can be developed, but only with control near maximum. Sound is free of buzz and hum; thus, driver or output stage is suspected trouble spot.

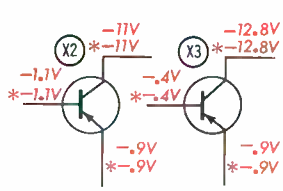
Waveform Analysis





Since symptom indicates trouble in output circuit, base of output transistor (W3) is logical point to begin scope checks. Preceding stages are proven to be okay by presence of normal W3. Reduced amplitude of W4 strongly suggests loss of amplification in output stage. W5 is increased in amplitude, and during pauses in transmitted audio, 60-cps ripple is present. Ripple present at emitter is definite clue to leakage in transistor.

Voltage and Component Analysis



Since symptom points to trouble in audio output circuit, voltage measurements on output transistors should prove helpful. This check does provide valuable information, since voltages on all elements of X2 and X3 are incorrect. X2 leakage is more likely since voltages on this transistor are considerably more abnormal than those on X3. Amount of leakage determines exact symptom. Slight leakage may be unnoticed, while excessive leakage results in severe loss of volume or, in some cases, complete absence of any audible signal.

Best Bet: Voltage checks and circuit analysis.

Symptom 6

No Audio

Picture and Raster Normal

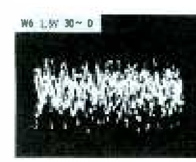
Open Connection in Earphone Jack

(Broken Contact)

Symptom Analysis

Audio section of receiver is completely dead; absolutely no sound is heard from speaker. Raster and picture are both normal. Touching finger to base of driver or to base of output stages still results in no sound being heard from speaker.

Waveform Analysis



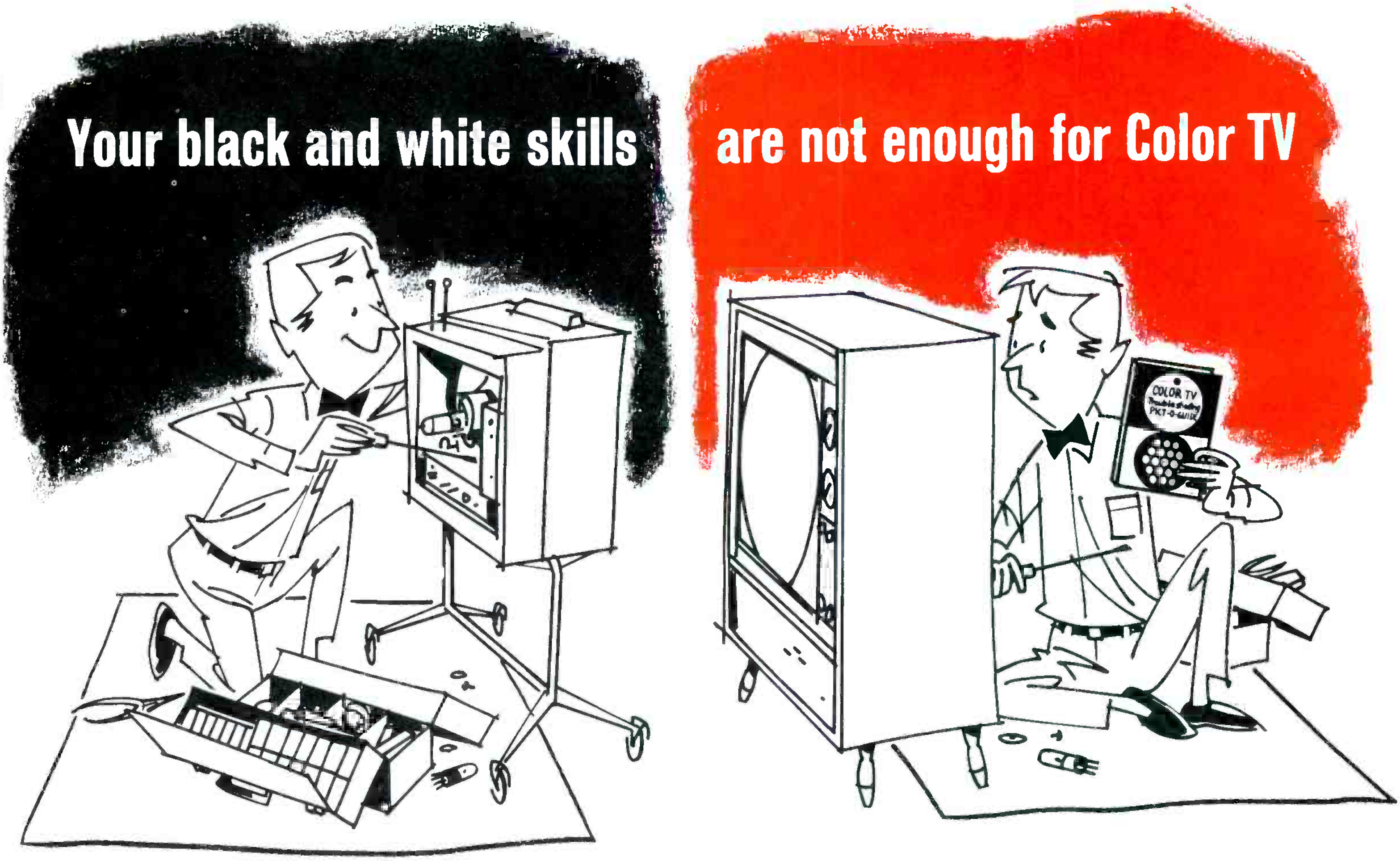
Audio signal at output of driver (W2) is normal, localizing trouble area to between this point and speaker. Normal W4 eliminates output transistors and associated components; thus, only output transformer and speaker circuitry remain as possible causes of trouble. Normal W6 (at input to speaker) proves transformer isn't responsible for loss of sound and points to open circuit somewhere between point A and speaker return to transformer.

