JULY, 1970 75 cents

A HOWARD W. SAMS PUBLICATION

Electronic Servicing

Solving color temperature problems

page 12

The servicing market defined

page 16

The first and only solid-state test equipment guaranteed for 5 years.

Now EICO, because of its emphasis on *reliability* in engineering and manufacture, offers the industry this breakthrough.

EICO's new line of solid-state test equipment comes with an unprecedented 5-year guarantee of performance and workmanship. (Send for full details of this EICO 5-year GUARANTEE on factory-assembled instruments.)

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All the versatility of the EICO 240 plus: AC/DC Milliammeter, 1 ma to 1000 ma in 7 non-skip ranges; single all-purpose DC/AC-Ohms — MA Uniprobe®; and large 6½" 200 μA meter movement.

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5 sine wave and 4 square wave bands. Low distortion Sultzer feedback FET circuit. Sine: 20 Hz to 2 MHz; 0-7.5V rms into hi-Z, 0-6.5V into 600 ohms Max. distortion 0.25%. Square: 20 Hz to 200 kHz; 0-10V p-p into hi-Z, pos. direction, zero ground. Rise time at 20 kHz less than 0.1 μ sec. 105-132 VAC, 50/60 Hz, 10VA. HWD: 7½", 8½", 8½". 9 lbs.

New EICO High Performance Instruments

EICO 385 — Solid-State Portable Color Generator $79.95 Kit, $109.95 Wired.
EICO 465 — Wideband Vectorscope/Oscilloscope $179.95 Kit, $249.95 Wired.
EICO 1025 — Solid-State Power Supply $79.95 Kit, $119.95 Wired.
EICO 443 — Semiconductor Curve Tracer $69.95 Kit, $99.95 Wired.
EICO 633 — CRT Tester & Rejuvenator $69.95 Kit, $99.95 Wired.
EICO 635 — Portable Tube Tester $44.95 Kit, $69.95 Wired.

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July, 1970 • Volume 20, No. 7

Electronic Servicing

Formerly PF Reporter

in this issue...

DEPARTMENTS

Second class postage paid at Kansas City, Mo. and additional mailing offices. Published monthly by INTERTEC PUBLISHING CORP., 1014 Wyandotte St., Kansas City, Mo. 64105. Vol. 20, No. 7. Subscription rates $5 per year in U.S., its possessions and Canada; other countries $6 per year.

ELECTRONIC SERVICING (with which is combined PF Reporter) is published monthly by Intertec Publishing Corp., 1014 Wyandotte Street, Kansas City, Missouri 64105.

Subscription Prices: 1 year—$5.00, 2 years—$8.00, 3 years—$10.00, in the U. S. A., its possessions and Canada.

All other foreign countries: 1 year—$6.00, 2 years—$10.00, 3 years—$13.00. Single copy 75¢; back copies $1.

Robert E. Hertel, Publisher
Intertec Publishing Corp.
Subsidiary of Howard W. Sams & Co., Inc.

electronic scanner

news of the industry

Large-Screen Color TV More Promising Than Three-Dimensional TV

Three-dimensional TV is a long way off, if it ever materializes.

This basically is the judgment of Dr. Dennis Gabor, a staff scientist of CBS Labs who fathered the basic principle (holography) on which most proposed three-dimensional TV systems are based.

Dr. Gabor, addressing engineers at the National Association of Broadcasters Convention, stated that he "couldn't believe in three-dimensional TV except in that remote and rather unlikely future" when consumers will be able and willing to spend as much on entertainment as they now spend on everything.

Large-screen color TV is more promising for the near future, according to Dr. Gabor, if a less expensive display system can be developed. The most promising large-screen TV system, he says, is the laser and fibre optic technique that amplifies light coming from a small, conventional color CRT—a system that now is being developed in Canada.

Hitachi Introduces Pre-Set Customer Controls

A spring-loaded linkage which, at the push of a button, deactivates customer controls on the front of the set and internally adjusts the picture to pre-determined settings is offered on three color TV models in Hitachi's 1971 line.

Called Automatic Picture Setting (ATS), the system, which changes color saturation, tint, brightness and contrast to levels pre-set by the factory, can be re-adjusted by technicians in the field, to satisfy customer preferences or compensate for component aging.

The ATS system reportedly does not compensate for color variations related to changes in the broadcast signal.

U.S. Color TV Homes Up To 24.3 Million

U.S. homes having color TV totaled 24.3 million on April 1, according to a **TV Digest** report of National Broadcasting Corporation (NBC) estimates.

The report stated that the new total represents an increase of 900,000 color sets over the NBC estimate for January 1 of this year.

Study Indicates 1969 Average TV Shop Profit Was 12.98 Percent

Radio and TV service shops in 1969 showed an average before-taxes profit of 12.98 percent of total receipts, according to a study conducted by the Accounting Corporation of America and reported on by the National Federation of Independent Business (NFIB).

This and other statistical facts about 48 basic types of small businesses, including radio and TV service shops, are revealed in an Accounting Corporation of America publication titled "Yearbook for 1969." Data for the statistical analysis reportedly was supplied by several hundred accountants serving small business enterprises doing from $25,000 to $300,000 annual volume.

Copies of "Yearbook for 1969" can be obtained for $10.00 from Accounting Corporation of America, 1929 First Avenue, San Diego, California.

Mobile Showroom Franchise Offered

A completely stocked mobile showroom of home electronic products is included in a new home electronics marketing franchise developed by Van Electronics Corporation of New York.

The van is a standard Dodge Tradesman model equipped with a custom-built interior especially designed to showcase approximately 70 to 100 pieces of merchandise ranging from portable TV sets to electric

can openers. Included are radios, stereos, tape recorders, mixers, toasters, waffle irons, frying pans, ice crushers, as well as personal care items such as electric toothbrushes, hair dryers, etc. The products re-

portedly will be primarily name brands, to be selected by the franchisee.

The interior of the van is designed so that one of the sides and the rear open into individual 9-ft. display areas. An electronically operated, carousel-type arrangement in the center of the van rotates into view those products in the center of the van.

Called Vantron, the new mobile showroom permits the demonstration of products in customers' homes so that they can see how a particular TV set or radio blends with the decor and furnishings of their home.

Vantron reportedly was conceived primarily for suburban areas, as an extension of an established electronic retail store.

Further information can be obtained by writing Van Electronics Corporation, 18 E. 41st Street, New York.

Channel Master Appoints New York TV Distributor

Leck Industries of Long Island City has been appointed exclusive New York Metropolitan area distributor of Channel Master's line of color TV.

Leck also will continue to distribute this manufacturer's radios, tape recorders, indoor antennas and other consumer products.

Magnavox Home-Study Color TV Course

A new home-study color TV service course designed to provide the necessary basic training for persons considering TV service as a vocation has been announced by Magnavox.

To be eligible for the course, students must be sponsored by a servicing dealer or service contractor and be given access to shop facilities, equipment and Magnavox products required to accomplish specific lesson assignments, according to Ray Yeranko, Magnavox national service manager.

Completed lessons are sent to Magnavox, where they are graded by service training department personnel.

Students who successfully complete the course are presented with a certificate which qualifies them for advanced studies at any one of seven Magnavox service training centers.

Further information about the program can be obtained from Magnavox Service Training Department, 1700 Magnavox Way, Fort Wayne, Indiana 46804.

New Address for Electronic Measurements

Electronic Measurements, manufacturer of test equipment, has moved to 405 Essex Road, Neptune, New Jersey 07753.

RCA Gives Full-Year Service Labor Coverage on Solid-State Color TV

A full year of service labor coverage on its new TransVista solid-state color TV receivers, a 90-day labor warranty on other new products, and the addition of portable phonographs and tape instruments to the existing 90-day-over-the-counter exchange plan for radios have been announced by RCA.

Owners of warrantied products will be permitted to make their own selection of a service dealer, even for RCA-reimbursed servicing, according to Barton Kreuzer, RCA Executive Vice President/Consumer Products division.

The decision to offer one year of free service labor on solid-state color TV receivers reportedly was based on the two-year performance record of RCA solid-state color TV sets in homes.

Under the existing factory warranty program, RCA will replace parts for one year on color TV sets and 90 days on black-and-white TV, radios, phonographs and tape instruments.

The new one-year warranty covers both labor and parts on 16 TransVista solid-state color TV receivers whose optional prices range from $600 to $1,750.

Twelve models of New Vista (tube-type) color TV receivers are covered by the 90-day service labor warranty, in addition to the one-year parts warranty.

The picture tube in all color TV sets will continue to be replaced during the second year for only the labor cost.

Society of CET's Formed

Formation of a society of certified electronic technicians (CET's) was formally approved recently by the National Electronic Association's (NEA) board of directors at a meeting in Lake Charles, La.

To qualify for the CET society, an individual must be a certified electronic technician (CET) and have "high moral character."

Annual membership dues for the society are $15.00, according to Richard Glass, executive vice president of NEA.

Mexican Station Begins AM Stereo Broadcasting

Stereophonic broadcasting of music using standard AM equipment made its commercial debut on May 2 of this year, when radio station XTRA, a 50-kw station in Tijuana, Mexico, began broadcasting AM stereo.

Reception of the AM stereo signals reportedly requires only two AM receivers, one tuned slightly higher than normal and the other slightly lower.

AM stereo broadcasts cover about fifteen times more area than those of a conventional FM stereo station having the same power, according to Leonard R. Kahn, president of Kahn Research Laboratories, Inc., developer of communications and broadcasting equipment.

Precision Tuner Has New Address In Indiana

The Bloomington, Indiana, facilities of Precision Tuner Service have been moved to a new building, according to a recent announcement by Roland F. Nobis, president of Precision.

The new address is:

5233 South Highway 37
Bloomington, Indiana 47401

Precision Tuner Service operates TV tuner repair facilities in Indiana, Florida, Texas and California.

1970 Consumer Electronics "Golden Anniversary" Annual Available

The consumer electronics industry marks its golden anniversary this year. It was born in 1920, with the beginning of radio broadcasting in the United States, and the offering of the first radio receiving sets to the public.

The 1970 Golden Anniversary edition of the EIA's Consumer Products Division, **Consumer Electronics Annual,** just published, outlines the industry's first fifty years and contains a year-by-year statistical review of the products through 1969: television, radios, phonographs and magnetic tape equipment. The special edition also contains a listing of the industry's contributions to the national economy, a chronology of important industry events, a glossary of terms used in the industry, and a list of the names and addresses of major industry allied trade associations.

Copies are available at 50 cents a copy, postpaid, from the Electronic Industries Association, Consumer Products Division, 2001 Eye Street, N.W., Washington, D.C. 20006. 25-99 copies are 25 cents each; 100 or more copies are 15 cents each.

FCC Says CATV Can Import Distant Signals

The Federal Communications Commission (FCC) has tentatively decided to permit cable antenna television (CATV) to import signals from distant stations.

Also being considered by the FCC is a proposal which would eliminate advertising from imported programs and would permit UHF TV stations operating on channels 14 through 83 to sell advertising on their own channels and on other channels on which the imported programs are carried.

Retailer Billing of Customers Draws FTC Warning

The Federal Trade Commission (FTC) has warned retailers that failure to furnish customers their revolving or open-end charge account statements in time to avoid finance charges might be a violation of the Truth-in-Lending Act, according to a report in **Home Furnishings Daily.**

The FTC said it voiced the warning because it has received many complaints from the public stating that some retailers send periodic billing statements several days or weeks after the billing date indicated on the statement.

Retailers are urged by the FTC "to send their periodic billing statements as promptly as possible so as to allow consumers the maximum advantage of the time period."

The FTC has further warned that "continued abuses in connection with this problem could result in formal commission action in individual instances, as well as the commission's recommendation for strong corrective legislation."

A bill already has been introduced in the U.S. House of Representatives which, if passed, would amend the Truth-in-Lending Act to require open-end creditors to mail their periodic statements at least seven days before the close of the next billing cycle. ▲

New Service Literature

TV TECH AID, Edward G. Gorman, Kings Park, L.I., New York 11754; printed monthly; yearly subscription $7.95.

A monthly summary of actual color and b-w TV trouble symptoms, their possible causes and the cure for each. Where needed, a schematic of the circuitry involved is included.

The troubles and cures are grouped according to manufacturers, which, in turn, are listed alphabetically. The format of the publication is designed to facilitate filing the troubles and cures according to manufacturer and chassis number—**a definite aid to quicker servicing.**

letters to the editor

Circuit Change in GE MXT Chassis

In the Troubleshooter department in the May '70 issue of ELECTRONIC SERVICING one of your readers asked for suggestions to correct recurring failures of the video detector in General Electric MXT chassis.

I doubt that replacing the 6AF11, as you suggested, will help. The General Electric Company recommends that you insert a 470-ohm, ½-watt resistor in series with the control grid of the 6AF11. This will not affect the gain or picture detail, but will prevent future detector failure.

R. D. Overman
Kansas City, Kansas

Thank you, Mr. Overman, for taking the time to inform us of the modification recommended by G.E.

We also thank the following readers who already were aware of the modification and also took the time to bring it to our attention: Bill Campbell, Asheville, N.C.; Everett Graff, Hart, Mich.; Robert C. Ireland, Pleasant Valley, N.Y.; and Kenneth R. Brown, Hartford, Ky.

Source for Tube Tester Set-up Charts

In nearly every issue of ELECTRONIC SERVICING in the Letters to the Editor department someone is trying to update their tube tester or find the latest tube set-up data.

I have found that Coletronics Service, Inc., 1744 Rockaway Avenue, Hewlett, N.Y. 11557, can supply the latest roll charts or tube set-up data for many different manufacturers' models. In addition, they can supply a Model B-16 adapter to update older tube testers to check newer tube types.

It should be noted that in order to test the newer type tubes, a checker should have from 12 to 14 switch positions; however, older checkers sometimes have only five or six. Thus, based on age and intended use, a purchase of a new tube tester is often advisable.

Prior to purchasing a new tube tester you should check manufacturers' literature; most manufacturers, if you write direct to their plant, will let you review their manuals prior to purchase. If you are not interested, just return the manual to them. Also keep in mind the good tube checkers available in kit form.

I hope the above information will be of help to fellow service technicians.

Bernard H. Serota
Philadelphia, Pa.

Tip for Hanging on to Tubes

I have a servicing tip for ES's readers. It's an old trick, but it works.

Many times when a tube is pulled out of its socket, it will go flying out of your fingers clear across the shop. To prevent this, get a little bottle of glycerin at the drug store and apply a small amount to the thumb, first and second fingers. Let it stand for perhaps 10 seconds and then rub it off with a tissue or clean cloth. After applying the glycerin, your fingers will not slip off the glass, and you can really hold on to those tough tubes. One word of caution: Do not pull out the socket, too. Reapply the glycerin as needed; you will never know it is on your fingers.

There are still plenty of tube jobs around, so I hope this will help someone.

J. Hamilton
Winchester, Ind.

Auto Antenna "Improvement"?

The article titled "Testing Windshield Antennas", which appeared on page 58 of the April '70 issue of ELECTRONIC SERVICING, is quite a paradox.

The auto industry claims it is trying to make cars easier to service, and then they come up with a mind-boggling "improvement" like this. If your car radio antenna goes bad, instead of a simple $3.00 replacement, now you'll have to replace a $50.00 (or more) windshield. Now that's what I call progress. I'm sure the glass replacement people are delighted.

Somehow, I think Detroit could have come up with a hidden antenna that was replaceable.

Ken Greenberg
Chicago, Ill.

Equipment For Sale

I would like to sell my radio and TV equipment. If anyone is interested, please write to me and I will send a list of what I am offering for sale.

G. G. Gibson
Box 66
Arnett, West Va. 25007

Rider Radio Manuals For Sale

I have noticed from reading the Letters to the Editor department of ELECTRONIC SERVICING that some readers need Rider radio manuals. I have Volumes I, II, III, IV, VII and IX for sale "dirt cheap". If anyone is interested, please write.

Jerry Vondruska
2921 E. 16th
National City, Calif. 92050

Parts Availability—Examples

As I sit here this morning going over my back order list on parts, I wonder what the independent shops in the western and southern parts of the country do to get parts shipped in a reasonable length of time. I am located 12 miles from Philadelphia—closer to many of the larger manufacturers than shops in other parts of the country.

On my list, I find a four-inch Motorola speaker for a b-w TV which has been on order seven weeks; an

antenna for a Magnavox AM/FM radio (one year old), on order eight weeks; a picture tube for a Motorola portable, on order six weeks; four automobile speakers, six weeks; a UHF tuning knob, Admiral, seven weeks on order and finally received this week from their factory located in Philadelphia, twelve miles away; a head for a Dual 1009 record changer, ordered four weeks ago, and I am told this part is not available; six weeks for a part to repair a General Electric radio, only to be informed this part is out of production and no replacement part available—all of these orders produced unhappy customers.

Also, I have Sams PHOTOFACTs back-ordered as long as six weeks from a Philadelphia distributor—with the February issue of PHOTOFACTs delivered the same day as the March issue.

I had a non-polarized capacitor, for a Motorola color TV, on back order eight weeks—another unhappy customer.

A UHF tuner shipped to a tuner service organization on February 17 came back to my shop on April 21. I had to call this tuner service twice, and each time was told they "had not gotten to it yet but would right away". I finally called their main office, and they had the tuner returned to me. The bill was $10.55 plus postage, three long-distance phone calls amounting to $8.00, and the tuner still did not work, so I had to return it to the customer at No Charge. *I could have purchased a new one for $15 or $16. One more customer lost.*

I find it impossible to purchase parts to fix sets manufactured in Japan. Of course, this is understandable when you cannot get parts to repair sets manufactured twelve miles away. It seems to me that the whole industry is in a comfortable rut on parts. If it is not in the store when you order it, nobody wants to go to the trouble to locate it. I feel it is the responsibility of the local distributors to find the parts for the independent shops. That is what they are in business for. The independent shop could spend all day, every day on the phone or writing letters to get parts, but then we could never get around to fixing television sets.

The customer does not and will not believe that it takes six to eight weeks to get parts to repair their sets. Everyone wants service right now, Not Next *Month. I do not feel that I want anything from the local distributors and manufacturers that my customers don't expect from me—service in the shortest possible time.*

I realize we could avoid many of these problems if we all had a warehouse and two hundred thousand dollars with which to buy parts to stock it. I do not know of any independent shop that has, or could afford, that. I believe we give the fastest and best service to the customer that is possible with parts problems such as I've mentioned, yet the customer never blames the manufacturer. The blame is always put on the man or shop servicing the unit.

I know there is no one answer to the parts problem, but I do feel we could and should do something about it. I don't like control of business by any organization, but some of the shop owners in this area have discussed the possibility of trying to put pressure on the distributors or manufacturers by getting together and withholding orders from certain stores and distributors until they start giving reasonable service. We could also refuse to service some types of sets. If we did this, their "pocketbooks" would soon begin to hurt and we would get the kind of service from them that our customers Demand *from us.*

Service—this is what we are in business for. We do not manufacture sets, we only service them—but not very well without parts!

I would appreciate hearing how other shops handle this problem.

Jack R. Fink, Sr.
Green Ridge, Chester, Pa.

Parts Available

I like ELECTRONIC SERVICING's monthly issues and I am always looking forward to the next one.

I have a 1955 RCA CTC4 color TV chassis, Model No. 21CT-662U, in the shop. It is complete except that it has a bad flyback transformer. Maybe some of your readers might be looking for parts—such as a yoke, convergence assembly, or a tuner (VHF and UHF)—for this set. If so, please write to me for details.

J. R. Racine
1291 Williston Road
South Burlington, Vt. 05401

Help Needed

I am in need of a replacement for a burnt-out high-voltage transformer for an oscillograph. The instrument, type #83Y945 148952, was originally purchased from Allied Radio, Chicago. Inquiries there brought the answer that the part (high-voltage transformer, part number 121500) was no longer available, but they failed to supply any further information as to where a substitute might be available.

According to the original instructions, the high-frequency transformer is fed by a 6W6 oscillator and power amplifier and oscillates at 80 to 100 KHz. The oscillations are amplified by one-half of a 12BH7 oscillator feedback amplifier and fed back to the grid of the other half of the 12BH7, in proper phase to sustain oscillations. There is a 600-turn secondary for a 3.4-kv supply to the post accelerator anode of the CRT and a 300-turn secondary for a −1.8-kv supply for the CRT control and focus grids and cathode. Two half-turn windings are used for the supply of the filament current of two 1X2B rectifiers.