NO VOLTAGE CLUES

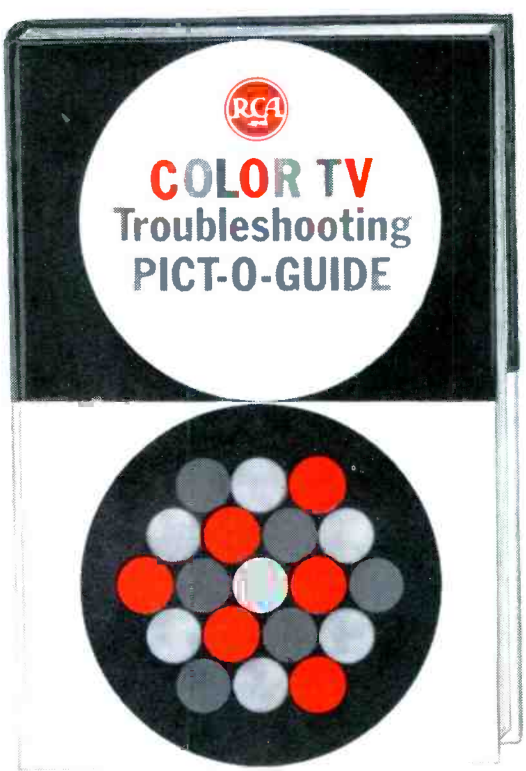
Voltage and Component Analysis

Fault can be located with continuity check. Such checks can be misleading because of parallel paths. Here speaker lead was disconnected from point A and check made from speaker terminal to ground. Without lead disconnected meter shows continuity through secondary of T2. With troubles of this nature, visual inspection prior to removing chassis will often save considerable troubleshooting time. Dirty, broken, or corroded contacts on earphone jacks aren't uncommon occurrences, especially in small portable transistor radios.

Best Bet: Visual inspection and resistance checks.



You need this book to help you cash in on Color TV business



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(For a complete course in the principles and practices of color TV you will find the 8 lesson Color TV Home Study Course by RCA Institutes, 1A1325, invaluable.)

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The Troubleshooter

answers your servicing problems

Unstable Sync

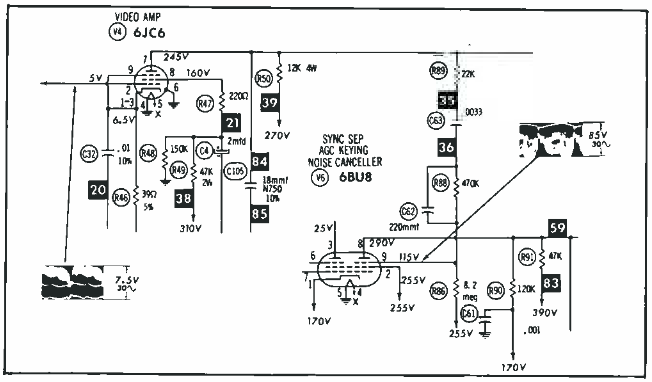
We have an Admiral color receiver Model T-1000 with critical horizontal sync. The horizontal hold control must be readjusted several times during warmup. The set invariably loses horizontal sync when the channels are changed, and sometimes even with a change in the video signal.

We have tested all tubes and even substituted for those in the sync and horizontal section. We also replaced the dual-diode horizontal-phase detector. All waveforms, voltages, and resistances seem to be within tolerance.

We know we have missed something; however, we don't know what else to do for this set. Could you give us any information on something else to look for?

CARL E. SABO

Moab, Utah



The critical horizontal-sync problem you're having in this receiver (covered in PHOTOFACT *Folder 703-1) may be caused by a defect anywhere in the video section through the sync-separator stage. Use your scope and trace the video signal from the grid of the video-output stage through the sync-separator stage. Look for a compressed sync pulse. Be especially careful when viewing the waveform at the grid (pin 2) at V4 and at pin 9 of V6.*

The loss of sync during channel change and during changes in the video signal is typical when incorrect sync pulses reach the horizontal-phase detector. The trouble is most likely in the sync-separator stage; be sure and check very closely, or replace capacitors C62 and C63.

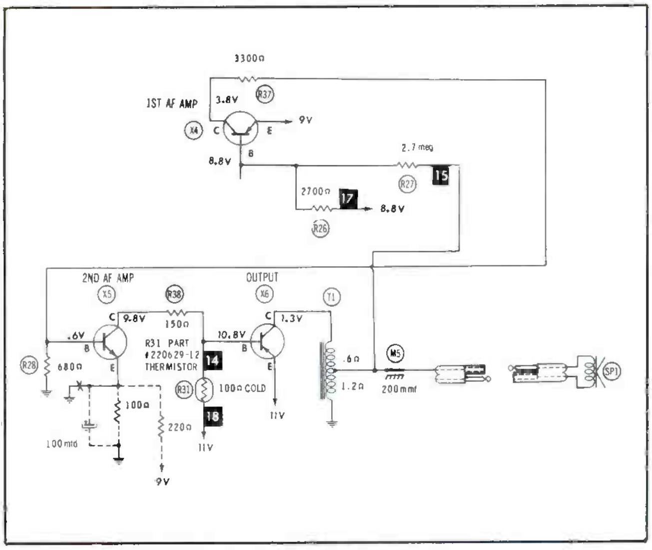
Radio Fades

I have in for repair a Ford Model 3TBD Radio (covered in PHOTOFACT series AR-19, page 75). The reception fades out when the set gets warm. I can open the switch for 15 to 20 seconds, and when I close it again, the reception is normal. When the sound begins to fade and I increase the volume, audio distortion occurs. The radio plays fine on the bench for 20 to 30 minutes before fading with a 60-watt light only inches away from it to induce heat. Concentrated heat anywhere near X5 causes this fading.

I have changed X1 and X5 with no results. Should I make the modification outlined at the emitter of X5?

JASPER WATERS

New Bern, N. C.



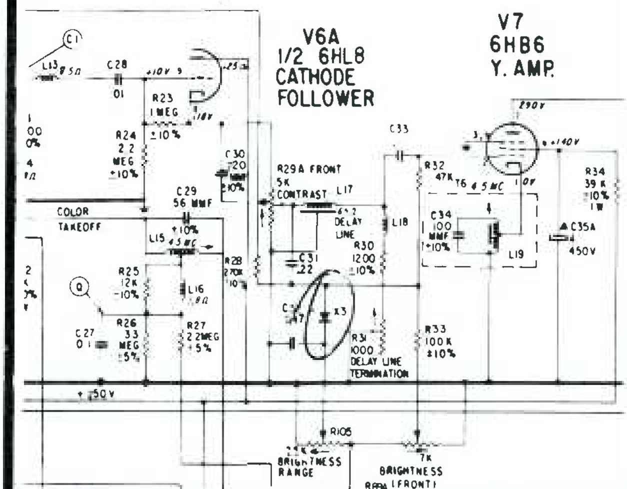
The driver stage of this receiver was changed in late production models. X5, Bendix part 2091260-3, was replaced with Bendix part 2092609-1; and the emitter of X5 was tied to ground. Check the circuit board to see if the emitter of X5 is connected to ground through a 100-ohm resistor to determine if this is an early- or late-production model.