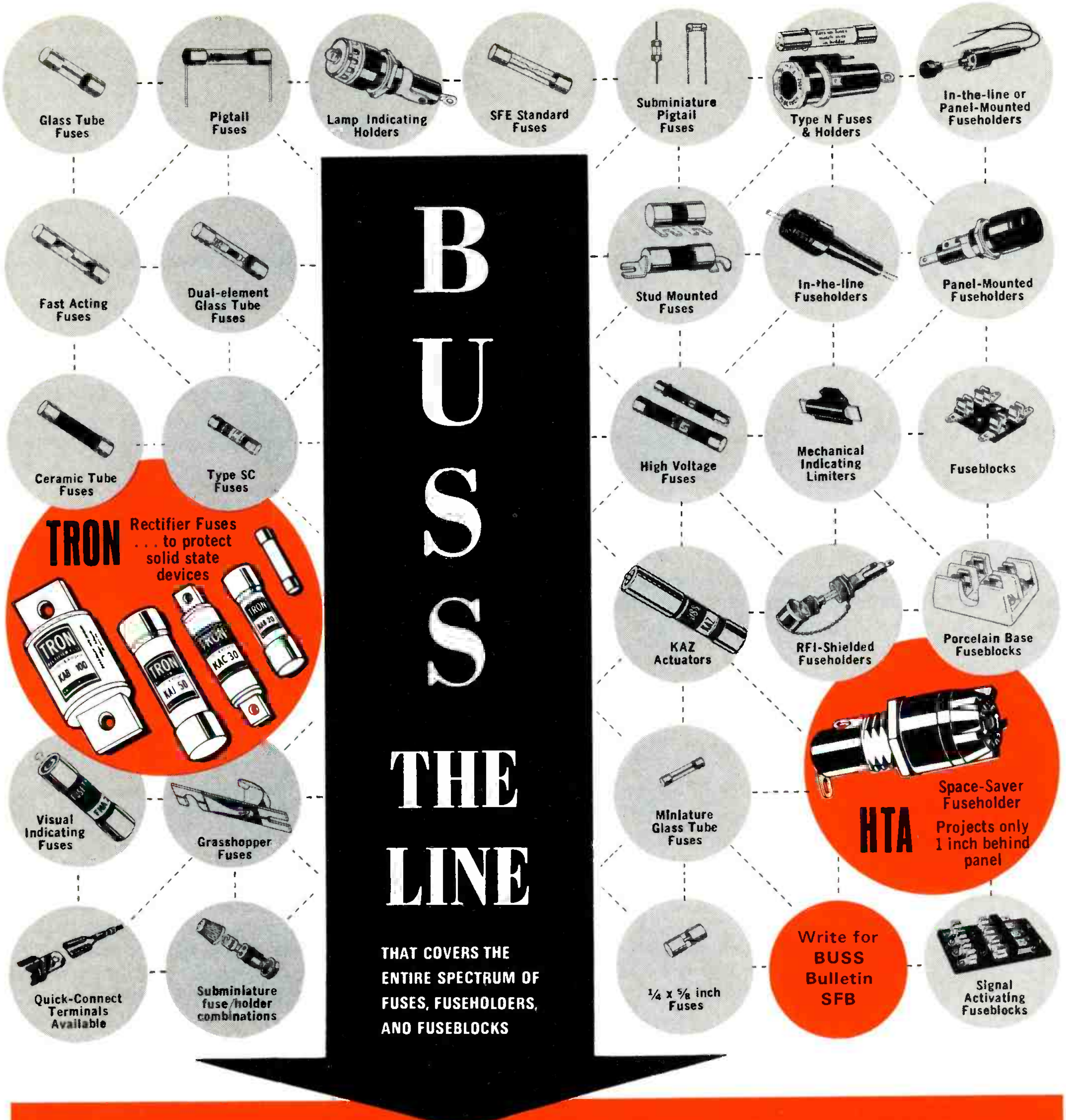
I would greatly appreciate it if someone could supply me with the address of a source of this part, which is essential for the operation of the oscilloscope.

Philip T. Van Engelen
1050 N. Clark
El Paso, Texas 79905

I am in need of the service notes and schematic for a Jackson Model TVG2 sweep and marker generator. Every electronic supply house I have contacted gives me the same answer: It is not available.

Could someone help me in this matter?

Ray's TV Service
2577 Parkside Drive
Jackson, Mich. 49203 ▲



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So, save time and trouble by standardizing on the BUSS Quality line. You'll not only find the right fuse and fuseholder everytime, but you'll simplify stock handling and inventory problems too.

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Circle 9 on literature card

Solving color temperature problems

TECHNIQUES FOR ADJUSTING AND TROUBLESHOOTING.

by Forest H. Belt

"Color temperature" in TV is just another name for gray scale. It refers to the shade of white produced by the tricolor picture-tube screen.

The term comes from science. A black object turns different colors when heated. It turns a certain shade of white when it reaches 6800 degrees K (Kelvin). That's the shade of white originally planned for the NTSC color raster. However, most of today's color sets end up with a white that is approximately 9000 degrees K.

From a practical standpoint, the exact degree isn't important. The raster can be warmish white, obtained by setting blue just slightly low. Or, it can be cold, with a touch more blue than it needs. When the raster is neutral white, the blacks and whites are as stark as this magazine page.

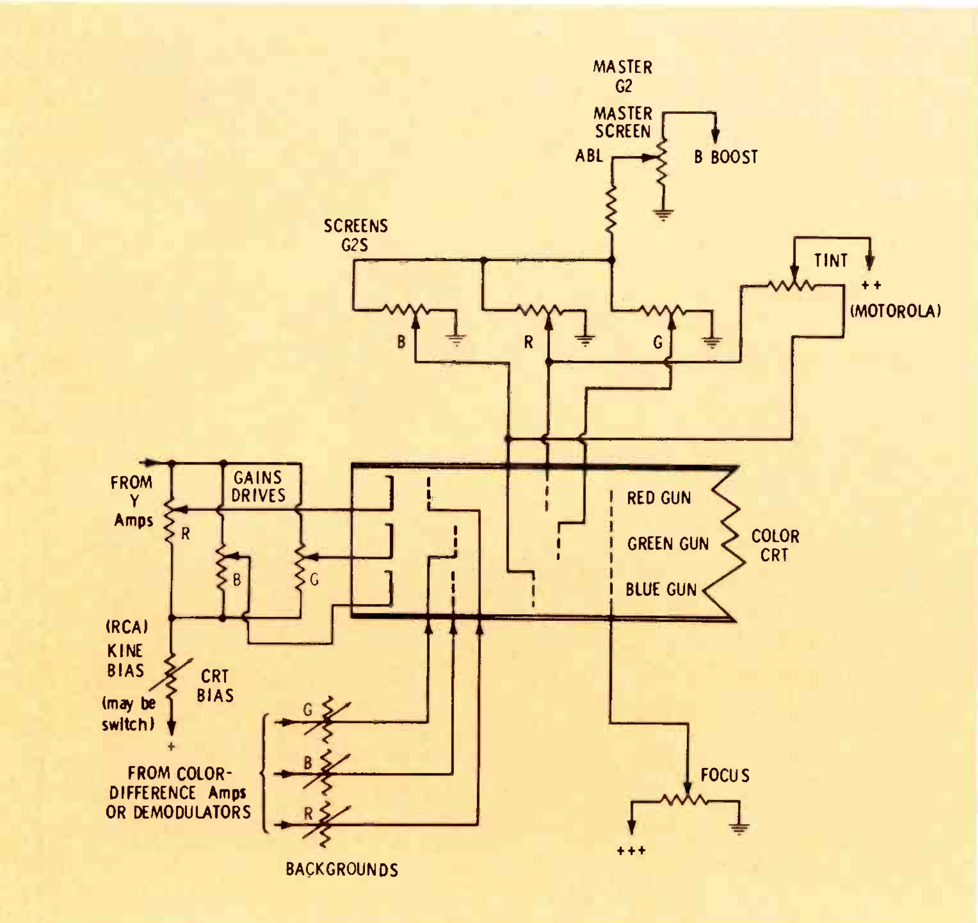

Fig. 1 Simplified schematic of various color-CRT control circuits. No single set has all these controls, but positions and relationships to other circuits are shown here. Control labels vary with chassis, too, and the most popular are listed.

An Exact Mixture

A white raster depends on how much light each of the three phosphors puts out. If they are excited by their beam currents in correct proportions, the raster is white. Gray-scale adjustments set these beam currents.

Because of difference in phosphor efficiency and in brightness of each color, beam current for each color is likely to be different. Therefore, measuring beam current or CRT voltages gives no hint of correct adjustment. You can generally decide only by looking at the raster.

The gray-scale adjustment steps given by each chassis manufacturer are one guide. Some make it easy, with a "cutoff" system. Others expect you to be able to judge a neutral white.

I use a trick to keep my eyes from misjudging. You can use it, too. Put a black-and-white set close by. Then, when your eyes start compensating—which leads to wrong gray scale—watch the true white on the black-and-white set for a few seconds. This will help you re-establish the correct reference level for truer white.

But sometimes, try as you might, you just can't get the proper white. Call it gray scale, or call it color temperature, what you have is a troubleshooting problem.

CRT Grids and Cathodes

Review, for a moment, how adjustments affect raster color. Fig. 1 is a diagram of gray-scale circuits for a color picture tube. This diagram is a composite. No set actually has them all. But in this diagram you'll find most of the adjustments any set **might** have. I'll explain them briefly.

Virtually every color set has the three Screen controls. They might be called **G2** controls. They apply individual DC voltages to each accelerator grid (G2) in the three CRT guns. A few chassis have the Master Screen control; it determines how much voltage is available for the weakest gun.

The screen (G2) controls set the cutoff characteristics for each gun. For gray-scale tracking, therefore, the screens mainly affect low brightness. In the "cutoff" method of setting them, you set the brightness control at about midrange and adjust each screen control to barely extinguish its color. This is easy if the set has a "Service", or "Setup", switch to kill vertical sweep.

You adjust the Master Screen, or Master G2, control if a screen control doesn't respond. In other words, suppose you can't get a color with one of them. Leave it at its maximum setting, and turn up the master control until the color shows. Then proceed with the others. The object is a white (gray) raster at low brightness levels.

The next most common controls in color sets are the Drive, or Gain, controls. They adjust how much Y, or brightness (video), signal is applied to the cathode of each gun.

Many sets omit the Red Drive control. Blue and green phosphors in older color CRT's were more efficient than red. They needed to be "turned down" on highlights (high-brightness scenes) to maintain tracking throughout the gray scale, from black to white.

In today's sets, with more efficient CRT's, there are still only two controls. But a jumper gives you a choice between red and green with one of the controls. The Blue Drive is included in all chassis.

The CRT Bias control is a DC potentiometer. The purpose is the same. It sets the operating level of all guns, so the screen controls can equalize variations in gain or in phosphor efficiency. It may be a switch. The alternate label, "Kine Bias", is peculiar to RCA, whose engineers like to call a color CRT a kinescope.

A few chassis have "Background" instead of Drive controls. Matrixing in the color CRT mixes color-difference signals from the color demodulators with Y, or brightness, signals from the video section. The **proportions** are important to proper gray scale at high brightness. But it doesn't matter whether the controls adjust the Y signal or the color signal.

So, the Background or Color Video controls do the same job for tracking that the Drive controls do. They make the raster white at high brightness levels.

Looking for Trouble

Solving color temperature problems is a matter of getting the gray-scale tracking right. The raster should stay white from very low brightness to very high.

Gray scale faults show up two ways. For one, colors don't hold true during color shows. A more noticeable one, though, is the difference in raster shade as monochrome scenes change; scenes in which whites predominate appear one shade, dark scenes look another.

The acid test of gray-scale tracking is this: Turn the contrast down. Then turn brightness all the way up and then almost all the way down. If raster color changes from white at any brightness level, the gray

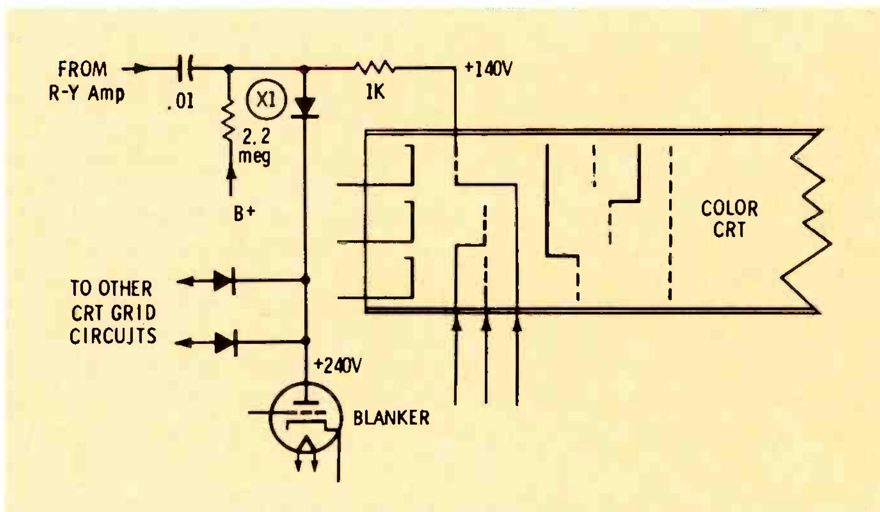

Fig. 2 DC restorer, or clamper, helps maintain proper DC level on CRT grid. A shorted or leaky diode can alter gray scale of the CRT raster.

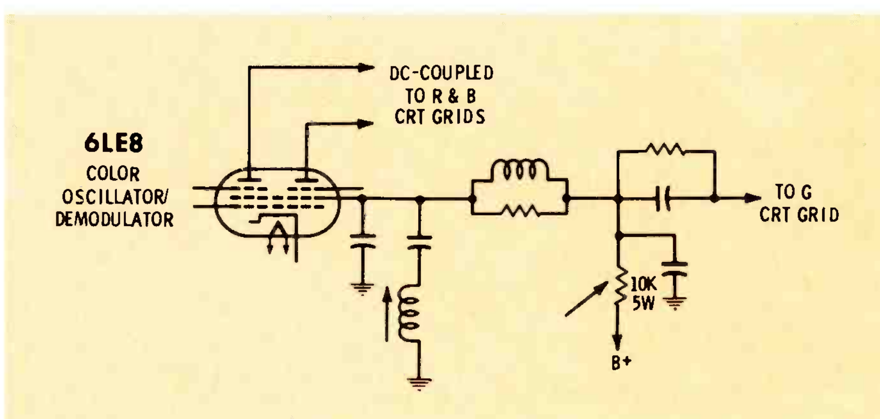

Fig. 3 Special tube oscillator/demodulator for color might fool you if you're not familiar with the stage. But that needn't keep you from tracing down DC trouble that puts a gray-scale symptom in the raster. Just start at the CRT and work back.

scale is not tracking properly.

Go through the adjustments. If the white is okay at low brightness but not at high, adjust the drive or background controls. If the white is off color at low brightness, adjust the screen or G2 controls. In Motorola sets, be sure the Tint control (Fig. 1) is centered.

Plenty of color-temperature problems are blamed on the color CRT. And it might be the culprit—particularly if gray scale is okay at first but goes bad as the set warms up. The solution is a new CRT whose guns aren't heating slowly.

If the case isn't too bad, you can warm up the set an hour or two before you adjust gray scale. The color will be off during warmup, but it'll be okay through most of an evening's watching. The only trouble is that, once the CRT starts to deteriorate, it usually continues. You'll have to keep readjusting every few weeks. (And you can't afford that many callbacks.)

In Unusual Spots

If you're any good with a voltmeter, you can track down faults in the networks that surround the picture tube. The toughies come up when these circuits are okay but you still can't make the gray scale track properly. Troubles can be hidden in some really out-of-the-way places.

For example, an RCA color portable came in with a pink raster. Ordinary gray-scale setup didn't help at all. The chassis was a CTC22. The CRT red grid had about 50 volts too much positive DC on it. Fig. 2 shows what I found. A DC restorer diode, X1, was leaky. The plate voltage of the blanker, which supplies a negative horizontal trigger pulse to the DC restorer diode, was feeding through the leaky diode to the CRT red grid. Each gun has one of these diodes. If a different DC restorer diode had shorted, it would have caused the raster to be the color associated with that diode.

The DC coupling in final stages sometimes lets a trouble in prior circuitry affect the gray scale of the raster. Like the time I took in a private-label set with an RCA-designed chassis. It had a red raster. New tubes in the color-difference amplifiers changed the shade of the raster, but didn't cure the gray-scale problem. Some quick voltage measurements led me to the cathode of a color-difference amplifier. The cathode resistor was open. It was common to all three color-difference amplifiers. I left in the new tube, because the original tube might have burned open the resistor.

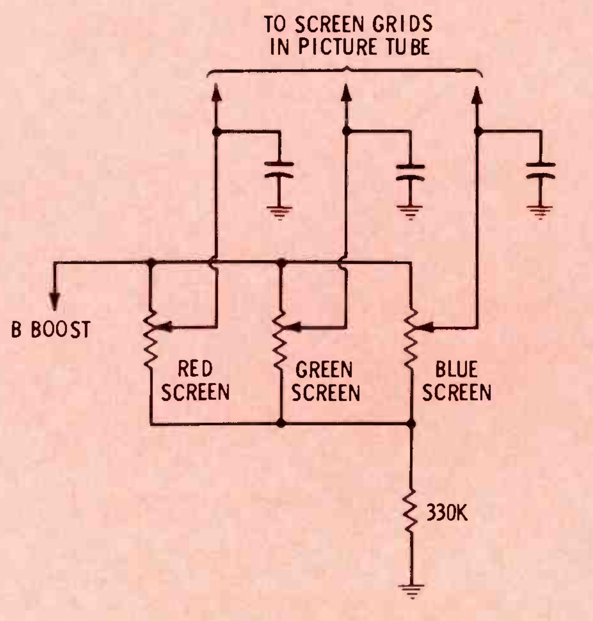

Fig. 4 Bypass capacitors along DC lines are susceptible to leakage and shorts. They might even damage a control by overloading it. Similar symptoms can be caused by shorted spark gaps.

Unfamiliar stages can waste your time, too. The Motorola TS-918 chassis has a one-tube color oscillator/demodulator stage (Fig. 3). It uses a 6LE8 tube. One was brought to the shop with a magenta raster. No amount of adjusting would put enough green into the picture.

With the voltmeter, I checked the DC on the CRT green grid. It was very low. Eventually, I traced the lack of voltage back to the demodulator stage. The supply resistor for the demodulator screen also set the DC level at the CRT grid. The resistor was open. Result: low green level.

Causes of improper gray-scale tracking show up in the least expected circuits. I've found coils open in peaking and decoupling circuits. If they carry DC or signal voltages that are applied to the color CRT, any one of them could foul up gray-scale tracking or raster color.

Bypass capacitors along the DC supply lines can be a problem. A shorted one usually is easy to find. A shorted spark gap is simple. But a leaky capacitor, such as one of those in Fig. 4, is easier to overlook, for a while. Careful analysis of DC voltages will usually lead you to the right defect.

Summary

These are just a few specific troubles I've come across. If you can't find the cause of improper gray scale in the input circuits of the color CRT, try these techniques:

Look for DC coupling from the demodulator or difference amplifiers to the CRT grids. It might be only a 270K-820K resistor shunting the coupling capacitor, but if it's there it means the stages are DC-coupled. Defects in those stages can affect gray scale.

Check the coupling circuits between the Y section and the CRT cathodes. Usually, DC circuits are employed here.

Check tubes and transistors that are DC-coupled to the color CRT. The faulty one could be back several stages.

Finally, don't let those words "color temperature" cause you to try for perfection. If the raster **looks** black-and-white, nobody's going to argue about a few degrees Kelvin.▲

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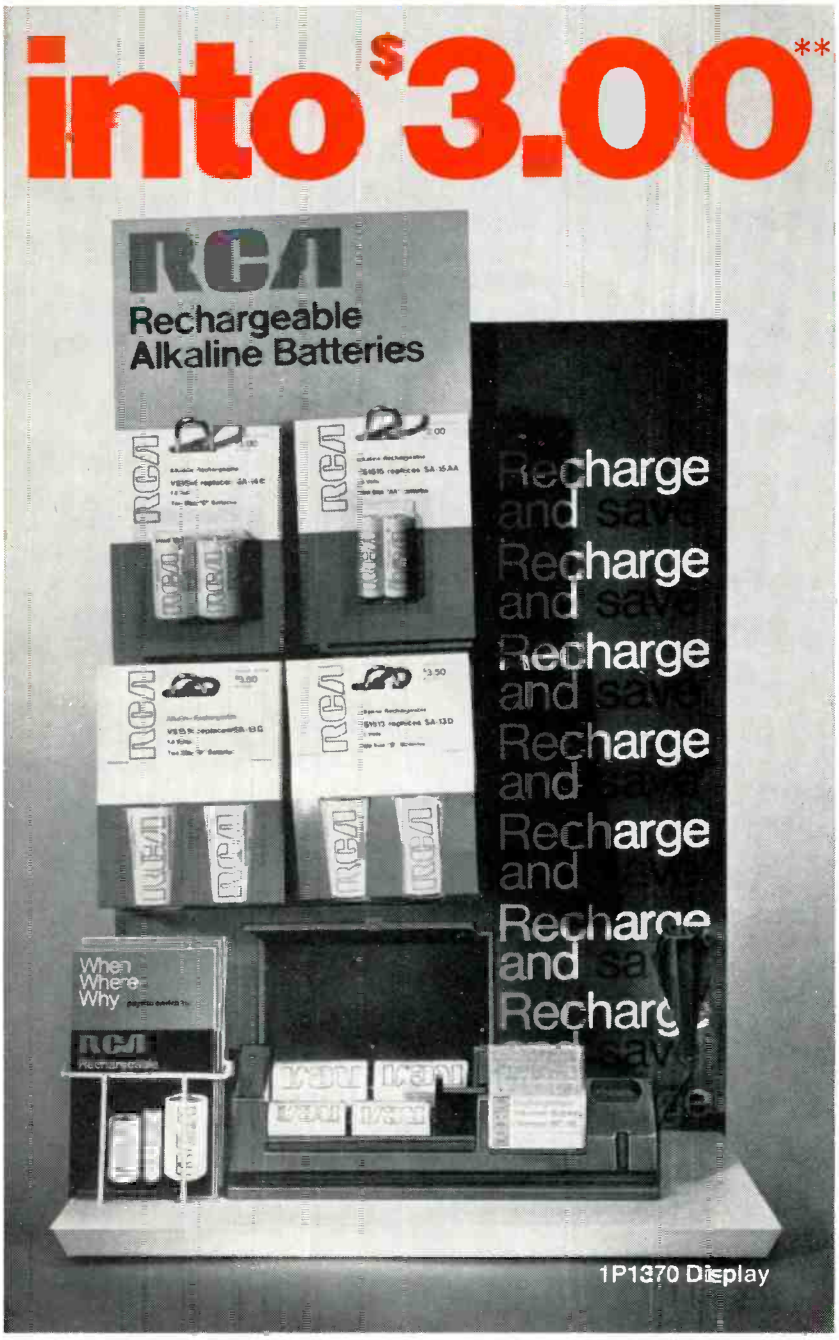

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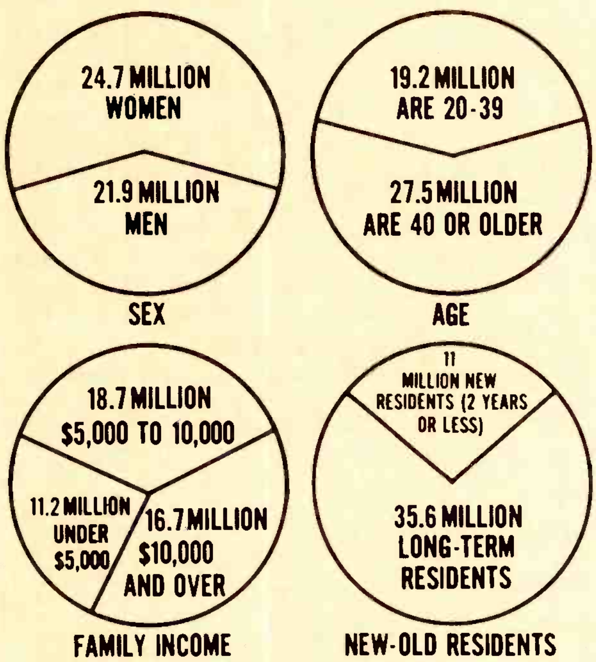
RCA

The demand for servicing of home entertainment electronic products-- who and how much

National survey profiles the characteristics of the market for a 12-month period.