Since X4, X5, and X6 are direct-coupled amplifiers, any drift in one stage would affect the DC levels in the following stages. Start the set; before fading begins, check base, collector, and emitter voltages of X4, X5, and X6. Apply concentrated heat around X4 and X5; note the first voltage that changes, and then check the associated resistors and the transistor. Don't overlook the possibility of thermistor R31 being defective. ▲

COLOR COUNTERMEASURES

Symptoms and service tips from actual shop experience

Chassis: Zenith 27KC20.
Symptom: Uncontrollable brightness.
Tips: Customer-operated brightness control on front panel is inoperative. Internal brightness-range control (located on the operating control-panel subchassis) is working normally. Check for a shorted crystal diode in the brightness circuit. Replace X3 (connected from center tap of brightness range control to junction of R28, R32, and C31) with Zenith part No. 103-23; be sure to observe polarity.



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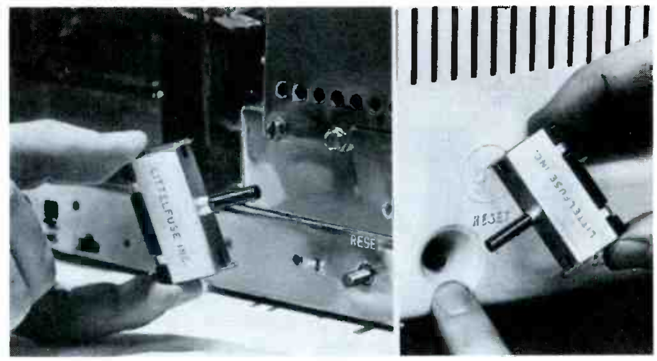
Product Report

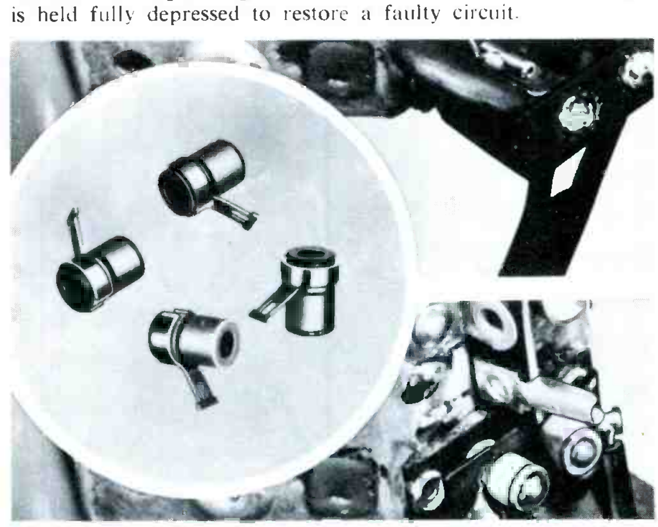
For further information on any of the following items, circle the associated number on the Catalog & Literature Card.



120

Circuit Breakers for TV

The "Littelbreaker," a manual-reset circuit breaker by **Littelfuse, Inc.,** is of completely enclosed construction. Units are available for exact replacement in all television sets now made using this type of circuit interrupter. The circuit breakers measure 1¾″ x 13/16″ x ½″ with two solder terminals on the back for connection. The 815(000) Series thermally responsive breakers are dual-operated bimetallic devices providing temperature compensation over a wide range of ambient temperature variation. They are rated at 125 VAC with current-carrying capacitives up to 3 amps. A built-in "trip-free" feature prevents the breaker from closing when dangerous overload currents are flowing through the breaker even if the plastic plunger is held fully depressed to restore a faulty circuit.



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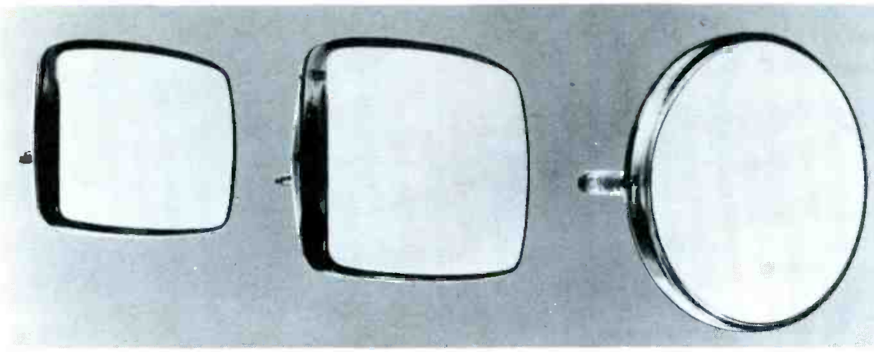
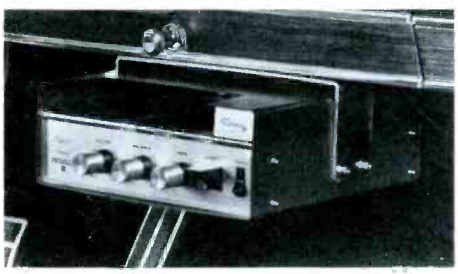
Lightning Protection

A new capacitor/resistor spark-gap component, designed especially for antenna coupling devices, is now available from **Centralab,** the Electronics Division of Globe-Union, Inc. Called the "Type-L Tube-R-Cap" the miniature device carries the Underwriters' Laboratories yellow-card listing. Hollow tubular construction permits these units to be slipped over antenna-terminal pins of any TV, radio, or communications unit and soldered directly to the pins. According to the manufacturer, this assembly method results in a considerable reduction in production time. Attachment and soldering operations, except for the antenna leads themselves, are eliminated. The Type-L measures only 9/32″ in diameter and is ⅜″ long. It is currently available as a .001-mfd/1-megohm combination. Voltage rating is 1.4 kv DC and 150 volts rms.



Rare Earth 19″ Color Tube
(122)

Sylvania Electric Products, Inc. has sent samples of its new 19″, 90°, rectangular color-television picture tube to the nation's leading TV set manufacturers. The 19″ tube uses Sylvania's exclusive red "rare earth" europium-activated yttrium-vanadate phosphor, plus improved green and blue phosphors. The phosphors are said to provide a substantially brighter picture than is obtainable with standard phosphors. The 19″ color tube is the third color tube using rare earth elements for brighter pictures introduced by Sylvania in the past six months. Shown in the photo are Sylvania's 21″ round, 25″ rectangular, and 19″, 90° rectangular tubes. The latter tube will be available in quantities during the second half of 1965.



(123)

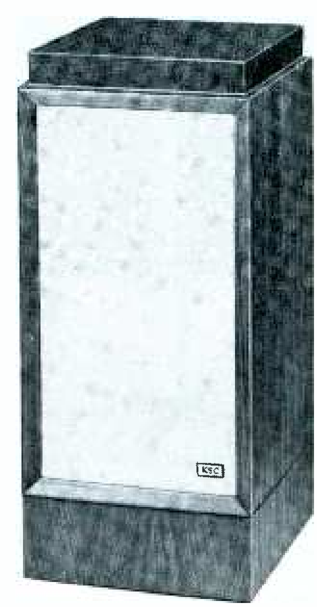
Auto Tape Recorder

This new car-mounted stereo tape recorder has such features as solid-state amplifiers, dual-stereo playback heads, electronic track selection, push-pull output, and a self-activating cartridge system. The case is of all-steel construction with a brushed-aluminum face plate. The Model C-502, a product of the Auto Sound Division of **Craig Panorama, Inc.**, is priced at $119.

(124)

New Caddy

A rugged but attractive luggage-type service case capable of holding 365 tubes is available from **General Electric Co.** Covered in rust-brown armored vinyl, the ETR-3915 service case has a strong, durable Bakelite handle. "Egg-crate" separators hold tubes in position, while a flexible curtain holds job tickets, alignment tools, and a characteristics booklet. Tools are carried in a separate covered compartment. The case features heavy nickle-plated steel hardware and snap locks. It is priced at less than $30.