Active Market for TV, Radio & Hi-Fi Service

About 46.7 million of the nation's 119.8 million men and women (20 and older) annually are in the market for TV, Radio & Hi Fi Repairs and Service.



Source: 1970 Yellow Pages National Consumer Usage Study

• During a given 12-month period, two of every five adults in the United States seek service for their television, radio or hi-fi equipment.

• Women represent a slightly larger percentage of the total potential market.

• Proportionately, nearly as many people in medium and small towns seek servicing as do people in metropolitan areas.

These and other characteristics of the home entertainment electronic servicing market are revealed by a nationwide study of consumer buying of goods and services, recently conducted for the Bell System by Audits and Surveys Co., Inc., an independent research organization.

The study, which covers 68 categories of products and services, reportedly involved extensive personal interviews of consumers throughout the nation.

The Market

	Population Over age 20	Number who seek servicing	Percentage of total who seek servicing
Men	55,917,000	21,969,000 (39%)	47%
Women	63,960,000	24,725,000 (39%)	53%
Total	**119,877,000**	**46,694,000 (39%)**	**100%**

Statistics Offered by Bell System

The study also revealed that 45.6 percent of the 46,694,000 people actively in the market for home entertainment electronic servicing can be expected to use the Yellow Pages to find service firms.

Brochures detailing all national findings of the Bell System study, including those relating to purchase and servicing of home entertainment products and Yellow Pages usage, are available on request from local telephone company Yellow Pages representatives.

Total demand

According to the study, in a 12-month period 39 percent of the adult population over the age of 20 seek service for their home entertainment electronic products.

Male demand versus female demand

Although women represent a slightly larger percentage (53%) of the total number who seek servicing, proportionately as many men seek servicing (39% of men over 20) as do women (39% of women over 20).

Age

Age	Population	Number who seek servicing	Percentage of total who seek servicing
20-39	49,856,000	19,207,000 (39%)	41%
40 & Over	70,021,000	27,487,000 (39%)	59%
Total	**119,877,000**	**46,694,000 (39%)**	**100%**

Because there are more of them in the total population, individuals 40 years of age or older represent a significantly larger percentage of the total who seek servicing; however, proportionately as many adults under 40 seek servicing as do people 40 or over.

Family income

Annual Income	Population	Number who seek servicing	Percentage of total who seek servicing
Under $5,000	32,166,000	11,172,000 (35%)	24%
$5,000-$10,000	50,426,000	18,748,000 (37%)	40%
$10,000 & over	37,285,000	16,774,000 (45%)	36%
Total	**119,877,000**	**46,694,000**	**100%**

As might be anticipated, the study revealed that the demand for service is related to family income—the higher the income, the greater the demand for service. Over 75 percent of the total demand for servicing is attributed to families who earn $5,000 or more income per year.

Family size

Size	Population	Number who seek servicing	Percentage of total who seek servicing
1-2 persons	45,723,000	16,031,000 (35%)	34%
3-4 persons	43,593,000	17,542,000 (40%)	37%
5 or more	30,561,000	13,121,000 (43%)	29%
Total	**119,877,000**	**46,694,000**	**100%**

Obviously, the more members in a family, the greater the use and number of home entertainment products. This fact is upheld by the study, which revealed that 43 percent of families having 5 or more members seek servicing during any 12-month period, compared to only 35 percent of those whose families have 1-2 members.

City size

Type of area	Population	Number who seek servicing	Percentage of total who seek servicing
Metropolitan	77,444,000	30,577,000 (40%)	65%
Non-metropolitan	42,433,000	16,117,000 (38%)	35%
Total	**119.877,000**	**46,694,000**	**100%**

Because a larger percentage of the total population lives in metropolitan areas, they represent a larger percentage of the total demand for servicing of consumer electronic products. However, proportionately, nearly as many people in small and medium-size towns seek service as do those who reside in large urban areas.

Length of time lived in area

Time in area	Population	Number who seek servicing	Percentage of total who seek servicing
Moved within past two years	28,836,000	11,001,000 (38%)	24%
Lived in area two years or more	91,041,000	35,693,000 (39%)	76%
Total	**119,877,000**	**46,694,000**	**100%**

Proportionately, the demand for service is about the same for transients as for those who remain in a neighborhood or locality for two years or more.

Home ownership

Status	Population	Number who seek servicing	Percentage of total who seek servicing
Rent or lease	37,119,000	13,362,000 (36%)	29%
Own or buying	82,758,000	33,332,000 (40%)	71%
Total	**119,877,000**	**46,694,000**	**100%**

Proportionately, the demand for service is nearly the same for renters and owners of homes; however, because the bulk of adults own or are buying the homes in which they live, they also represent the bulk of the total demand for service. ▲

troubleshooter

Overheating Horizontal Output Tube

I am servicing an Admiral 23A1 chassis (PHOTOFACT 211-2) which has sound but no high voltage. The plate of the 6CD6 horizontal output tube glows cherry-red, and the grid bias is positive instead of negative. C75, the coupling capacitor between the oscillator and the horizontal output, has been replaced, without any change in the trouble symptom. How can I make the necessary voltage measurements without burning out the 6CD6 tube?

John Szczepanski
Lackawanna, N.Y.

You are very close to the answer, John. It is almost a certainty the basic problem is a dead horizontal oscillator. The −12 volts that is supposed to be present at the grid of the 6CD6 is produced by the grid acting as the anode in a shunt-rectifier circuit. If the oscillator pulse is not present on the grid, rectification does not take place, and the voltage on the grid, at first, will be zero DC volts—the tube draws too much current, gets too hot, the heat makes it gassy, the gas makes the grid run more positive, and the positive grid makes the tube draw much more current, which makes it run hotter, etc., in a self-feeding action.

Voltage measurements in this case should be accomplished in two steps: because there are no other voltages brought in or sent out of this circuit, the DC grid voltage should be zero with the 6DC6 tube unplugged. If it isn't, C75 is leaking (new or not) or there is leakage across the wiring or board connections. If it is zero, reinstall the tube, but leave the plate cap off, while you check the horizontal oscillator. Operation without the plate cap overloads the screen grid slightly, but not seriously, and the grid and cathode provide a negative "drive" reading if the oscillator starts running.

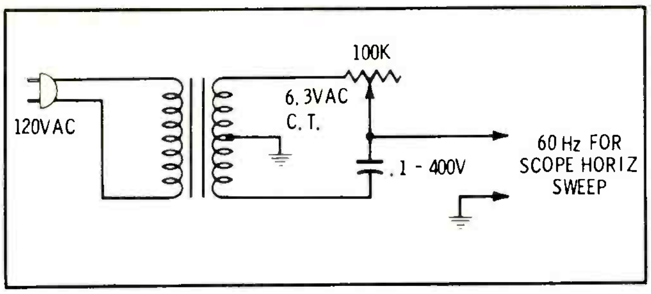
60-Hz Scope Sweep For Alignment

I have been following your articles on triggered sweep scopes with great interest because I need to purchase a new scope for my shop.

However, after borrowing a certain scope for a few days, I found it will not work with my RCA sweep alignment equipment because it does not have 60-Hz horizontal sweep with an adjustable phase control. What can be done?

W. D. Courtney, Jr.
Hurst, Texas

Variable phase 60-Hz sine-wave horizontal deflec-



tion can be added easily to almost any scope.

Your scope might already have a center-tapped 6.3-volt winding. If so, all the parts you need are the 100K-ohm control, the .1-mfd capacitor and the connecting wire. If not, a separate filament transformer can be used, as shown here.

Output of the phase shifting network goes to the "external" jack of the scope, and the horizontal sweep selector knob should be set for "external sweep".

If there is room, you can build the circuit inside the scope. Otherwise, enclose it in a small box or cabinet external to the scope.

No High-Voltage Regulation

There is no high-voltage regulation in a Zenith 24NC31Z color chassis. All tubes in the high-voltage and horizontal sweep circuits have been replaced, and all components in the grid and cathode circuits of the 6BK4 regulator are okay. The only way I can obtain regulation is to decrease R55 from 2 megohms to 680K. With the original value of R55, the 6BK4 cathode voltage is 355, the grid measures 300 volts, and the high voltage is 30KV. I would appreciate any suggestions you can offer.

Dale Foster
Homer, La.

Dale, the 6BK4 grid voltage is too low, and indications are that the resistance from this grid to ground is too small. A 1.5-megohm resistor is the only component between the grid and ground, and you have checked it. Two defects could occur that are not true component failures. A leakage path from the carbon element to the metal case inside the high-voltage adjust control could account for the symptoms. Such a leakage path might be caused by moisture. Or a high-voltage arc might have carbonized a path from grid to ground across the 6BK4 socket. These possibilities should be investigated.

You are right in not changing the value of the one resistor that makes the circuit regulate; this would be side-stepping the source of the trouble. If the original defect became worse, regulation would be lost again. (In a letter received just before this issue went to press, Mr. Foster confirmed that a defective high-voltage adjust control actually was the cause of the trouble symptom, as we had predicted in a personal letter to Mr. Foster.) ▲

Testing TV remote control systems

Theory of operation, common troubles and practical testing and alignment techniques.

by Bruce Anderson

Although there are a lot of minute differences in TV remote-control circuits, most are basically similar. This article will point up some of the servicing techniques which apply to most remote control systems.

Testing the Transmitter

Early remote-control transmitters were nothing more than rather glorified chimes; a hammer struck a metal bar which emitted supersonic energy. This energy was picked up by the microphone of the remote receiver, amplified, and used to operate the circuit under remote control. Unfortunately, a lot of other things could produce sounds which also would actuate the receiver. Dropping keys on the floor, tossing pocket change on a night table, the ringing of a phone, etc., could cause the TV to turn on—or turn off, change channels or, usually, go to maximum volume at about 2:00 AM. Further, since the transmitter output was only an impulse, the continuously variable control needed for color or tint remote adjustment, and highly desirable for remote control of volume, was impossible.

The emergence of the transistor led to the electronic hand unit, which over a long period hasn't changed in its basic structure to any great extent.

Fig. 1 is a schematic of the hand unit used with the remote-controlled versions of RCA CTC16 and 17 chassis. Depressing a button connects battery voltage to the transistor oscillator, and also connects a capacitance across the coil to form a circuit tuned to the desired frequency.

In this particular unit the frequencies ranged from 17.5 KHz to 22 KHz, and each of the seven frequencies could be tuned individually. Because the transmitting transducer doubled the frequency of the control signal, the early receivers, such as the one used with this hand unit, operated on the second harmonic—35 to 44 KHz in this case. Later hand units operate on higher frequencies, and the receiver is tuned to the fundamental of the control signal.

The transmitter oscillator output was used to drive a transducer (a rather impressive name for what is essentially a loudspeaker), which radiated supersonic energy in whatever direction it was pointed. It is important to remember that the radiated energy is acoustic and **not** electromagnetic, although there usually is an inductance field near the transducer.

Although the transmitter diagrammed in Fig. 1 has a tuning adjustment for each frequency, some hand units have only a single, variable capacitor. The hand unit used with the RCA CTC40 remote chassis is an example of this type of design. Each pair of fixed capacitors in parallel with a variable capacitor, shown in Fig. 1, is replaced by a single fixed capacitor in the circuit of Fig. 2. The advantage of this design is that the number of parts is reduced and alignment is much simpler. On the other hand, the tolerances of the capacitors are critical, and sometimes are a problem if a replacement is required.

To check the frequencies of a transmitter, some frequency standard must be used. If a similar hand unit which is known to be good is available, it can be used; otherwise, a service-type audio oscillator can be used—if it is properly calibrated. As mentioned before, there is an inductance field in the vicinity of the transducer of the hand unit, and so, if the unit is held very close to a direct scope probe, there will be enough radiation to produce an indication on the scope.

If another hand unit is used as the frequency standard, hold it near a test lead connected to the horizontal input of the scope, key it, and set the horizontal gain of the scope to provide a couple of inches of deflection. Then hold the unit to be tested near the vertical-input probe and set the vertical gain for about the same amount of deflection. With both hand units keyed—the same button, of course—a Lissajous pattern indicating the frequency relationship will be produced. (The frequencies should be the same.)

Since the oscillators of the transmitters will continue to drift slightly, this Lissajous pattern will shift from a diagonal line going from upper right to lower left, to a circle, and then to a diagonal line extending from upper left to lower right. The number of times that the pattern goes through a complete cycle of change each second is the frequency difference, in Hz, between the two oscillators.

Once the pattern is obtained, use the third hand (all technicians have one) to adjust the trimmer capacitor of the hand unit being serviced. (If you are an obsolete model technician equipped with only two hands, use your elbow, your foot, a piece of tape or your apprentice to hold one of the buttons.)

When setting up a transmitter which has a separate trimmer for each frequency, each trimmer is set individually. Transmitters having but a single trimmer should be set at the highest frequency and checked at all others. Usually, manufacturers allow a tolerance of from 100 to 200 Hz above or below the specified frequency.

Measurement of frequency error with another hand unit for a reference is quite difficult unless the two units happen to be operating very near the same frequency.

The technique is a lot simpler if an audio oscillator is available. To use it, simply connect its output to the horizontal input of the scope, and proceed as before.

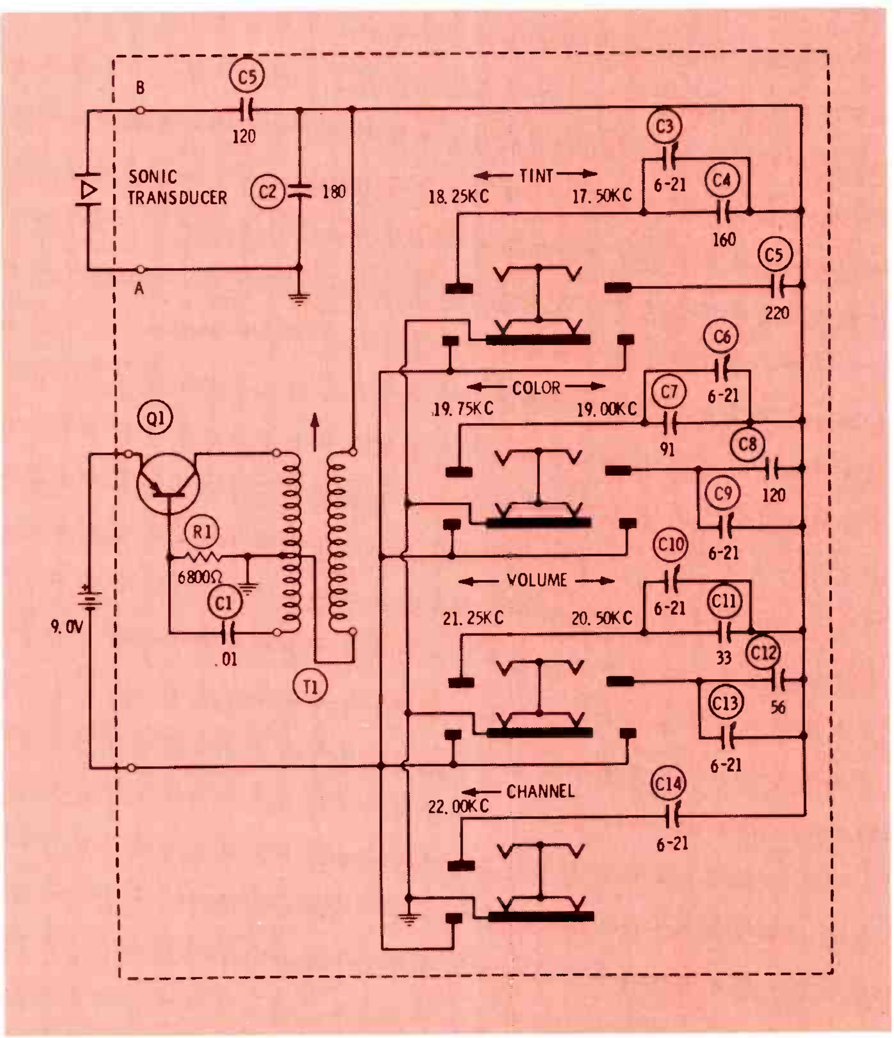


Fig. 1 Remote transmitter with a trimmer for each frequency.

A service-type oscillator can be used, but it must be calibrated periodically for frequency accuracy. If a hand unit which is known to be good is available, it can be used to calibrate the oscillator by proceeding as detailed previously, but mark the audio-oscillator dial instead of tuning the transmitter.

If no accurate hand unit is available, the frequency of the audio oscillator can be "spot calibrated", using horizontal sync pulses from a TV receiver as a frequency standard. Connect the audio oscillator to the horizontal input of a scope, and connect the vertical input of the scope to the sync separator of a TV set which is locked to a color program. Adjust the oscillator until a single sync pulse appears on the trace and remains stationary; then mark the audio-oscillator dial for 15.734 KHz. By setting the oscillator frequency so that a sync pulse appears on alternate scope traces, it can be calibrated at 31.468 KHz. Typical waveforms obtained in this manner are shown in Fig. 3. Notice that they are similar except the sync pulse is twice as wide with the oscillator set to 31.468 KHz.

Common Transmitter Faults

In general, two things go wrong with hand units: They fail to oscillate, or they oscillate off frequency.

If the hand unit fails completely on all frequencies, it is likely that the transistor is at fault, assuming the battery is good. If it fails on a single channel or pair of channels, suspect the switch.

Off-frequency problems which cannot be corrected by adjusting the trimmer for the particular channel being used indicate that the fixed capacitor has changed tolerance and must be replaced. In units which have a trimmer for each frequency, the replacement capacitor usually can be slightly off value, because the trimmer can be used to compensate for the error. Sometimes a series or parallel combination of capacitors can be used to tailor the value.

If a capacitor fails in a hand unit having one trimmer, it is best to obtain an exact replacement. But parts availability being what it sometimes is, it might be easier to find a substitute off the shelf. If the exact value is not available, try this: Make up a capacitance value which produces a frequency slightly higher than desired, then construct a "gimmick" by soldering short lengths of insulated solid hookup wire to each end of the capacitor; twist these together until the frequency is right on the button. Then snip off the ends, and you have solved the problem.

Operation of the Remote Receiver

The receiver has a lot more parts in it, but it really isn't as complicated, if you approach it logically. The block diagram in Fig. 4 shows the important functions.

The microphone output is amplified by about four stages, or by an IC and perhaps a single output stage in late-model instruments, and fed to the distribution line.

Earlier remote receivers often had a sensitivity control which was set to allow the unit to operate only from a short distance, to prevent spurious responses.

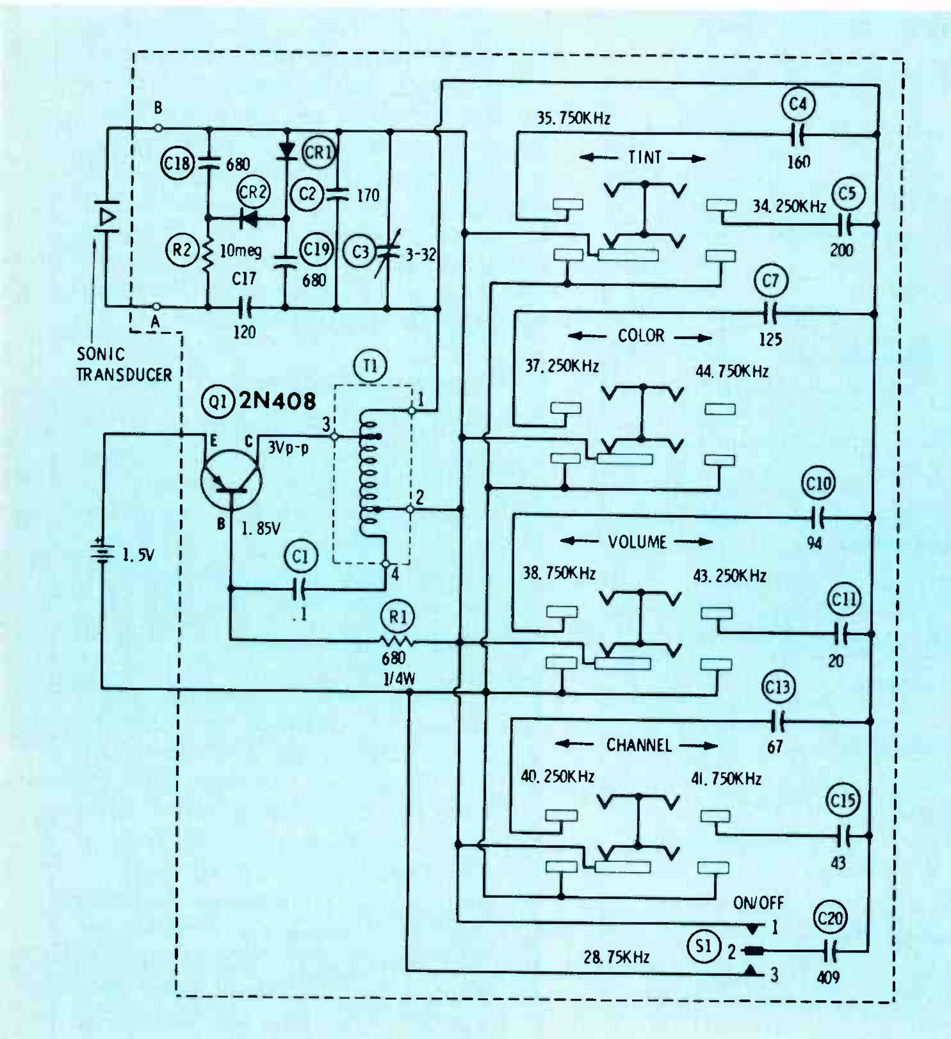


Fig. 2 Remote transmitter with a single tuning adjustment.

Later models often have a built-in noise-immunity circuit. A convenient means of making the system noise immune is to detect any amplitude modulation of the incoming signal and use this detected output as a bias voltage to hold the amplifier output to a very low level that is insufficient to actuate the relays. The reasoning behind this technique is that a true signal from the transmitter will have constant amplitude and fairly long duration; whereas a spurious input will have either a short duration or variable amplitude.