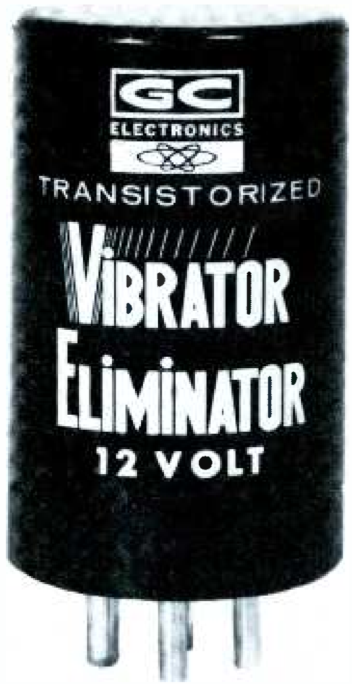


(125)

360° Speaker System

The Model KSC-3 speaker system is designed to permit the mid- and high-frequency speakers to radiate in a 360° pattern. This **KCS Systems, Inc.** system contains three speakers made by **SEAS of Norway:** a 10" woofer, a 6" mid-range, and a 3½" tweeter. A three-way crossover network is included, and there are two potentiometers for balancing the volume of the mid- and high-frequency speakers to suit individual preference and room acoustics. In the American built cabinet (patent applied for), the tweeter and mid-range section is completely separated from the woofer section; the 360° dispersion is confined to the high and mid-range area.

Impedance is 8 ohms, power-handling capacity is 30 watts, and the frequency range is 30 to 20,000 cps. The cabinet measures 13" x 13½" x 29¾" and is finished in oiled walnut. Price of the KSC-3 is $185. It is available from franchised distributors only.



(126)

Transistorized Vibrator Eliminator

This 12-volt vibrator eliminator is designed by **GC Electronics** for CB-mobile and car radios. No tools are required for installation. The unit has no moving parts and is housed in an aluminum case to keep out dust. It oscillates with battery voltages as low as 5 volts. The eliminator operates over a temperature range of −50° to +180°F; its power capacity is sufficient for the maximum CB transmitter output authorized by the FCC. The unit is supplied with installation instructions and a list of CB sets in which it can be used to replace original equipment.

Solid-State CB Transceiver

The 12-channel **Hallicrafters** CB-12 fully transistorized CB transceiver includes a three-stage transmitter rated for full authorized power. The receiver employs a dual-conversion superheterodyne circuit; sensitivity is less than 1.0 uv for 10 db S/N. Audio output is 3.5 watts. Battery

(127)

drain is .2 amp on receive, 1 amp on transmit. Chassis dimensions are 2⅝" x 6" x 9½".

The CB-12 is supplied complete with push-to-talk microphone, one set of crystals, and mobile-mounting kit. List price is $179.95. A pedestal AC power supply, the P-12, is available at $34.95 for base-station installations.

(128)

Desoldering Tool

Solder may be melted and vacuumed away from connections of printed circuit boards in a one-hand operation with the **Ungar Electric Tools** "Hot-Vac." The complete assembly, Model No. 7800, includes the No. 777 Clean Room handle, a standard Ungar heating unit, the No. 7806 Hot-Vac tip, and a rubber aspirator bulb.

No tinning is necessary because the tip has a coating that resists solder and thus prevents clogging of the tip orifice. A stainless-steel check valve is provided in the tip to prevent molten solder from being drawn into the aspirator bulb. The tip is set at an angle so that the tool can be held as a pencil iron normally is held. After each desoldering operation, molten solder in the collector is discharged into a metal waste receptacle by depressing the rubber bulb.

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57. *ANTENNACRAFT* — Literature on new 75-ohm TV and FM antennas for use with RG-59/U coaxial cable.
58. *FINNEY*—Catalog 20-322 showing newest addition to the All-Band Color-Ve-Log series of UHF-VHF-FM antennas.*
59. *JFD*—Literature on complete line of log-periodic antennas for VHF, UHF, FM, and FM stereo. Brochure showing converters, amplifiers, and accessories; also complete '64-'65 dealer catalog plus dealer wall chart of antenna selection by area.
60. *MOSLEY ELECTRONICS* — Illustrated catalog giving specifications and features on large line of antennas for Citizens band, amateur, and TV applications.
61. *MULTITRON* — Illustrated literature on FM-stereo antenna No. MA-44, multi tuner Model M-11, and Minitenna No. MINI-4T.
62. *PARKER*—Bulletin describes new *Da Vinci* indoor UHF antenna.
63. *TRIO*—Brochure on installation and materials for improving UHF transistor reception.
64. *WINEGARD*—Catalogs describing new: Conicals, UHF antennas, transistor preamplifiers, noise filter, transformer package, couplers, and Chroma-Tel line.*
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70. *GC ELECTRONICS* — New up-to-date phono wall chart, No. FR-250-G, including new drives and hundreds of newly cross-referenced models.*
71. *KARG* — Data sheets for Model X-1 transistor stereo amplifier and Model T-9 stereo FM tuner.
72. *JENSEN* — 24-page catalog, No. 165-K, illustrates and describes speakers and speaker system kits.
73. *NUTONE*—Two full-color booklets illustrating built-in stereo music systems and intercom-radio systems. Includes specifications, installation ideas, and prizes.
74. *OAKTRON* — "The Blueprint to Better Sound," an 8-page catalog of loudspeakers and baffles giving detailed specifications and list prices.
75. *OXFORD TRANSDUCER*—Product information bulletin describing complete line of loudspeakers for all types of sound applications including replacements for public address and intercom systems.
76. *PERMA-POWER*—Literature describing Model S-2000 *The Diplomat* transistorized attache-case public address system which operates on flashlight batteries.*
77. *QUAM-NICHOLS* — Catalog 65 listing replacement speakers for public address systems, hi-fi, auto radio, and radio-TV applications.
78. *RANGER*—Folder Form No. RA-65-13 describes under-dash mounted *Stereo-Magic* car radio reverberation unit.
79. *SAMPSON* — Full-color catalog pages showing new line of Waltham transistor radios, tape recorders, and portable televisions.
80. *SONOTONE*—Specification sheet SAH-97 on new RM-1 *Sonomaster* speaker system.*
81. *TENATRONICS* — Descriptive literature on new line of solid-state 110 volt AC table model radios.

COMMUNICATIONS

82. *EICO*—Data sheet on Model 753 *Tri-Band* transceiver and other ham gear, plus full-line catalog.*
83. *LAFAYETTE*—New 512-page 1966 catalog 660 describing electronics equipment for home, hobby, and industry.
84. *PEARCE-SIMPSON* — Specification brochure on IBC 301 business-band two-way radio, *Companion 11, Escort,* and *Guardian 23* Citizens-band transceivers.

COMPONENTS

85. *BUSSMANN*—Bulletin SFUS, a 12-page booklet listing the complete line of BUSS and FUSETRON small dimension fuses by size, type, and list prices—also indicates proper fuseholder.*
86. *CLAROSTAT* — 1965 full-line catalog covering switches, potentiometers, and resistors.
87. *J-B-T INSTRUMENTS*—General catalog 565; bulletins on reed relays, oscillator controls, toggle switches, and subminiature rotary-lever switches.
88. *RAWN* — Detailed instruction sheets on TV knob and plastic repairs with *Plas-T-Pair.*
89. *SWITCHCRAFT*—New product bulletin No. 152 describes: series H-100 and H-200 "HI-D" switch, and series DA "*DATA-SWITCH*".*
90. *TRIAD*—1965 replacement catalog and television guide on transformers for television, hi-fi, home and auto radios.
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95. *LUBRA CLEAN* — Information on new tuner cleaner.
96. *PRECISION TUNER*—Literature supplying information on complete, low-cost repair and alignment services for any TV tuner.*
97. *YEATS* — The new "back-saving" appliance dolly Model 7 is featured in a four-page booklet describing feather-weight aluminum construction.

SPECIAL EQUIPMENT

98. *ATR* — Descriptive literature on selling new, all-transistor *Karadio* Model 707, having retail price of $29.95. Other literature on complete line of DC-AC inverters for operating 117-volt PA systems and other electronics gear.*
99. *GREYHOUND* — The complete story of the speed, convenience, and special service provided by the Greyhound Package Express method of shipping with rates and routes.
100. *SPRAGUE* — Circular M-853 describes SK-1, SK-10, SK-20, and SK-30 *Suppressikits* for vehicles with alternators or DC generators.*
101. VOLKSWAGEN — Large, 60-page, illustrated booklet, "The Owner's Viewpoint," describes how various VW trucks can be used to save time and money in business enterprises, including complete specifications on line of trucks.