The amplifier output is fed simultaneously to all the tuned circuits, which usually are series resonant. As shown in Fig. 5, the tuned circuits and amplifying detectors which follow are identical, except for frequency.

When a signal at the resonant frequency of the tuned circuit is received, the current through the circuit becomes quite large, since the impedance of a series-resonant circuit approaches zero at resonance. This large current produces a significant drop across the inductance, and forward biases the transistor during positive half cycles (negative half cycles if a PNP transistor is used). This is the process of class "B" detection. Amplified current pulses in the relay coil of the collector circuit close the relay contacts to start a motor.

The emitter resistor, which is common to all the transistors, limits emitter current, but more important, it reverse biases the emitters of all the other transistors to insure that they do not operate on some spurious beat between the transmitter signal and the horizontal oscillator of the TV set, for example.

Remote Receiver Alignment

To align the tuned circuits in the remote receiver, the best signal source is the hand unit which will be used with the particular instrument. Simply key a function on the hand unit and tune the appropriate

circuit in the receiver for maximum DC voltage across the relay coil.

To prevent overdriving the receiver during alignment, cover the transducer or the microphone with a piece of tape to attenuate the signal.

If you prefer, a scope may be used as an indicator instead of the VTVM.

Troubleshooting the Remote Receiver

When troubleshooting the remote receiver, remember that failure of all functions probably indicates trouble in either the microphone or the amplifier.

If some channels work but others do not, look for trouble in the tuned circuits and beyond.

Since the frequencies involved are low, even a narrow-band scope is adequate for signal tracing; however, it must have high gain for practical use near the input stages.

Signal-injection techniques using an audio oscillator also are valid; but be careful to observe the usual precautions to prevent overdriving a transistor.

The Controlled Circuits

The usual method of actually controlling the TV receiver is by means of motors coupled to the shafts of the local-control "pots" for volume, tint and color, and to the rear end of the tuner shaft. These motors can be checked simply by shorting across the contact of the control relays in the remote receiver, to see if the motors will turn properly.

In the last few years, it has become popular to use a separate remote-control channel for turning the TV receiver off and on, rather than placing the power switch on the volume-control shaft. This allows the volume to be left at a pleasing level instead of always being at minimum when the set is first switched on. The independent on/off switch is a ratchet-type relay, also called an impulse relay, or a bistable relay. In any case, it alternately opens and closes each time the remote-control signal is received.

The motors used for remote control of volume, tint and color are simple two-phase motors which can run in either direction.

Fig. 6 shows the circuitry from remote relays to the motor. If K1 is closed, winding No. 1 is connected directly across the AC line and winding No. 2 is in series with C1. This causes the motor to run in one direction. Obviously, if K2 is closed instead of K1, the capacitive current is through W1, and rotation is in the opposite direction.

When checking one of these motors, notice that the resistances of the two windings should be almost equal, and, of course, capacitor fail-

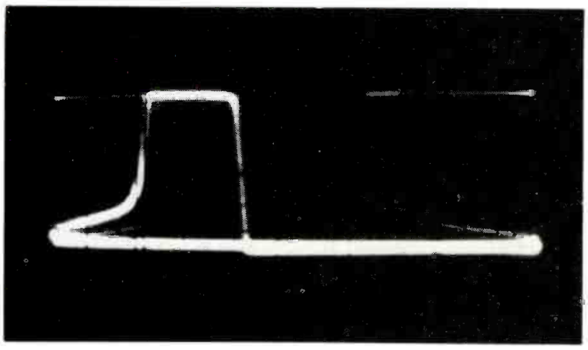
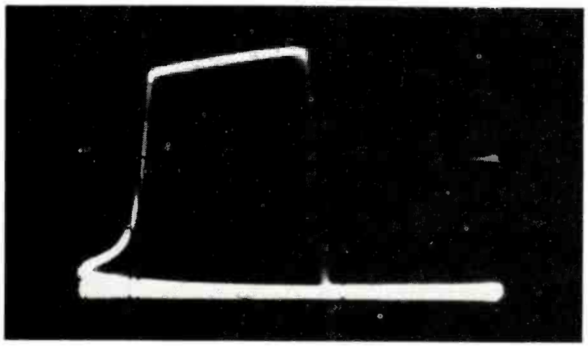


Fig. 3 Sync pulses used to calibrate an audio oscillator.

(A) Audio oscillator tuned to 15.734 KHz.



(B) Audio oscillator tuned to 31.468 KHz.

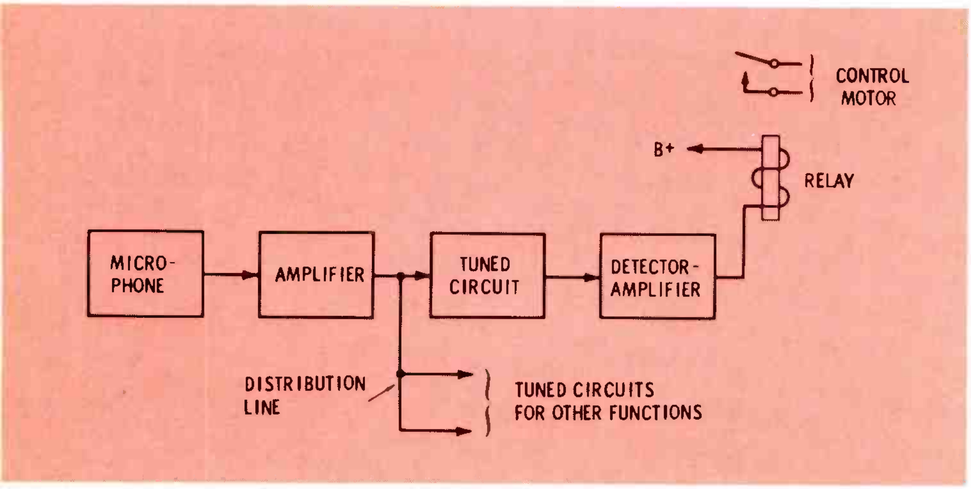
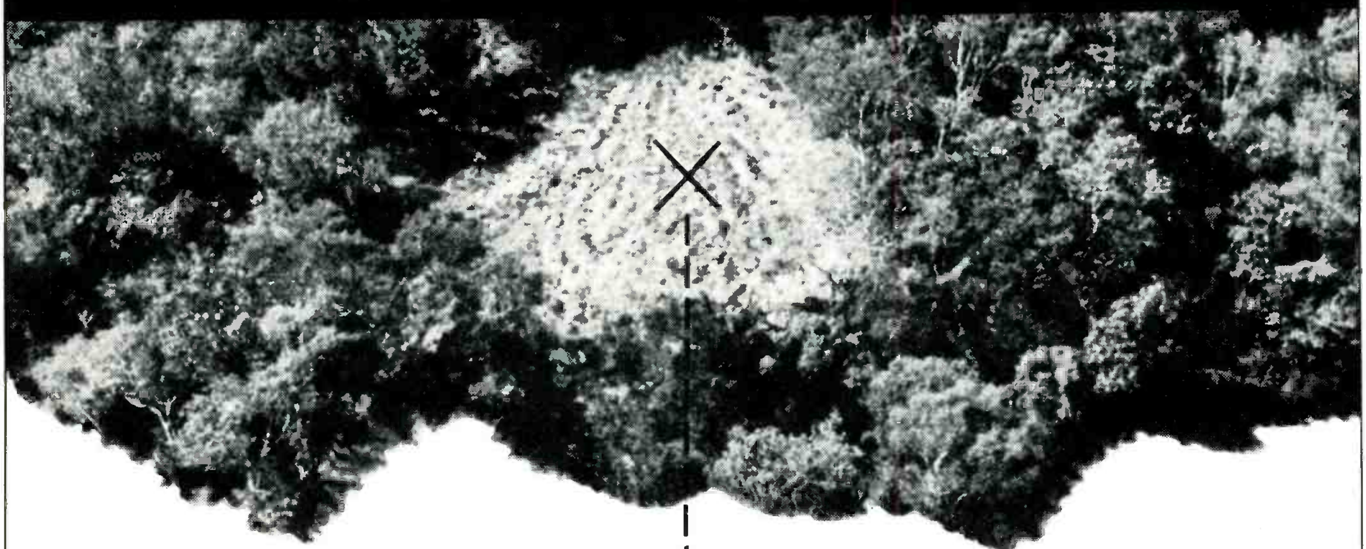


Fig. 4 Block diagram of a typical remote receiver.

The hunt is on!

(Beware of the Grope.)



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ure will make it inoperative.

The channel-change motor usually runs only in one direction, but an "open-seeking" switch circuit is required to stop it only on desired channels. These all function in about the same manner, and sometimes the toughest part of the job is physically locating the switches. The motor itself can be tested simply by applying power to it. Be careful, though, not to accidentally connect the power line across a relay or switch contact—disconnect both motor leads before checking it.

With more UHF stations going on the air, many "top-of-the-line" receivers now have separate remote channel selecting functions for VHF and UHF. This has produced some fairly complex switching circuits. (Also now in the art is the motorless remote control. In a subsequent article, these systems will be explained and some new troubleshooting techniques will be presented.)

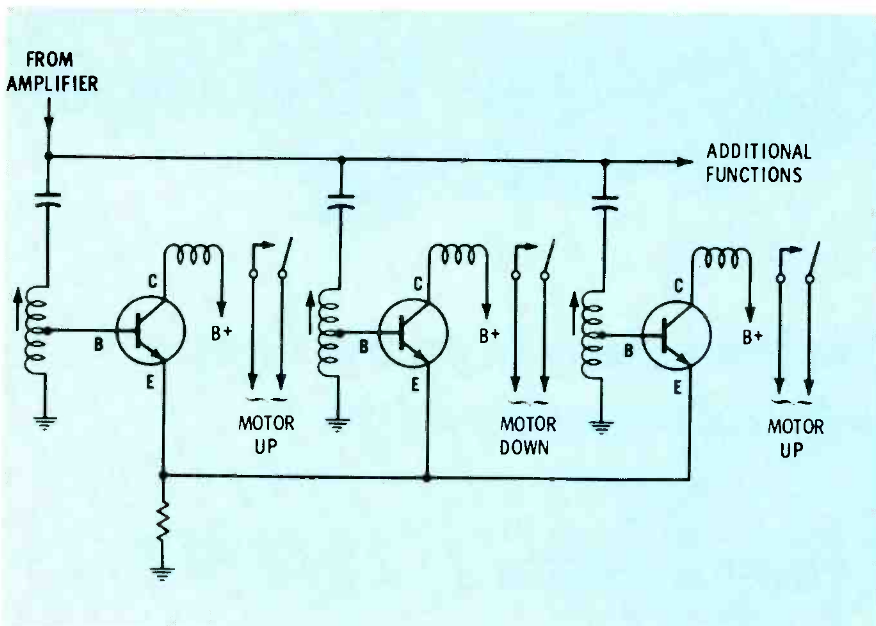


Fig. 5 Typical remote-receiver output circuits.

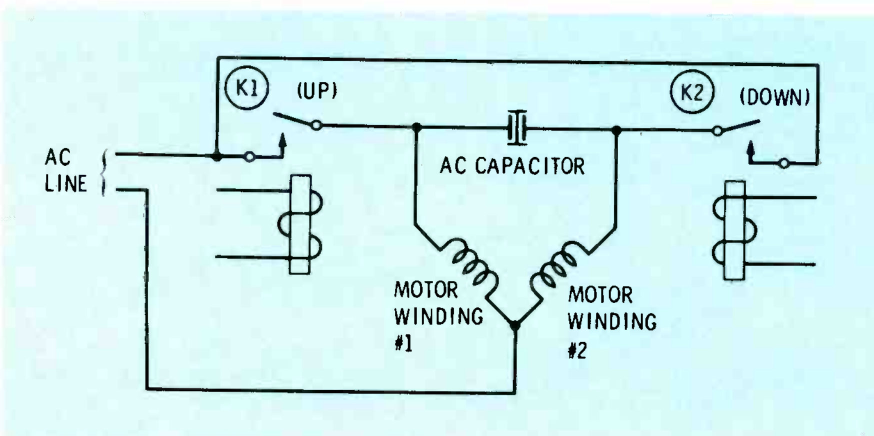


Fig. 6 Circuitry of two-phase motor used to remotely control volume, tint and color saturation.

Summary

When servicing a remote transmitter, first check to see if there is an output—a scope is the most convenient tool for this purpose. Remember that short-range or intermittent operation can be the result either of weak or intermittent output; just as likely, it can be incorrect frequency or a defective transducer.

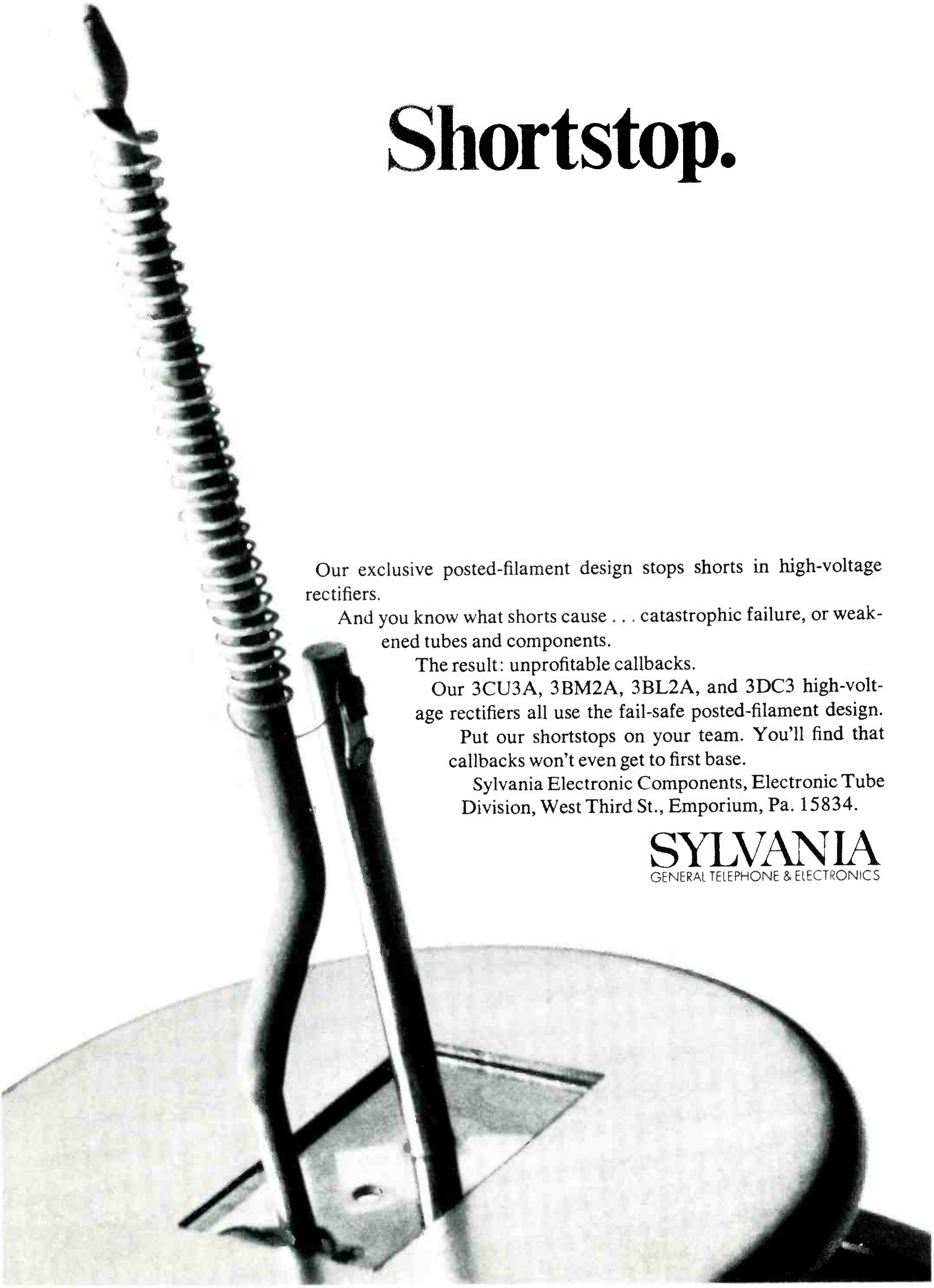
Transmitters which have individual tuning adjustment for each frequency can be compared with and tuned to another transmitter which is known to be good.

Transmitters which have a single trimmer can be tuned to another transmitter, but a calibrated audio oscillator is almost a necessity for checking the tolerances of other frequencies.

A remote receiver can be checked by signal tracing with a high-gain scope, or by signal injection using an audio oscillator.

To align a remote receiver, it is best to use the companion transmitter as a signal source. Slight variations from specified frequencies are not too serious, as long as both transmitter and receiver are tuned the same. Nevertheless, be careful not to tune a function to the same frequency as the horizontal oscillator. Another sneaky spurious signal comes from supersonic burgler alarms used in some buildings.

The motors and their circuits are easily checked; just apply power and see if they will turn. (Remember, some motors require 6 volts AC, others require 120 volts AC.) Be careful not to get the AC line connected directly across a relay contact while doing this. Common problems are open motor capacitors and dry motor bearings. The motor capacitor can be checked by substitution. Your favorite lubricant for record-changer motors should solve dry bearing problems, if the bearings are not excessively worn. And, by the way, don't stock up on lubricant; it looks like motors are on the way out. ▲



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Circle 17 on literature card

With Carl Babcoke
ES Technical Editor

Practical information about testing and replacing capacitors

After many years as a shop technician, I recently reviewed the theory of capacitors, and was amazed to find the strengths and weaknesses of the various basic types of capacitors, pictured in Fig. 1, to be exactly in accord with my own observations and experiences. (Just think of the time I could have saved had I read the book first.)

If you would like to make your servicing time more productive, join me in this streamlined and service-oriented review of capacitors.

Dielectric Materials vs Losses

The figures in Table 1 might seem unimportant, until they are translated into practical characteristics. Any capacitor physically consists of two conductors, or plates, separated by an insulator, which is called the dielectric.

To increase the capacitance, the conductors must be moved closer together, or the area of the conductors increased, or the dielectric improved (or all three methods employed). In Table 1, the dielectric constant (K) column indicates that one type of mica produces 6.85 times as much capacitance as that obtained using air for a dielectric (conductor area and spacing the same). Paper has less "K" than mica, while aluminum oxide has a higher "K" than either. However, the "K" figures are more for the designers and manufacturers of capacitors; they mean little to us, except to give a hint about the relative physical size of the various types. The higher the "K" number, the smaller the physical size of the capacitor for a given capacitance.

In the last column, under the heading of "Power Factor", is the information we need to intelligently select proper replacement capacitors. Aluminum oxide (used in nearly all electrolytic types) has a "K" factor of 10, which means a .047-mfd capacitor probably could be made about the size of a video detector diode. Then why aren't all capacitors made with an aluminum oxide dielectric to save space? Poor stability with relation to time and temperature are two of the reasons, but one of the major deterrents to universal use is the power factor rating of 10 percent.

The lower the power factor percentage, the more efficient the capacitor. Because power factor is so important in choosing the proper replacement capacitors, we will discuss it later in greater detail.

TABLE 1 Power factors and dielectric constants of commonly used dielectric materials.

Dielectric Material	Dielectric Constant (K)	Power Factor (%)
Vacuum	1.0	0
Air	1.0001	0+
Paper (Kraft)	4.0	3.0
Mylar	3.0	0.5
Glass	6.7	0.06
Mica	6.85	0.02
Aluminum Oxide	10.0	10.0
Tantalum Oxide	11.0	10.0

Storage Capacitors vs Capacitive Reactance

The traditional concept portrays a capacitor as a storage reservoir for DC voltage. Yet, in many circuits, a capacitor will behave exactly as a resistor whose value varies with frequency, from nearly an open circuit at DC to almost a short circuit at very high frequencies. This characteristic is called "capacitive reactance".

At first analysis, there seems to be no connection between these two normal functions of capacitors. However, with the help of the graphs in Fig. 2 (including some not found in the textbooks), we will find that capacitive reactance is only one specialized application of

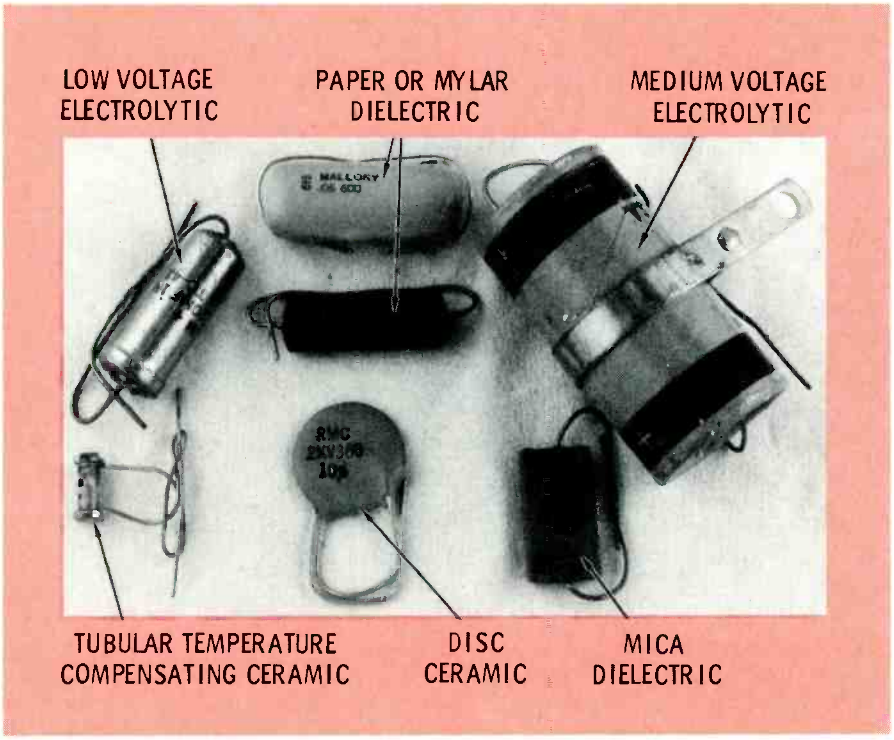


Fig. 1 Although capacitors vary in physical size and shape, voltage rating and capacitance, those shown here are typical of the basic types used in consumer electronic equipment.

the storage reservoir theory.