TECHNICAL PUBLICATIONS

102. *CLEVELAND INSTITUTE OF ELECTRONICS*—Free illustrated brochure describes electronic slide rule with four lesson Instruction Course and grading service.*
103. *RCA INSTITUTES* — 64-page book, "Your Career in Electronics" detailing home study courses in telecommunications, industrial electronics, TV servicing, solid-state electronics, and drafting. Preparation for FCC license, and courses in mobile communications and computer programming also available.*
104. *HOWARD W. SAMS* — Literature describing popular and informative publications on radio and TV servicing, communications, audio, hi-fi, and industrial electronics, including special new 1965 catalog of technical books on every phase of electronics.*

TEST EQUIPMENT

105. *B & K*—Bulletin 108-R on Model 801 Capacitor Analyst. Bulletin No. 124-R on Model 1240 color generator. Catalog AP-21R describing uses for and specifications of Model 1076 Television Analyst, Model 1074 TV Analyst and Color Generator, Model 700 and 600 *Dyna-Quik* Tube testers. Model 445 CRT Tester-Rejuvenator, Model 960 Transistor Radio Analyst, Model 360 *V-O-Matic* VOM, Model 375 *Dynamic* VTVM and other test instruments.*
106. *HICKOK*—Specification sheets on Model 662 installer's color generator. Model 677 wideband scope, Model 470A uni-scale VTVM, and Model 799 *Mustang* tube tester.*
107. *JACKSON* — Complete catalog describing all types of electronic test equipment for servicing and other applications.
108. *LECTROTECH* — Bulletins on *Metergards, Lectrocells,* Models V-6 and V-7 color-bar generators, and Model T-100 horizontal-deflection circuit meter.*
109. *MERCURY*—Catalog describing full line of electronic test equipment.
110. *PRECISE*—8-page catalog describing kit and factory-wired test equipment.
111. *SECO*—New colorful folder describing 20 test instruments including tube testers.*
112. *SENCORE* — Information on all solid-state color generator Model CG135 plus full line catalog.*
113. *SIMPSON* — Complete 16-page brochure on entire line of electronic test equipment; also, catalog on line of panel meters.
114. *TRIPLETT* — New catalog No. 47-T covering the company's entire line of test equipment.

TOOLS

115. *ARROW* — Literature outlining "How, When, and Where" to use 3 staple gun tackers.
116. *ENTERPRISE DEVELOPMENT*—Time-saving techniques in brochure from Endeco demonstrate improved desoldering and resoldering techniques for speeding up and simplifying operations on PC boards.

TUBES & TRANSISTORS

117. *SEMITRONICS* — Bulletins describing new No. TV1000 UHF transistor and No. CTV358 color crystal.

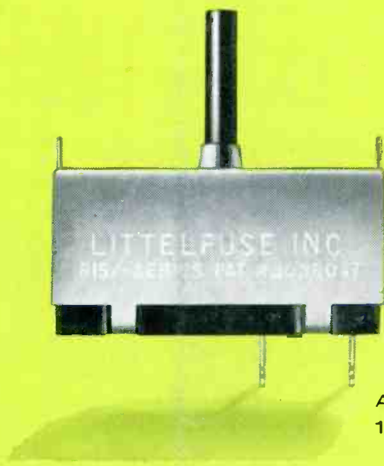
RCA announces a complete new line of color television picture tubes for the replacement market... Hi-Lite. RCA Hi-Lite tubes are all-new. Glass. Gun. The works! Rare-earth phosphors applied by RCA's advanced screening process create vivid, natural colors, and color picture brightness unsurpassed in the color TV industry! Better black-and-white pictures, too! RCA's Hi-Lite line includes 19-inch and 25-inch rectangular and 21-inch round tube types. RCA Hi-Lite Color Tubes lead the color parade.

Join it!

RCA ELECTRONIC COMPONENTS AND DEVICES, HARRISON, N. J.

RCA The Most Trusted Name in Electronics

Introducing a Complete Line of Littelfuse Quality Circuit Breakers



Actual Size
$1\frac{3}{4}'' \times 1\frac{3}{16}'' \times \frac{1}{2}''$

Exact replacement from factory to you

Designed for the protection of television receiver circuits, the Littelfuse Manual Reset Circuit Breaker is also ideally suited as a current overload protector for model railroads and power operated toy transformers, hair dryers, small household appliances, home workshop power tools, office machines, small fractional horsepower motors and all types of electronic or electrical control wiring.

LITTELFUSE DES PLAINES, ILLINOIS

Circle 55 on literature card