Capacitors With DC Applied

A voltage-vs-time curve plotted for the voltage across C1 in Fig. 2A would be similar to the solid-line on the left of Fig. 2B. By definition, time constant (TC) is the duration of time necessary to charge a capacitor to 63.2 percent of the supply voltage. In this case, one time constant is equal to R X C.

The formula is T=RC, where time "T" is in seconds, resistance "R" is in ohms and capacitance "C" is in farads.

After 5 time constants (5RC) the capacitor is considered completely charged (although theoretically it is never completely charged).

Capacitor current (or the voltage drop across R1, which will have the same waveshape) during the charging process is shown by the dashed-line curve on the left of Fig. 2B.

Discharge of the capacitor by opening switch S1 and closing switch S2 produces the dot-and-dash curve on the right of Fig. 2B.

The facts presented thus far have been textbook information. Now, let's take the curves of Fig. 2B and extract some practical information.

When voltage is first applied to a capacitor, the current is high and, because of the voltage drop across intentional or undesired resistances, the voltage is low at the capacitor. Any component that draws large current at low voltage has low resistance; therefore, at this point in time, the capacitor is effectively a low-value resistor. The voltage gradually increases while the current decreases—the equivalent of an increase in resistance. When the capacitor is fully charged at the end of 5 time constants, the voltage is almost equal to the applied voltage and the current is nearly zero. The capacitor now is effectively an open circuit.

Capacitors With AC Applied

When we substitute an AC supply for the DC supply in Fig. 2A, and measure the voltage across the capacitor and R1 with a scope or RC meter, completely different conditions are established.

The percentage of the DC input voltage to which a capacitor will charge has been shown to be in proportion to the length of the charging time. When AC is applied, the time available for charging the capacitor varies with frequency—the lower the frequency, the longer the charge time and the more the capacitor is charged. High frequencies shorten the charge time, so that the capacitor is charged to only a relatively small percentage of the applied voltage.

The positive-going part of the "very low-frequency" sine wave in Fig. 3 charges the capacitor for about 2 time constants (2RC), then the sine-wave voltage (which is also the charge on the capacitor) becomes less positive and falls to zero. The same action is repeated on the negative-going part of the sine wave. This is one cycle of AC. Although the equivalent resistance of the capacitor changes from nearly zero at the zero, or center, line to high resistance at both +85 percent and −85 percent, the average is fairly high. The equivalent resistance for the capacitor, at that frequency, is high.

The "low-frequency" sine wave does not charge the capacitor to as high a percentage of the applied AC voltage because the frequency is higher, and the voltage is applied for a shorter period of time. Because the capacitor is a low resistance for more of the cycle, the average equivalent resistance is lower than that produced by the "very low-frequency" AC signal.

The higher the frequency, the lower the equivalent resistance. Ultra-high frequencies reverse so rapidly the capacitor charge is virtually zero, and the equivalent resistance is very low.

Capacitive Reactance in Action

A capacitor's equivalent resistance to AC is called capacitive reactance, and is measured in ohms. For the mathematically inclined, the formula for capacitive reactance is as follows:

$$Xc = \frac{1}{2\pi fC}$$

where: Xc is the capacitive reactance in ohms,
f is the frequency in Hz,
C is the capacitance in farads.

Capacitive reactance, inductive reactance and resistance all impede the flow of alternating current. The

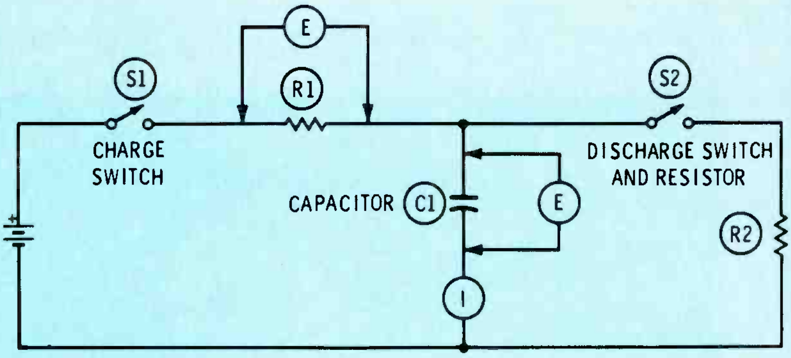


Fig. 2 (A) Schematic of the circuit used to chart the charge and discharge of capacitors.

(B) The voltage across a capacitor during charge is shown by the solid-line curve on the left side of the graph. Capacitor current during charge is shown by the dashed-line on the left side. The dash-dot-line on the right shows the capacitor current or voltage, or the voltage drop across R1 during discharge. Continuations of the solid and dashed lines from the center to the right side of the graph show the capacitor voltage and current when the voltage supply is increased after the capacitor is fully charged by the original voltage (100 volts).

sum of all three, or any two, is called impedance.

Fig. 4A shows an example of capacitive reactance in action in audio circuits. The value of C1 should be large enough to pass all the desired audio frequencies to the next stage without loss. If a design engineer wants to reduce the extreme low bass to keep a poorly baffled speaker from bottoming, or to minimize hum, he will reduce the size to .01 or even .005. On low frequencies, the smaller capacitor will charge more completely than would a larger one, the equivalent resistance or capacitive reactance will be higher, more signal will appear across the capacitor and less at R1 and the grid of V2.

C2 in Fig. 4A reduces the extremely high audio frequencies. At lower frequencies the capacitive reactance is very high and has no effect on the circuit. At higher frequencies the lower capacitive reactance is in parallel with the plate resistance of the tube; this lower load on the tube reduces the gain of the treble frequencies.

Another typical application of capacitive reactance is illustrated in Fig. 4B, in which a capacitor (C3) is shown bypassing a screen grid. Using a capacitor to decouple a B+ supply or to bypass a cathode involves the same principle. The capacitive reactance must be low enough (capacitance large enough) to "smooth out", or eliminate, the AC.

You probably have been wondering why my examples all have both DC and AC on the capacitors, yet the explanations have covered separately the DC and AC actions. Perhaps one of your questions would be: Since a capacitor charges completely on DC and becomes an open circuit, how can AC pass through this open circuit?

The answer is found in the smaller charging curve on the right of Fig. 2B. The capacitor has charged to almost 100 volts at the end of 5 time constants, and has full voltage with almost no current, which is the equivalent of an open circuit. At this point, without discharging the capacitor, suppose we increase the supply voltage to 140 volts and plot the capacitor voltage and current as before. The resultant curve will be the same as the original on the left, except the amplitude will be higher. The capacitor voltage forms another parabolic curve which begins where the 100-volt curve finished. It reaches 63.2 percent of the added 40 volts at the end of 1 time constant and is fully charged after 5 time constants. Also, note that the capacitor charging current increased to maximum at the exact instant the new voltage was applied, and it dropped to minimum in the same time as did the original charging current produced by the 100-volt supply.

From these facts, it is clear that a capacitor with only DC voltage across it eventually will charge up completely (becoming an open circuit to **that** value of DC voltage), but when an AC signal is added, the capacitor responds to this new voltage level as though it was the only one present. Capacitive reactance is unchanged, regardless of any DC voltage which also might be across the capacitor.

Residual Charge

Have you ever thoroughly discharged the anode of a picture tube only to find there later a substantial voltage? If so, you have noticed a capacitor characteristic called "residual charge". The curve shown in Fig. 5 illustrates this action. Some dielectric materials have a miserly characteristic that causes them to hold a portion of the electrons, even when the capacitor is discharged. Later, these captive electrons are released slowly, and a small charge again is built up across the capacitor.

The next time one of your technician friends receives a surprising shock from a discharged capacitor or picture tube, tell him he is the victim of "dielectric absorption". He'll thank you for enlightening him.

Power Factor

For such a simple device, a capacitor has many different types of losses. The total loss is called "power factor", and is usually expressed as a percentage because it is the ratio of power lost to the power used in charging the capacitor.

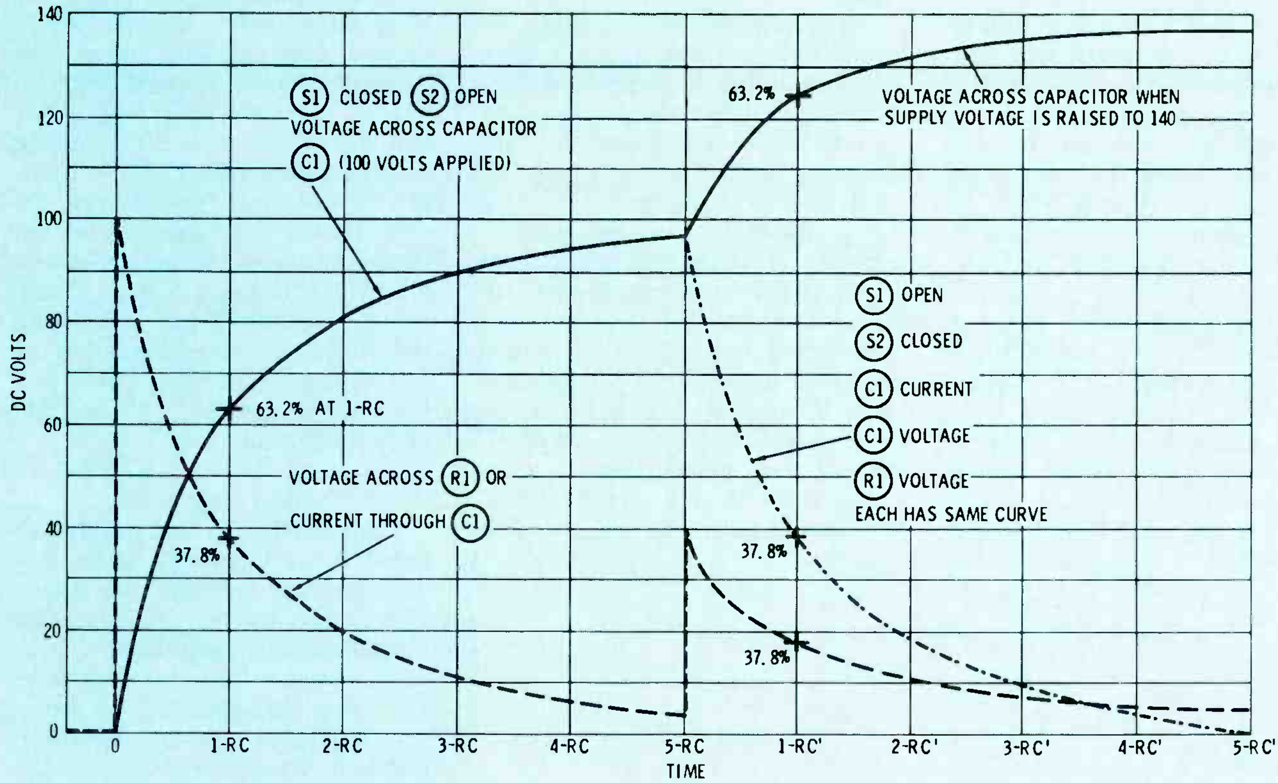


Fig. 6A shows the schematic symbol for a perfect capacitor, and Fig. 6B illustrates the equivalent of an actual capacitor with losses. Resistance R1 is the total resistance (sometimes called the "effective series resistance") of the plates and leads, resistance R2 is the dielectric leakage resistance, and inductance L is the inductive reactance of the leads and plates. Although all of these are losses, the effects of each type of loss depends on the circuit in which the capacitor is used.

For example, in many bypass applications, a large load current is flowing in the circuit. A small amount of dielectric leakage would be of little importance in such a circuit. But if the capacitor was employed in a coupling application, this small leakage would be unsatisfactory.

A few percent of effective series resistance (ESR) in an audio coupling capacitor probably would go unnoticed, but too much ESR in a filter or bypass capacitor should be considered an untolerable defect.

Table 2 lists capacitors with the most commonly used dielectrical materials in approximate order according to their losses. No one formula for rating ceramic dielectric exists; consequently, the position of ceramic capacitors on the chart is my own guess based on observations. It is entirely possible that certain specific formulas or brands of ceramics may have lower loss than Mylar. Also the remark in the "Disadvantages" column that ceramics are thermally unstable applies only to the general-purpose type. Ceramics also are made with

TABLE 2

Dielectric Material	Power Factor	Advantages	Disadvantages
Air	0%	very stable, low loss	very large for small capacitance
Mica	.02%	stable, low loss	cost more than ceramic or paper
Mylar	.50%	fairly stable and low loss	none
Ceramic	***	small and inexpensive	unstable with heat, moderate loss
Paper	3.0%	inexpensive	some delayed failures from impurities, some loss
Tantalum Oxide	10.0%	very small per capacitance, does not deform in storage	tantalum is rare and expensive
Aluminum Oxide	10.0%	small size per capacitance, not expensive	deforms in storage, often loses capacitance with age

zero and several negative temperature coefficients.

Replacement capacitors usually should be of the same type and have the same ratings as the factory-installed original, if you can determine those specifications. In case the service data and capacitor markings are not definite about the type and ratings, use the next higher quality of capacitor listed in Table 2.

If the specified voltage rating is obtainable and cost is no deterrent, a tantalum always can be substituted for an aluminum oxide type.

Aluminum oxide nearly always is the dielectric employed in modern dry-electrolytic capacitors.

A Mylar dielectric capacitor is a superior replacement for a paper type.

Mica or silvered-mica capacitors are far superior to ceramics in every way except that they cannot be used for temperature compensation, and for the same capacitance they are larger.

It will be many years before I forget the time I wasted when I replaced a mica with a ceramic capacitor in a remote control receiver. (The receiver was one of the older types, with a coil-and-mica-capacitor tuned circuit for each remote frequency. The output from each tuned circuit was rectified, filtered and used to bias a relay tube.) After the new ceramic capacitor was installed, the tuned circuit was carefully aligned for maximum rectified voltage, but one circuit was weak. Other remote functions would operate from 20 feet away; the weak one would respond from no farther than about 8 feet. After wasting much time and finding nothing wrong except that the output of the tuned circuit with the ceramic was about half that of the others equipped with micas, I obtained and installed a mica capacitor of the correct size. After that, the range was the same for all remote functions. (Note: Power factor even affects the "Q", or gain, of tuned circuits.)

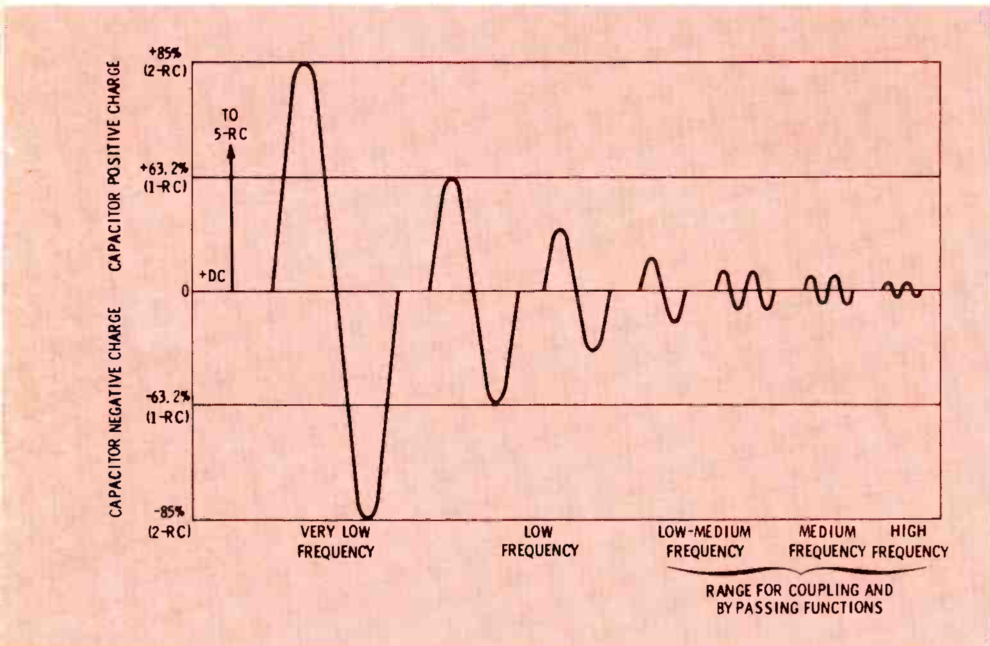


Fig. 3 If the supply voltage is changed to AC, the amount of charge the capacitor accepts is determined by the frequency of the AC.

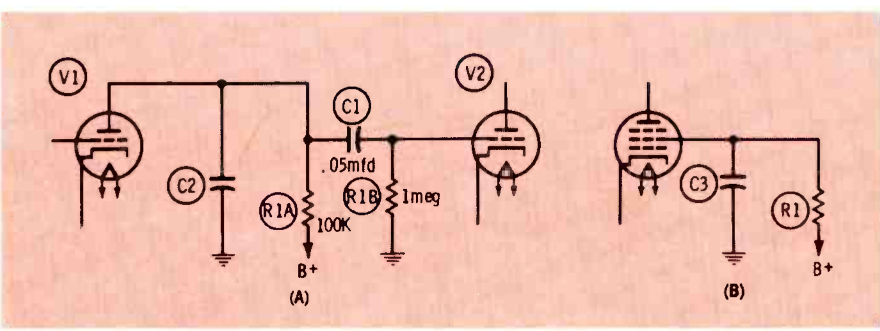


Fig. 4 (A) Two typical applications of capacitors as coupling and "high-frequency-decrease" capacitances. (B) An example of the removal of an AC signal by use of a bypass capacitor.

Testing Capacitors

Undoubtedly the best way to test capacitors is by use of a laboratory-quality precision bridge with a variable-voltage leakage test; such an instrument accurately checks capacitance, power factor and leakage. The only drawback is the comparatively high price of the bridge. However, bridges with sufficient accuracy for effective service work are available at a price within the budget of most shops.

Some tube testers and VOM's have capacitance scales that look and operate much like voltage scales. These meters measure the AC voltage drop across the capacitor under test; the voltage drop is produced by the capacitive reactance of the capacitor to a 60-Hz test signal. Accuracy is fair for medium values of capacitance, but very small or large sizes usually cannot be tested with acceptable accuracy.

In-circuit capacitor checkers are a convenience, but they give essentially a go/no-go indication. In many cases, this is sufficient. It is good technique to try the fast tests first, then go on to more elaborate and more accurate ones if the simple tests don't produce definite results. **Severe** leakage or **dead** shorts in capacitors tested in-circuit can be found easily with an ohmmeter, just as open capacitors can be identified by use of an in-circuit capacitance tester.

Leakage Tests

Small amounts of leakage in an out-of-circuit capacitor cannot always be detected by using an ohm-

meter, even though the top scale of the ohmmeter reads up to 1,000 megohms. This is because the leakage might not be proportional to the voltage applied. For example, the leakage might be quite low with only 1.5 volts from an ohmmeter applied to the capacitor. Increase the voltage across the capacitor to 100 volts or more and the capacitor might develop an excessive leakage.

Other problems involve specific capacitors in vertical circuits, in which a low leakage of several megohms with normal voltage applied is enough to cause picture rolling or other malfunctions.

Fig. 7 illustrates one simple, but effective, method of testing all capacitors (except electrolytics) for tiny amounts of leakage: 1) Remove the capacitor from the circuit. 2) Connect one end of the suspected capacitor to a source of voltage in the receiver which is slightly less than the voltage rating of the capacitor. 3) To the other end of the capacitor connect a VTVM or FET meter set to measure DC volts. 4) Select a high DC scale on the meter, turn the receiver on to supply the necessary voltage, then "follow" the voltage down by selecting lower voltage scales as the capacitor charges. 5) When the voltage reading on the meter has stabilized (except for the line voltage bounces), note the reading. The higher the voltage, the greater the leakage of the capacitor. If you have several capacitors of the same size in stock, test them the same way and notice if the new capacitors measure less leakage than the suspected one. If they do, replace the suspected capacitor.

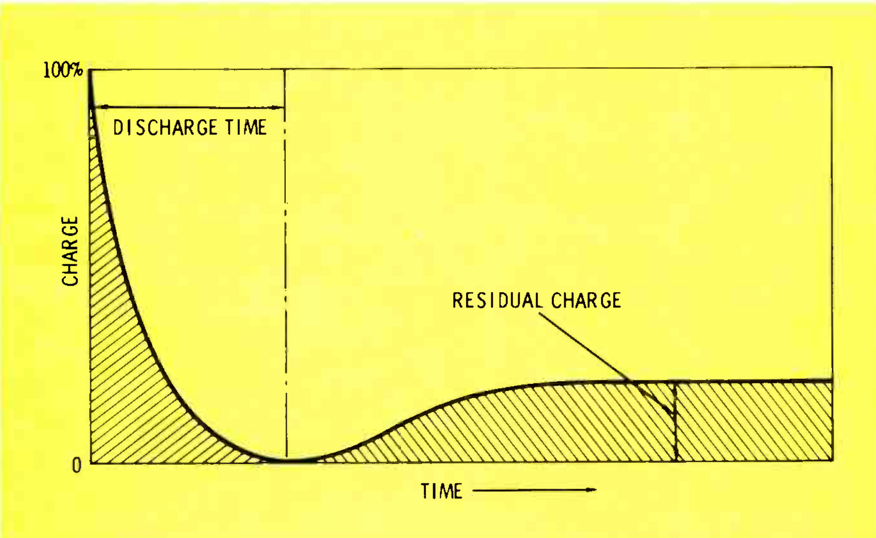


Fig. 5 Dielectric absorption holds some electrons so they are not discharged with the majority. Later they are released slowly to form a **residual** charge.

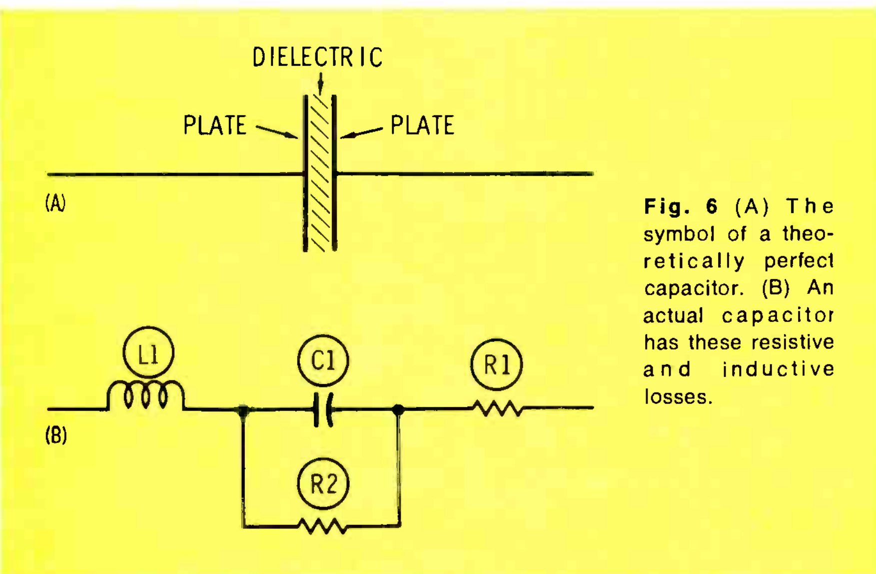


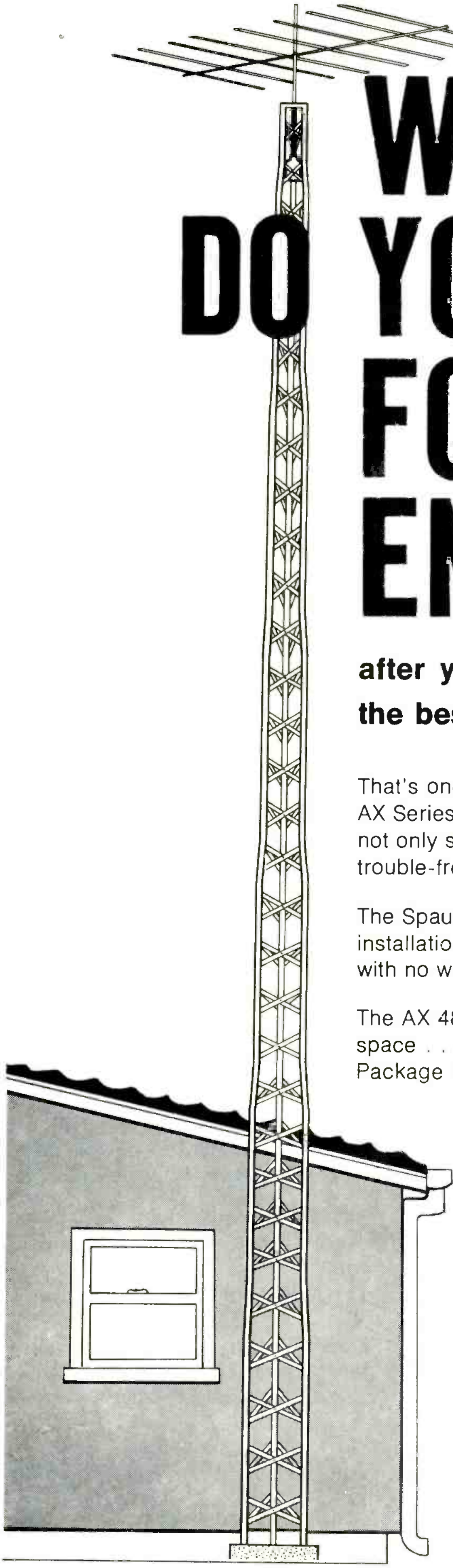
Fig. 6 (A) The symbol of a theoretically perfect capacitor. (B) An actual capacitor has these resistive and inductive losses.

You will find this test so sensitive that even new, good-quality capacitors usually will show some leakage. Paper dielectric types show the most leakage of non-electrolytic types. About 3⅓ percent (or 1/30) of the applied voltage is the approximate upper limit for leakage of a good paper capacitor in the .005- to .1-mfd capacitance range. This would amount to a reading of 10 volts from a supply voltage of 300, for example, or about 320 megohms of leakage.

While the capacitor is being measured for leakage is an ideal time to heat the capacitor, perhaps with a soldering iron, to check for an excessive reaction to heat. Then spray the capacitor with circuit cooler and notice the reduction in leakage. Try other capacitors known to be good under the same conditions; use an average of these results as a reference. (All capacitors will change during heat-and-cold cycling tests).

Measuring Capacitance With an Ohmmeter

The accuracy of one simple method of measuring the actual values of large capacitors might surprise you. Most of us have used a go/no-go quickie test for open capacitors by watching for the bounce of the meter hand when the ohmmeter leads were touched to an out-of-circuit capacitor. The accuracy of this test can be increased easily. Compare the schematic used for charging capacitors in Fig. 2A with the ohmmeter function of a typical VTVM or FET meter, as shown in Fig. 8. Note the remarkable resemblance of the circuits if we connect a capacitor across the ohmmeter leads. As stated previously, the definition for time constant is T=RC, where T is the



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time in seconds necessary to charge the capacitor to 63.2 percent of the supply voltage, R is the total series resistance, and C is the value of the capacitor being charged. For our purpose here, let's transpose the formula to read:

$$C=T/R$$

The value of R in Fig. 8 can be determined by noting the ohms scale multiplier in use, and time can be measured with a standard watch or clock, when it is several seconds or more. From the two values, capacitance C can be calculated very easily.

Here is the step-by-step method of using a VTVM ohmmeter to measure capacitance:

- Warm up the meter to eliminate drift, set the function switch to ohms, zero and ohms controls should be set correctly, estimate the ohms scale multiplier needed for the size capacitor to be tested. In this case, it is a 25-mfd, low-voltage miniature type. Experience shows that the X100K scale is the one to select in this case. Make sure the VTVM probe (if the same one is used for volts and ohms) is set for ohms function.
- Short together the capacitor leads for several seconds to drain any charge. Connect the meter ground lead to the capacitor negative lead and, with a watch or clock, note the seconds it takes for the meter hand to read 63.2 percent of full scale. On ohmmeters with faces that have 10 in the center of the scale, 63.2 percent is at about 17 on the ohms calibration scale.
- Connect the ohmmeter lead to the positive end of the capacitor and measure the seconds it takes for the ohmmeter hand to move to zero ohms on the left, then back to the right. Stop the count when the meter hand reaches 17 on the swing back to the right (on the X100K scale it would be the 1.7 megohm point).
- In this case, the time measured on the second hand of a watch was 33 seconds. Here is the mathematics:

$$C=T/R \text{ or } C=33/1{,}000{,}000$$
$$=.000033 \text{ farads (33 mfd).}$$

(Multiply the answer in farads by 1,000,000 to arrive at microfarads.)

Did you notice that we divided by 1 million, then multiplied by 1 million? This happens only when the resistor R is 1 megohm and scale X100K is selected, but it gives us a way to eliminate nearly all the complicated mathematics. On the X100K scale, the number of seconds required to reach 63.2 percent (or 17 on the ohms calibration scale) is the same as the capacitance in microfarads. It couldn't be more simple. Just remember (or write and leave in a convenient place) these 3 correction factors, and the math can be done in the head:

- On the X1K scale, multiply the time in seconds by 100 to give the capacitance in microfarads.
- On the X10K scale, multiply the time in seconds by 10 to give the capacitance in microfarads.
- On the X1Meg scale, divide the time in seconds by 10 to give the capacitance in microfarads.

When this method is used to measure capacitors of .05 mfd or less, the meter hand will not swing to zero, even on the X1Meg scale, and the time interval is really too short for practical measuring. A .1 doesn't appear to quite reach the zero mark, but the charge time is about 1 second; .25 mfd is about 2½ seconds; and .47 mfd is about 4½ seconds. Using the X1K scale, a 2,000-mfd electrolytic would charge in around 20 seconds. This system permits you to estimate (closely enough for most service work) capacitances from .1 to about 5,000 mfd.

Only one condition causes this method to yield completely wrong answers: leakage across the capacitor. Thus, readings taken in-circuit or with a leaky capacitor are highly inaccurate. The reason is simple:

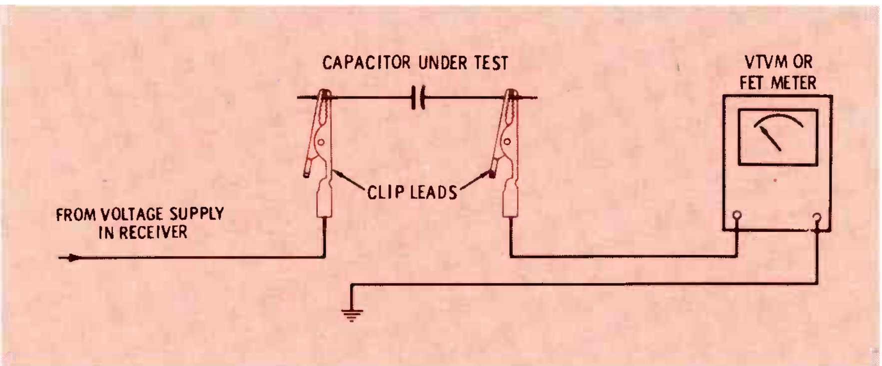


Fig. 7 A simple way to check, under proper voltage, the slightest leakage in all capacitor types except electrolytics.

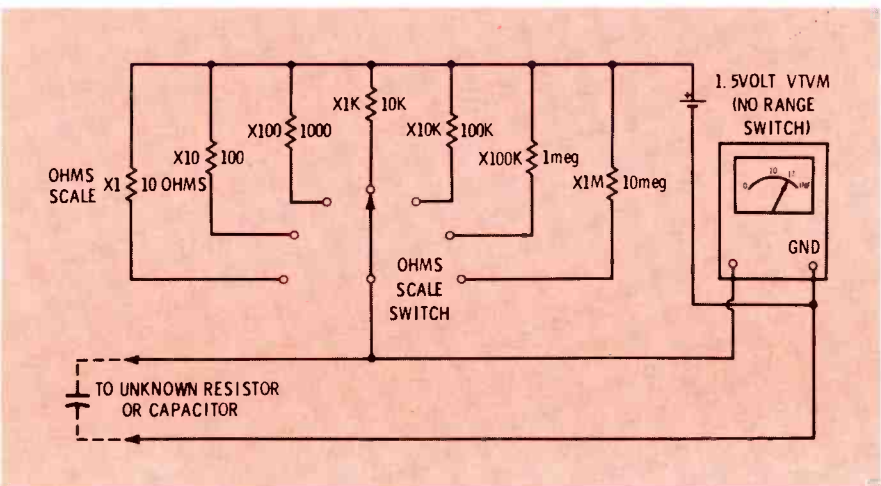


Fig. 8 Schematic of a typical ohmmeter function in a VTVM or FET meter. Connect the ohmmeter leads to a capacitor and notice the similarity of this circuit and the diagram of the capacitor charging circuit in Fig. 2A. This similarity is the basis for a very simple method of measuring with an ohmmeter the capacitance of most electrolytic capacitors.

Suppose you were trying to time the charge of a capacitor on the X10K scale, but the capacitor had internal leakage of 100K. This leakage in conjunction with the 100K of the ohmmeter multiplier resistor limits the maximum voltage that can be applied to the capacitor to 50 percent, or ½ of the ohmmeter battery voltage. Since we want to measure the time required to charge the capacitor to 63.2 percent, we would have a long wait! The "17" mark on the scale is 170K ohms on the X10K scale, 1.7 megohms on the X100K scale or 17 megohms on the X1Meg scale. If the capacitor leakage in ohms is less than three times the "17" ohms value for the scale we are using, our answer will be very inaccurate. The capacitance in microfarads will appear to be double, for example, that of a similar capacitor without the excessive leakage.

Capacitors in Series and Parallel

Capacitors can be connected in either series or parallel, if necessary, to obtain values that are not available otherwise.

When capacitors are paralleled, the capacitances add; however, the voltage ratings are not changed, so the working voltage of the combination is that of the capacitors having the lowest rating.

Capacitors in series produce less capacitance than any of the individual values. For two identical units, the resulting capacitance is ½ the capacitance of each capacitor, and the voltage rating is not quite doubled. Differences in capacitance, and leakage between the two, cause dissimilar voltage drops across them, so the full combined voltage rating of the two should never be used. Use the formula for resistors in parallel to calculate the resultant value of non-identical capacitors in series. For more than two capacitors, the formula is as follows:

$$Ct = \frac{1}{1/C_1 + 1/C_2 + 1/C_3 + \text{etc.}}$$

for only two capacitors:

$$Ct = \frac{C_1 \times C_2}{C_1 + C_2}$$

Other Useful Tips

A few more tips from the capacitor experts are:

- Do NOT discharge a capacitor by shorting the leads with a wire or a screwdriver. To avoid damage to the capacitor, discharge it through a resistor. A 10-watt resistor with a value of 1,000 to 2,000 ohms is recommended for voltages up to 600 volts.
- Do NOT draw an arc or discharge the picture tube anode without using a limiting resistor. The size of resistor is not critical; 47K to 56K ohms at 2 watts is reasonable.

Replacement capacitors for critical circuits such as tuners, IF's, color oscillators and others should be the same type of capacitor as the original, and the same capacitance (don't use a larger one). The replacement should be installed in the same location as the original; if it is on a circuit board, the leads should go through the same holes in the board, and the leads should be as short as those on the original capacitor. You might have to pay for any differences in specifications or installation techniques by struggling against a regenerative stage, or being forced to realign the receiver. ▲

audio systems report

Paging Talk-Back Speakers

A new series of paging talk-back speakers has been introduced by American Geloso Electronics, Inc.

Four models are included in this series: Model 18/1 features an 8-inch round speaker rated at 10 watts, 8 ohms.

Model 18/4T is an 8-inch round speaker rated at 10 watts, with a

18/1 - 18/4T

built-in line transformer and a rotary-type impedance selector for 8, 45, 500, 667, 1000, 1430, 2000 or 4000 ohms. It also features a 70-volt line tap with power ratings of 10, 7.5, 5, 3.5, 2.5 and 1.25 watts.

Model 18/5 is a 13¾-inch by 6¾-inch rectangular speaker rated at 30 watts, 16 ohms.

Model 18/8T is the same as Model 18/5 with the addition of a

18/5 - 18/8T

built-in line transformer, rotary-type impedance selector for 16, 167, 333, 500, 667, 1000, 2000 or 4000 ohms and 70-volt line taps for 30, 15, 10, 7.5, 5, 2.5 or 1.25 watts.

Other features of the series reportedly include: all-nylon, non-corrosive, high-impact construction; replaceable self-aligning diaphragm; quick clip-on polarized line terminals; patented ball-type swivel mounting with die cast support base, which permits vertical, horizontal and diagonal orientation; and continuously variable thumb-type impedance selector which is adjustable from the front of the unit.

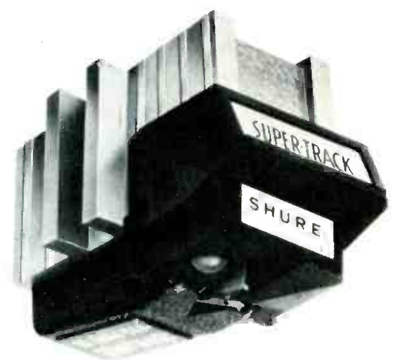
The prices range from $32.65 for Model 18/1 to $53.65 for Model 18/8T.

Circle 50 on literature card

Phono Cartridge

A new model of the Shure V-15 Type II Super Trackability Phono Cartridge has been introduced by Shure Brothers, Inc.

The new V-15 Type II Improved model is said to offer increased trackability across the entire audible



spectrum at the lightest possible tracking forces. Shure states that the new cartridge is capable of tracking the majority of records at ¾ gram.

List price of the complete V-15 Type II cartridge is $67.50, while the Model VN15E elliptical stylus alone sells for $27.00.

Circle 51 on literature card

Sound System Packages

Four packaged "Simple Sound Systems," designed for use in churches and large auditoriums, have been introduced by Bell P/A Products Corp. The systems range from 20 watts for audiences of up to 200 (or up to 20,000 sq. ft. area) to a 100-watt system for audiences of up to 1,000 (or up to 110,000 sq. ft. area).

Bell states that all four systems utilize the "cardioid microphone" and the six-speaker "sound column" principle for maximum audience coverage, resulting in 120-degree horizontal and 30-degree vertical dispersion. All systems have pre-wired, pre-matched components, and include lengths of cable. Customizing to meet unusual requirements also is available.

List prices range from $285.00 for the 20-watt, 2-microphone, 2-

column system to $920.00 for the largest system, consisting of a 100-watt amplifier with 3 microphones and 6 sound columns.

Circle 52 on literature card

Background Music Amplifier

A new model in the Power-Line series of music amplifiers, Model UPB-10T, has been made available by University Sound.

This background music amplifier reportedly features low distortion and high efficiency. Either high or low microphone input is selected by a switch, and separate controls

for microphone level, program level and tone are provided. Other features include either 25-volt or 70-volt constant voltage and direct outputs.

Model UPB-10T is list priced at $99.92.

Circle 53 on literature card

Miniature Microphone Transformers

Stanford International has introduced a 200- to 50K-ohm miniature microphone transformer.

Available in a variety of voltage ratios and with or without full mu-

metal shields, the transformers come in two types: Model BV-16 is rated at 200 to 50K ohms and is mu-metal encased for chassis mount. Model BV-16E is electronically identical to Model BV-16 and comes encapsulated in vinyl, with an 8-inch length of microphone cable. Model BV-16E can be installed in or out of the microphone case, or it can be installed in the line.

Model BV-16 lists at $6.00; Model BV-16E sells for $7.00.

Circle 54 on literature card

Automatic Volume Control For PA Systems

A new voice control monitor, which automatically lowers the volume output of public address (PA) systems when the sound is too loud,

has been announced by Bell P/A Products Corp.

The Model VCM-1 "Vox Limiter" is a compact, solid-state instrument employing integrated circuits. Bell P/A reports that the unit splices easily into any line between the microphone or telephone and the amplifier.

By setting the sound level to the softest voice likely to use the system, the volume reportedly is reduced automatically to this pre-determined level. The unit also protects sound systems from damaging overload, according to Bell P/A.

Model VCM-1 weighs 3 lbs., measures 2⅞ inches X 8 inches X 9 inches, and sells for $120.00. ▲

Circle 55 on literature card

MOBILE RADIO SERVICING

Part 2
Troubleshooting techniques

by Leo G. Sands

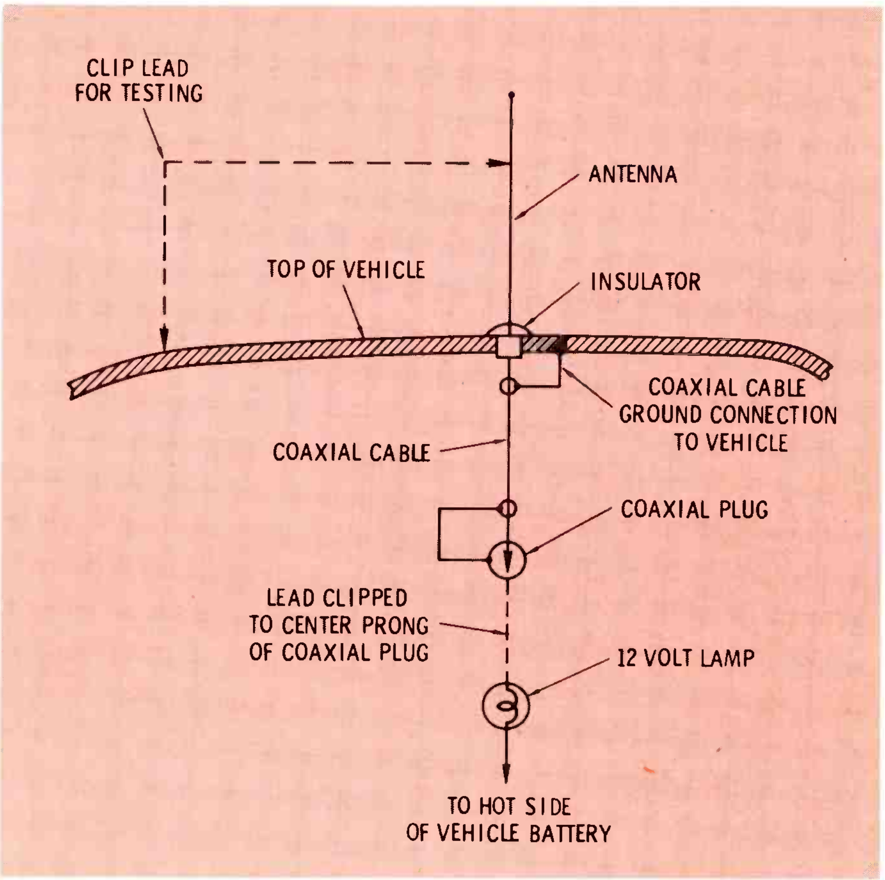


Fig. 1 Test setup for checking out a whip antenna not equipped with a built-in shunt impedance matcher. Ground the whip to the body of the vehicle and connect a test lamp between the "hot" lead of the coax and the 12-volt battery of the vehicle. If the lamp lights, the antenna is not open. If the lamp remains lighted after the antenna-to-vehicle test lead is removed, the antenna or coax is shorted.

The "cost effectiveness" of a technician and the profitability of a two-way radio service shop, as well as customer satisfaction, depend upon the rapidity with which troubles are diagnosed and corrected.

The user of a mobile radio system bought or leased the system for one very significant reason: Two-way radio enables him to reduce costs by getting more production from his employees and, often, to enable him to increase his income by being able to serve more customers more efficiently.

The failure of the base station or repeater station shuts down the entire system. The failure of a mobile radio unit puts the vehicle back on a less efficient basis. Unlike a home TV set, mobile radio down-time costs the user money.

Mobile radio troubleshooting includes all components of a system. The work must be done in the field as well as in the shop.

To minimize down-time, customers should be urged to install a stand-by base station and to buy or lease spare mobile units. Then, it would not be necessary to dispatch a technician to repair a base station immediately after its failure. And when spare mobile units are available, an inoperative vehicular radio station can be made operational in minimum time.

Since all customers do not use identical equipment nor operate on the same frequencies, it is not feasible for an independent service shop to maintain an inventory of spare mobile units, except when supplied by the customer.

Checking Out Mobile Installations

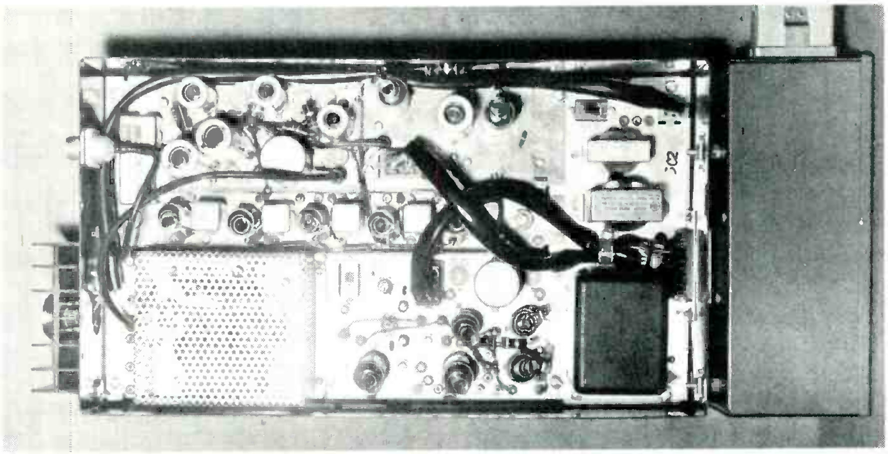
When spare mobile units are on hand, ready for use when one fails, and if a fault within the transmitter-receiver unit is the cause of malfunctioning, it should be replaced with a spare, and repairs to the defective unit should be made later in the shop. There are exceptions, however, such as when a tube obviously is the cause of the trouble, or when the set employs a vibrator and it has given up the ghost.

But, the trouble is often in some other part of a vehicular installation. So a logical procedure should be used for checking out the installation.

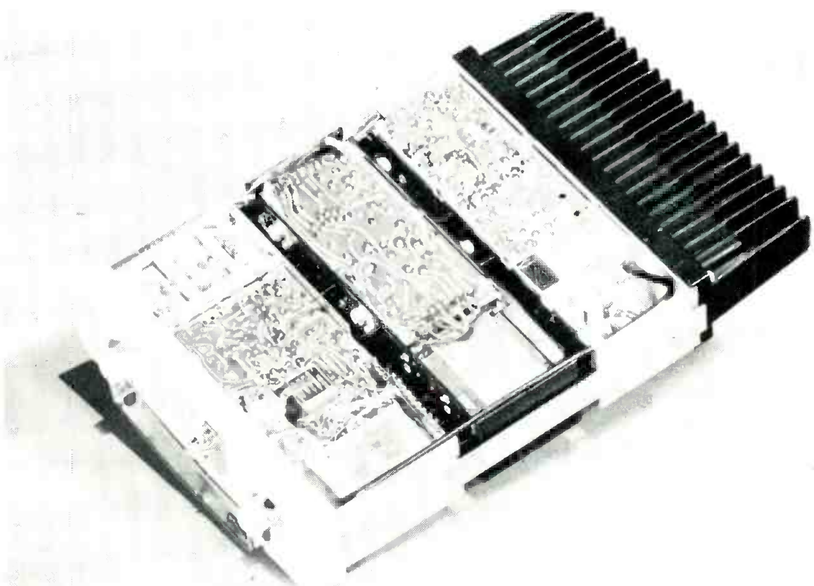
First, find out if the vehicle battery is okay by trying the horn and the lights with the engine not running. When the power switch is turned on and the pilot lamp does not glow, check the fuse and the battery cable, as well as the control head and its interconnecting cable. (Of course, the pilot lamp could be burned out.)

If there is power, operate the mike button to see if the transmit light goes on and, perhaps, the click of the T-R relay might be heard. Turn up the volume and disable the squelch; noise should be heard in the speaker. If there is no noise, use clip leads to parallel a test speaker across the set's speaker leads to find out if it is the speaker that is defective. If it is an external speaker, replace it.

If there is noise in the set's speaker, but the unit will not transmit or receive, disconnect the antenna and insert a wire into the set's antenna connector (18-inch for 150- to 174-MHz high band, 7-foot for 30- to 50-MHz low band). If signals now are heard, you know there is a defect in the antenna system. If the antenna is a quarter-wave whip type (with no shunt impedance matchers built in), ground the whip to the vehicle body with a clip lead and connect a test lamp across the coax plug at the set end of the coaxial cable, as shown in Fig. 1. The lamp should light. If not, the coax is open or there is a bad connection at the antenna or coaxial plug. If the lamp lights with the clip lead removed, there is a short in the antenna system.



Example of a typical tube-type mobile communications unit.



Example of a solid-state mobile communications unit employing printed-circuit boards.

WARNING! Don't turn on the transmitter except when the set is connected to its own antenna (not a test lead), if it employs a solid-state final RF amplifier. Without a proper load, the output transistor probably will be damaged. Instead, connect an RF wattmeter (with an internal or plug-in 50-ohm load) to the mobile unit's antenna terminal. Then, you can safely press the microphone button.

If adequate RF power output is indicated, you still won't know if modulation exists when you talk into the mike because in FM, power output does not vary with modulation. An easy test is to try to communicate with the base station or another mobile unit. Another way is to take along a tunable portable police monitor receiver and use it to listen to the mobile unit's signal.

By these simple tests you will know if you should replace the mobile unit or look for trouble elsewhere in the installation.

Checking Out Base Stations

A base station check-out is similar to that employed for a mobile unit, if it is locally controlled. But the customer seldom has (but should have) spare base station equipment, unless it is identical to his mobile equipment. Therefore, it is sometimes more expedient to make a simple repair on the site. But if it is not an easy job to make the repair then and there, hook up a spare mobile unit as the base station. Of course, you'll have to get a storage battery and perhaps even a charger, or a 12-volt rectifier power supply, to power the mobile unit.

(Don't overlook the possibility of using a walkie-talkie as a spare mobile unit, or even as an emergency base station. Most have a jack for connecting an external antenna.)

If very short range is the trouble, suspect the antenna system or the line voltage. In one case, the author found that the center conductor of the coaxial cable had shrunk and pulled out the pin on the coax connector, which was 85 feet up a pole, and the temperature was –20 degrees F. But the base station (high band) was quickly put on the air—a coat hanger was handy. With a pair of diagonal cutters, an 18-inch stiff-wire antenna was made. It was plugged into the base station antenna terminal, and communication was restored. Later, the necessary antenna system repairs were made when it warmed up enough to get a man to climb the pole.

In this case, the trouble was verified with an ohmmeter. It indicated an open circuit and charge and discharge of the cable's capacitance. If it had been an ordinary ground plane antenna, the same results would have been obtained. But, in this installation, the antenna employed a matching stub, which normally would have produced a DC short indication at the set end of the coax (see Fig. 2).

Checking Out Controls

In the case of either a mobile unit or a base station, failure to transmit could be caused by a defective push-to-talk switch or an open in the mike cable or connector.

When a base station is remotely controlled over a leased telephone circuit, all components might check okay but the transmitter might operate intermittently or not at all if ground currents are excessive. In one case the transmitter would go on, but would shut off intermittently. Checking the voltage across the coil of the line relay at the base station site showed that the voltage varied enough to allow the relay to drop out. This was due to ground currents (see Fig. 3), which opposed the control current. A representative of the telephone company in the area said it was a common problem there. The solution was to modify the control circuit as shown in Fig. 4.

Don't forget that the telephone circuit itself could be faulty. In this day, when the telephone companies are having a difficult time with maintenance, the trouble could be at the central office or at any point in the circuit. This is a problem that the telephone company should correct.

Low line voltage can have a drastic effect on range. In one case, range was normally 8 to 10 miles. But at night it would fall off to 1½ miles. Upon checking, it was found that the line voltage would drop to as low as 90 volts. By using a Variac to boost the line voltage, full range was restored. The cure was to get the power company to fix the trouble so it would not happen again. Or, an automatic voltage regulator could have been installed.

Receiver front-end overloading and intermodulation are also common base station problems. They can affect mobile units, but since mobile units travel from one location to another, the effects vary in magnitude and probably do not occur at all at most locations. To determine if loss of receiver sensitivity or interference from stations on other channels is caused by a defect in the receiver, drive a mobile unit to the base station site and connect it to the base station antenna, and compare results. If the problem continues, it might not be easy to correct if the interference or desensitization is caused by nearby transmitters. It may be necessary to install cavity filters in the antenna transmission line. If the problem does not exist when a mobile unit is used with the base station antenna, it could be that there is a defect in the base station receiver (including design defect), but in most cases the use of a filter will alleviate the trouble.

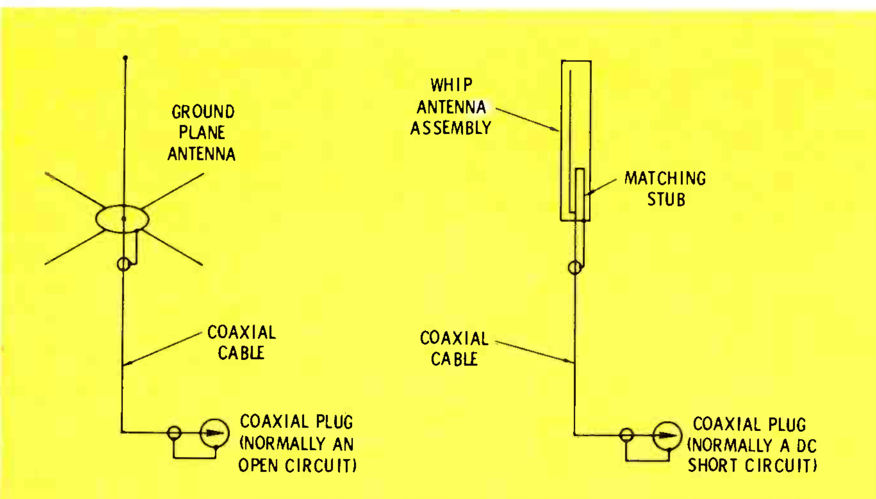


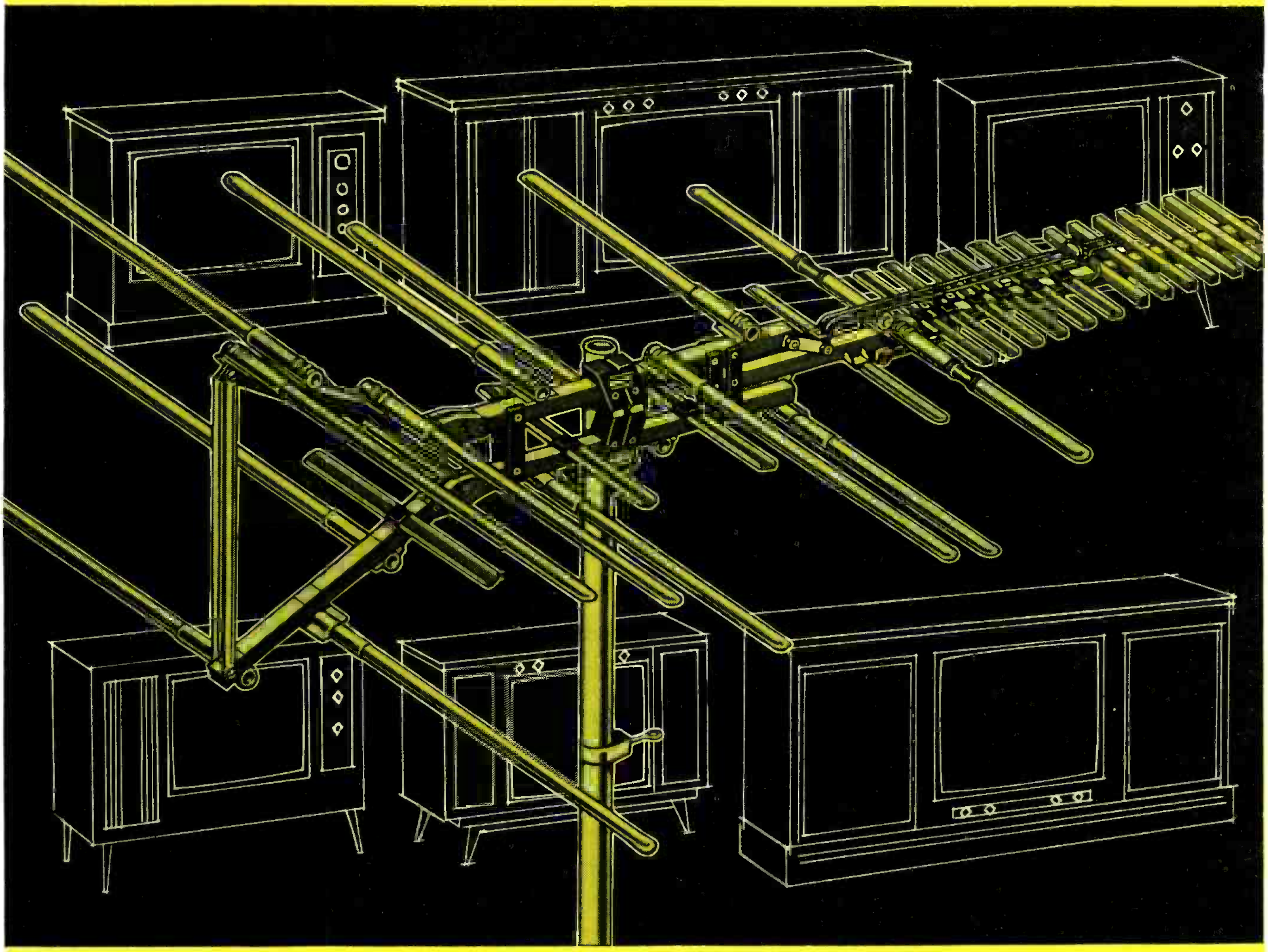
Fig. 2 Whip antenna equipped with a matching stub normally indicates a dead short when checked with an ohmmeter; ground-plane type on left normally indicates an open circuit.

Troubleshooting In The Shop

Troubleshooting mobile radio equipment is not as complicated as diagnosing TV troubles. A mobile radio unit is a relatively simple device by comparison. As the block diagram of an FM communications receiver in Fig. 5 indicates, such a receiver is not any more complex than an FM stereo receiver. And, as Fig. 6 shows, an FM transmitter is not a very complex device either.

There is a need for scopes and lab-grade signal generators and other instruments for conducting proof-of-performance tests (which will be presented in the third part of this series). But, for finding a defective component or printed-circuit (PC)

the set choice is yours...



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board, unsophisticated testers can be used.

When background noise is produced by a receiver with the squelch disabled, but no signals are heard, suspect the antenna switching circuit. Since the antenna relay is operated as a dry circuit switch when receiving, its contacts might be open, even if they seem to make contact. To find out, simply momentarily shunt the contacts with the end of a screwdriver.

No background noise should be heard if the first or second local oscillator is inoperative. But, if a crystal is off-frequency, noise will be heard even though the receiver is mistuned to a frequency on which there are no signals to be intercepted. Try a new crystal.

Or, first, apply a signal to the antenna terminal from a frequency meter set to the receiver frequency. If the receiver is operating, the background noise will quiet when a signal at the correct frequency is applied. Or, apply to the set's antenna terminal an unmodulated signal from a tunable signal generator. When the signal generator is tuned to the receiver frequency, the noise should quiet.

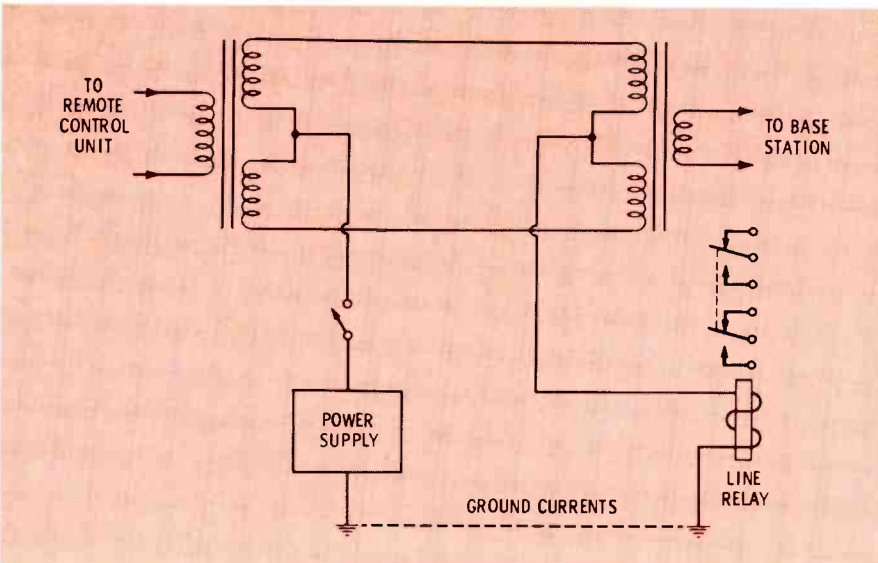

Fig. 3 Ground currents (indicated by dotted line) caused voltage across line relay to vary, causing the transmitter to operate intermittently. System shown here is a simplexed-to-ground remote control system.

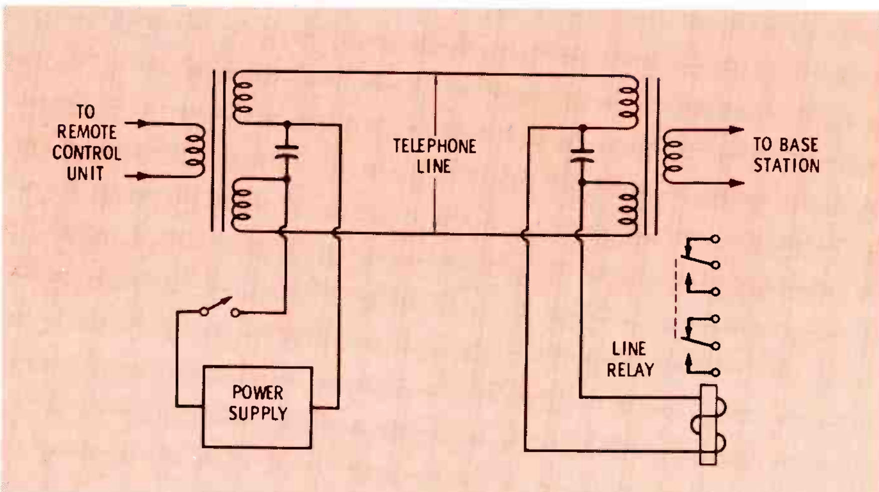

Fig. 4 Modification of grounded remote control system in Fig. 3. System shown here is ungrounded, which eliminates ground currents and their effects.

To isolate a defect in a totally inoperative receiver, use a multivibrator signal injector (such as an EICO PSI, Knight signal injector, Don Boscoe Mosquito, etc.) to apply a signal to each circuit section, working back from the speaker. A beep should be heard when the signal is applied to the input or output of each circuit. For example, if a beep is heard when the test signal is applied to the output of the detector and none is heard when the signal is applied to the input of the IF amplifier PC board, you will know there is a defect in the IF amplifier PC board or in the power feed to it.

Signal tracing also can be done in reverse. Apply an FM signal (at the receiver operating frequency) to the antenna terminal and look for presence of signal at the output of the first mixer, second mixer, detector, and so on, using a low-capacitance probe and a VTVM or scope. If there is no signal at the output of the first mixer, suspect the first local oscillator. Use a tunable RF signal generator loosely coupled to the first mixer. If you can tune in signals with the signal generator dial, you will know that the local oscillator is not functioning. You can check the second local oscillator in the same manner.

Never troubleshoot a transmitter until **after** you have connected an RF wattmeter or a 50-ohm dummy load to the antenna terminal. RF output transistors can cost as much as $100 each and can be destroyed if the transmitter isn't loaded properly.

If there is power output, but it is very low, chances are that only a tune-up is required. Fortunately, most transmitters have a test meter socket or test meter pin jacks, which permit measuring voltages and input drive to various stages, to facilitate tuning.

If there is no RF power output, the trouble could be in almost any stage. Again, the metering jacks or socket can be used for checking for presence of signal from a preceding stage. Or, a low-capacitance or RF probe can be used with a scope or VTVM to check for presence of signal at the output of each stage.

A common source of trouble is the oscillator stage. If this stage is tuned for maximum output, the oscillator might fall out of oscillation. Tune this stage (if it has a tuning adjustment), for about 70 to 80 percent of maximum output on the "gentle" slope of its output curve. After tuning, key the transmitter on and off several times to make sure the oscillator starts every time.

NOTE: Always use the applicable service manual.

Input Voltage

In an automobile, the source voltage can vary from 11 volts in cold weather with the engine off to almost 15 volts in warm weather with the engine running. Because of this wide variation, the nominal input voltage to a 12-volt mobile unit is 13.8 volts. In the shop, a variable output rectifier should be available so that a mobile unit can be operated through the range of input voltages experienced in the field. Some causes of malfunctioning will not occur except at voltages lower or higher than the rated input voltage. In the case of an AC-operated transmitter and/or receiver, vary the line voltage with a Variac or similar autotransformer.

Temperature

Some malfunctions are not obvious or present at normal room temperatures. Equipment can be warmed up quickly by placing it under an infrared lamp or letting it run for a while when covered by a carton which inhibits ventilation. To simulate the conditions a mobile unit is subjected to in the trunk of a car when parked in the open in the winter, the unit should be cooled. In the winter, this is easy. Just put it outside for a while. In the summer, a refrigerator is handy for this purpose.

Shock and Vibration

Very few shops, if any, have a shake table for testing radio equipment. But, to test for the effects of

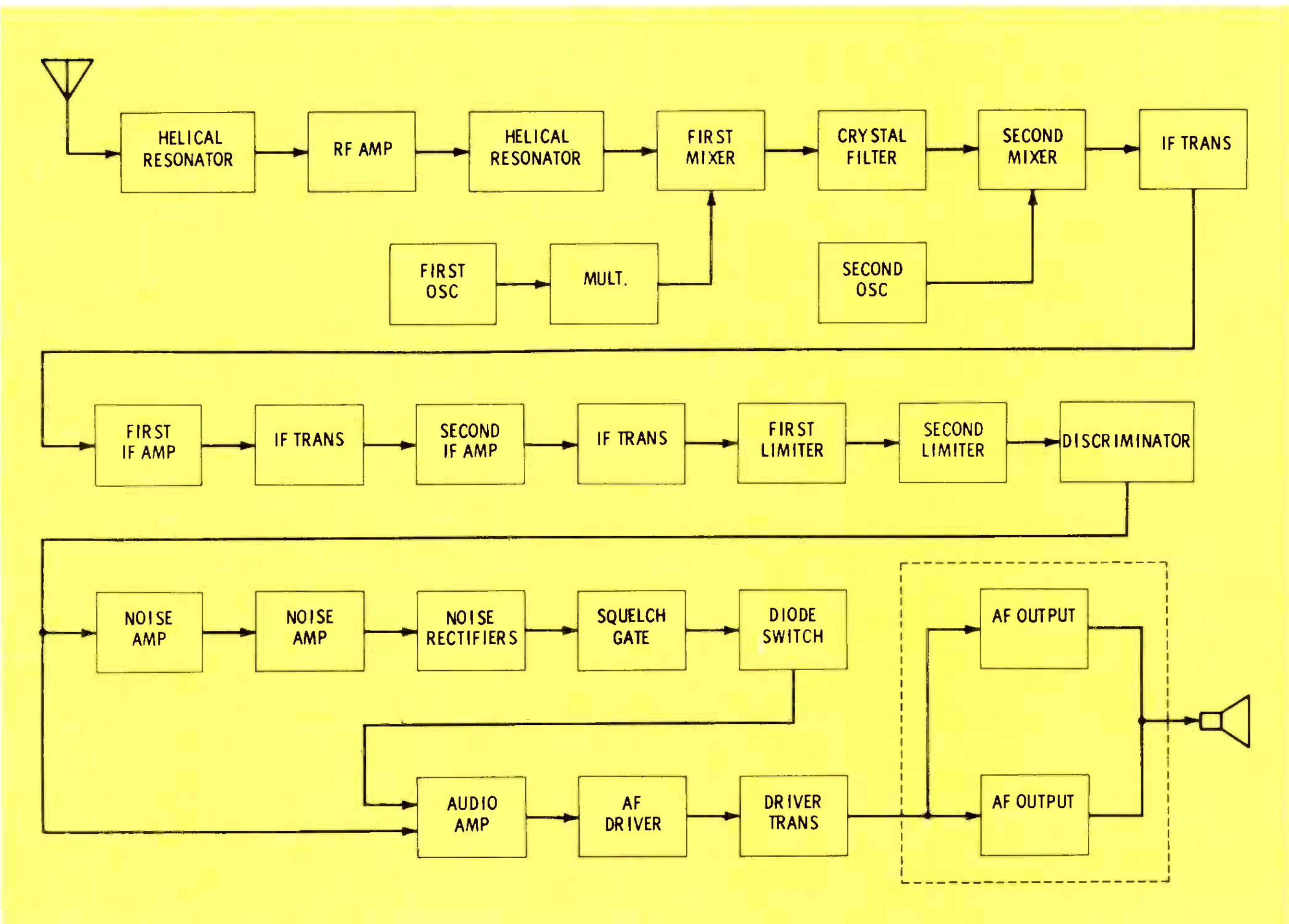

Fig. 5 Block diagram of a typical FM communications receiver. Compared to a color TV receiver, it is relatively simple. (Courtesy E. F. Johnson Company)

shock, you can use a plastic-headed mallet to **lightly** tap the chassis. (In fact, the author has seen this sort of shock test being used at the end of a TV set production line.)

Tubes

Since many tube-type mobile radio units are still in use, tube-caused troubles should not be overlooked. Tubes that still test normal on a transconductance or mutual dynamic conductance type tube tester, even if not in tip-top shape, should not be replaced; experience shows that new tubes are subject to more frequent failures than tubes that have been aged in use. However, tubes used in RF and IF stages should be tested for grid emission, which is not detected by most general-purpose tube testers. Use either a grid-circuit tube tester or a general-purpose tube tester capable of checking for grid emission.

Discrete Components

Conventional troubleshooting techniques are used for isolating discrete components not mounted on PC boards. When a capacitor, RF choke or other component in the front end is found to be defective, replace it with an identical spare or at least one of the same electrical value.

CAUTION! In VHF and UHF circuits, capacitors are particularly critical. If, for example, a ceramic is used, replace it only with a ceramic.

Circuit Tracing

Trying to match a schematic with the connections of a PC board can be extremely time consuming. Fortunately, most service manuals now include pictorials of PC boards with components referenced to the schematic diagram. At least one manual contains removable color templates which make it easy to identify components and test points. Without PC board pictorials, circuit tracing is a formidable job.

Basic Test Equipment

Although there is need for a variety of test instruments for troubleshooting tough dogs, only a few are needed for finding most defects. These include an RF wattmeter for determining if the transmitter is putting out RF power; a combination frequency meter and deviation meter for use as a receiver signal generator and for determining if the carrier is being frequency modulated, as well as for measuring transmitter frequency; and a VOM for voltage and resistance checks. And, of course, a multivibrator type signal injector is invaluable.

Exclusive of finding power supply and power distribution circuit troubles, and in transmit-receive circuits, the basic diagnostic chore is signal tracing.

Summary

This article is intended to explain general mobile radio troubleshooting techniques, but not how to check each and every circuit, since voltage and resistance measuring techniques would already be known to those in the electronics servicing profession. Details on how to check components on PC boards are usually explained in service manuals. But, the trend is toward replacing PC boards to get the equipment back into operation quickly, and to be concerned later about what to do about repairing the PC board or getting it repaired or replaced by the manufacturer. The technician who turns out the most units per day is the one who earns the most for his boss, even if he is his own boss.

Next

The final installment of this series about mobile radio servicing will present step-by-step techniques for performing proof-of-performance tests. ▲

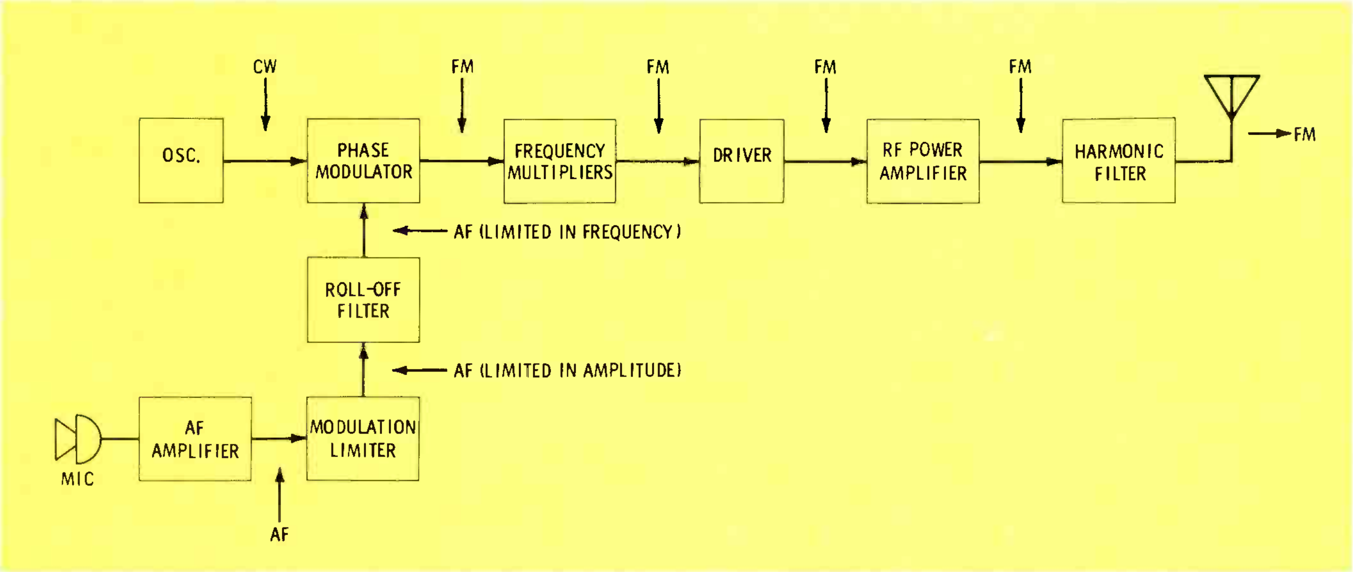

Fig. 6 Block diagram of a typical FM transmitter. It, too, is relatively simple compared to a color TV.

photofact bulletin

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Remote Control Receiver 704054-1, Transmitter 704041-1 1109-1-A

Chassis T935-01-AA 1110-1

PENNCREST

4868B-49 1110-2

PHILCO-FORD

B710TBE, B730TWA, B740TWA (Ch. 20S32, 20S32A) 1108-1

B411TBE (Ch. 20L23) ... 1111-2

RCA

Chassis CTC40AB/AC/AD/AE/AF/P/R 1111-3

SEARS

4022 (Ch. 562.10500) 1108-2

4121, 4158 (Ch. 564.80130/131/132 1110-3

SYMPHONIC

TCT-185 1109-2

TRUETONE

MIC2DC-3909A-86 (2DC3909) 1109-3

ZENITH

Chassis 14A9C17, 14A9C19, 14A10C19 1108-3

book review

Tape Recorder Servicing Guide: Robert G. Middleton, Howard W. Sams & Co., Inc., Indianapolis, Ind. 46206, Catalog No. 20748, 1970; 96 pages, 8½ inches X 11 inches, paperbound, $3.95.

This book begins with a thorough discussion of the general principles of tape recorders, emphasizing the magnetic circuitry and bias circuits which are unique to tape recorders. The second chapter deals with preventive maintenance and evaluation, presenting a discussion of the basic facilities, tools and test equipment necessary for recorder servicing. Chapter 3 covers minor repairs and adjustments.

The next three chapters provide a systematic discussion of various trouble symptoms, their analysis and proper servicing procedures. The final chapter covers maintenance of the specialized test equipment used in tape-recorder servicing.

1-2-3-4 Servicing Transistor Color TV: Forest H. Belt & Associates, Howard W. Sams & Co., Inc., Indianapolis, Ind. 46206, Catalog No. 20777, 1970; 224 pages, 5½ inches X 8½ inches, paperbound, $4.95.

The text discusses the 1-2-3-4 method of troubleshooting transistor color television.

Chapter 1 covers the fundamentals of 1-2-3-4 servicing and Chapter 2 discusses the basics of transistor color TV. Next two chapters review the chroma sections and stages used, while Chapter 5 concentrates on the special stages used in certain transistor color TV's.

Chapter 6 is titled "Finding Your Way Around Transistor Circuits" and the next chapter applies the 1-2-3-4 method to transistor color TV. The remaining four chapters deal with the actual servicing of these sets. ▲

Circle 24 on literature card

by Allan Dale

Servicing the automatic turntable

Part 2 / the change mechanism

Last month I began showing how you could understand "complicated" automatic turntables. You simply break them down mechanically, much as you would a large electronic device. Bit by bit, no mechanism is hard to understand.

Electronically, you think of a unit as divided into sections, stages, circuits and parts. A mechanical device can be thought of as made up of operations, assemblies, motions and parts.

For troubleshooting, you first diagnose which **operation** is at fault. Then you examine the **assembly** that handles that operation. Once you are looking at the right assembly, you study the **motions** that assembly goes through. When you find which motion isn't occurring as it should, you'll probably spot the defective **part.**

So you see, the whole thing is very logical. I told you last month how to apply these principles to the motor/drive system. And I gave you some hints for servicing those assemblies. Now let's get into what scares most technicians away: the change mechanism.

Automatic Change Cycle

The change cycle of an automatic turntable consists of several operations:

1) Cycle initiation (what starts it)

2) Lift tone arm

3) Swing tone arm clear of turntable radius

4) Drop record and reposition remaining records

5) Index tone arm for accurate setdown

6) Lower tone arm to record (setdown)

7) Reset for next cycle

Using the BSR McDonald Model 600 turntable as an example, you would analyze the assemblies, motions and parts in the following manner.

Cycle Initiation

As the tone arm reaches the end of the record, an eccentric lead-out groove swings it quickly toward the center. Beneath the motorboard, a small lever on the bottom of the tone-arm spindle pushes a long slotted metal linkage (Fig. 1A). The other end of that linkage goes up through the motorboard. When the tone arm pushes it, the linkage pushes a trip pawl on the cycling gear (sometimes called a cycling cam). The trip pawl is pointed out in Fig. 1B.

On the geared hub of the turntable is a small projection (Fig. 1C) called a trip tab. Ordinarily it just turns, not engaging anything. But the change-cycle link pushes the trip pawl right out in front of the trip tab. The tab catches on the trip pawl and pulls the large cycling gear into mesh with the teeth on the turntable hub. The change cycle has begun.

The change cycle can be initiated while the record is playing, too. You just pull the REJECT lever. Two lever linkages (Fig. 1D) transfer that motion to the linkage that contacts the trip pawl. The rest of the motions are the same as I just described.

Trouble? Just follow the motions. For example, if the cycling gear doesn't engage the teeth on the turntable hub, see if the pawl is actually being pushed out. See if it's engaging the trip tab. If not, see if the long linkage is being pushed by the tone-arm lever or by the reject-lever linkages. Maybe the tone-arm lever is bent. Maybe a linkage is twisted or has dropped off. Perhaps a spring is gone, and the change cycle keeps repeating.

The point is: When you follow each motion through the various parts of an assembly, you can easily spot which part is at fault.

Lift Tone Arm

The arm might not lift high enough. Or it may lift too high and hit the records waiting to be dropped. Or it might not lift at all. To find out why, you study the motions of the assembly responsible for this operation.

The cycling gear turns as the turntable turns. Beneath the motorboard, the gear moves a cycling slide. A bent tab on the slide has a pushrod, with a spring, resting on it (Fig. 2A). As the slide moves sideways, the tab shoves out under the pushrod. It forces the pushrod upward through the motorboard right under the tone-arm mount.

The pushrod raises a small platform into contact with an adjustment screw on the tone arm (Fig. 2B). The movement lifts the tone arm. A cue lever (Fig. 2C) can also raise the platform.

If the arm lifts too little or too much, first check the adjustment screw. Then check the platform and pushrod. If the cue lever lifts the arm okay but the change cycle doesn't, suspect the bent tab on the change slide.

If the arm doesn't lift at all, suspect the change slide. Make sure the pushrod is free. Be sure the spring is there where it belongs.

In other words, check the motions of each part in the assembly. One part might be bent, missing, stuck, etc. **WARNING:** Do not—I repeat, do not—start bending parts (like the tab on the change slide) to repair an automatic turntable. If someone else has bent them and caused the trouble, you might be tempted to bend them back as best you can. Don't. **Replace** the part or assembly you think is bent.

An automatic turntable is put together with considerable precision. There's no way your eye can duplicate the angles of each part. Do the job right. Replace parts that don't go through their motions properly.

Swing Tone Arm Clear

The whole change cycle, once it has begun, centers around the cycling gear and slide. As the gear moves the slide, a metal finger eventually comes into contact with the lever on the bottom end of the tone-arm spindle (Fig. 3). As the slide goes further, the finger swings the tone arm sideways. At the end of the slide's travel, the tone arm hovers above its rest along the side of the motorboard.

The lever on the tone-arm spindle, as you see in Fig. 3, has a V-shape. The cycling slide, having swung the tone arm to the side, keeps moving; but it is now moving back in the opposite direction. The arm doesn't move back immediately, though, because the slide finger has to cross the open space inside the V.

Failure of the arm to swing clear should be easy to trace. There is only one motion, if the cycling gear and slide are working. Check the tone-arm lever, the positioning of the finger, and the tab on the end of the finger.

Drop the Record

This is the reason for all the other operations. In modern turntables it's done with a push-off tab in the automatic spindle.

The records rest on a push-off platform at the top of the spindle (Fig. 4A). They're held level by a hold-down arm. Inside the spindle, and extending out its bottom end, is a slim pushrod that activates the spring-loaded push-off tab. (You can't see the spring; it's inside the spindle.)

As the cycling slide has progressed, it has pushed another long metal linkage (Fig. 4B) along under the spindle pushrod. The link has a drop-slot. At a point in the change cycle when the tone arm is out of the way, the drop-slot reaches the spindle pushrod. It engages and pushes the rod, pulling the push-off tab sideways (Fig. 4C).

That tab is just high enough to engage the hole of one record, sliding the record sideways. It drops off the platform, and slides down the spindle to the turntable. Small guides (held up in Fig. 4A) keep the other records from moving sideways and dropping.

As the cycling slide continues, it pulls the dropping linkage backward. The spindle pushrod comes back down and the push-off tab returns to its normal position. The record stack drops to the push-off platform. The dropping assembly is thus reset for the next change cycle.

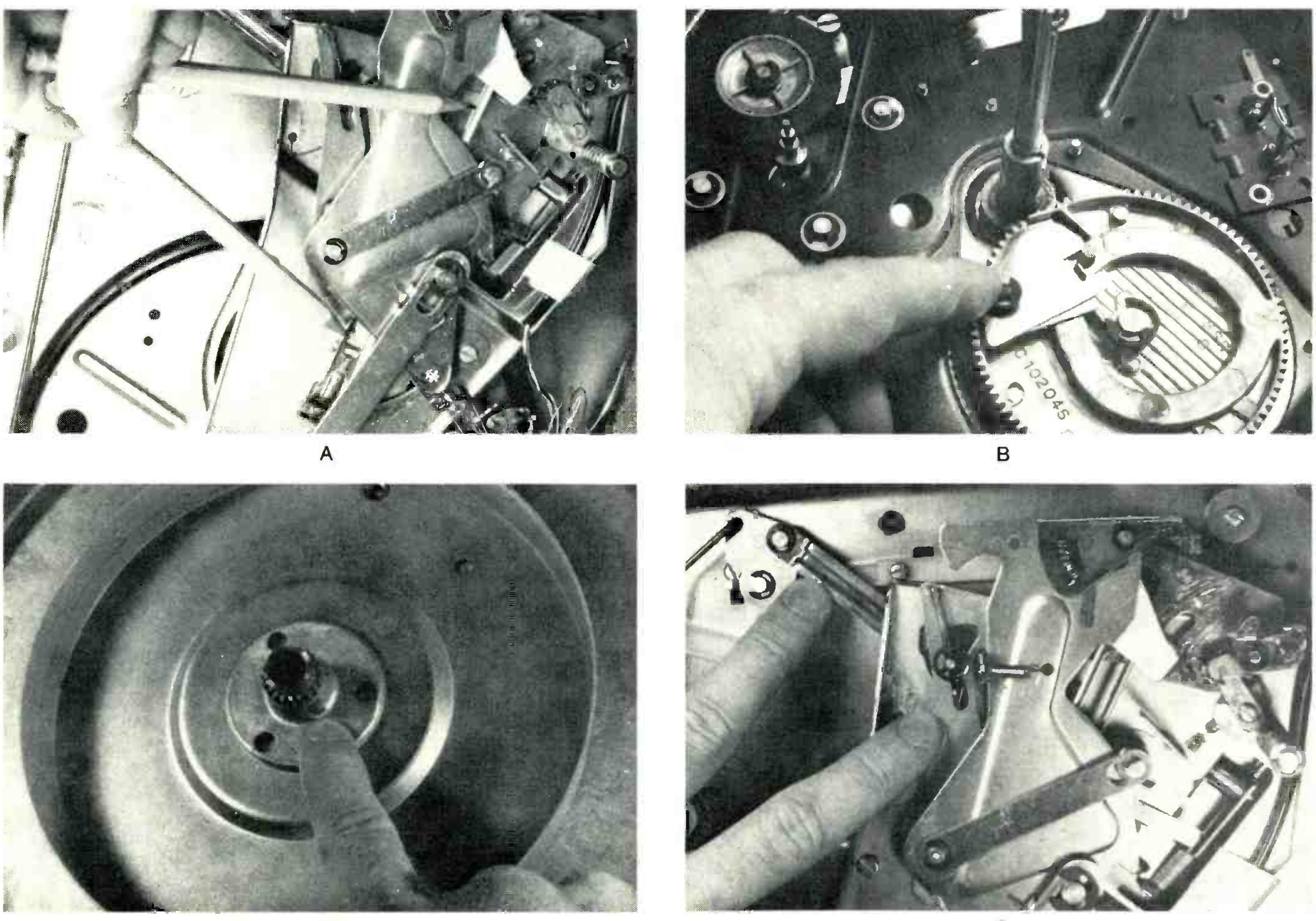
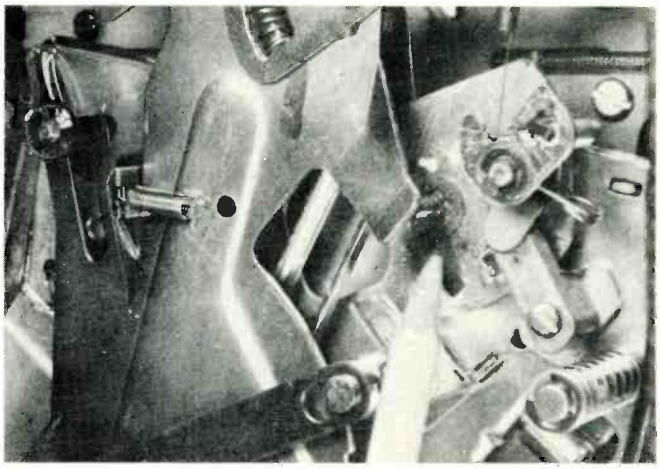


Fig. 1 Tripping mechanisms that initiate change cycle. (A) Pencil points to sliding linkage that is actuated by lever on bottom of tone-arm pivot. (B) Jointed trip pawl is part of cycling gear. (C) Cast-metal tab on hub of turntable catches trip pawl to start change cycle. (D) These linkages move trip pawl from reject lever.



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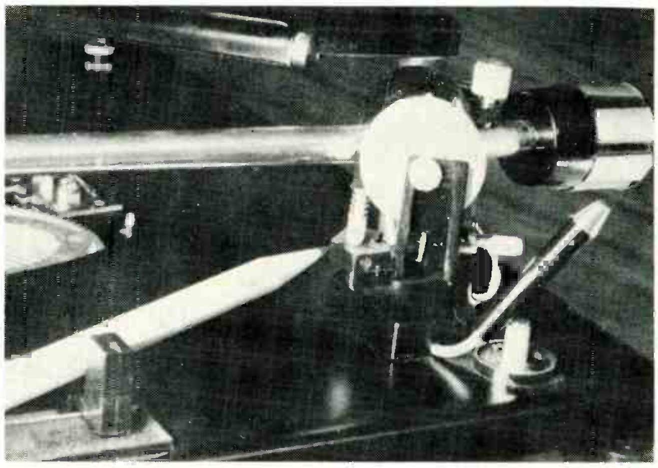
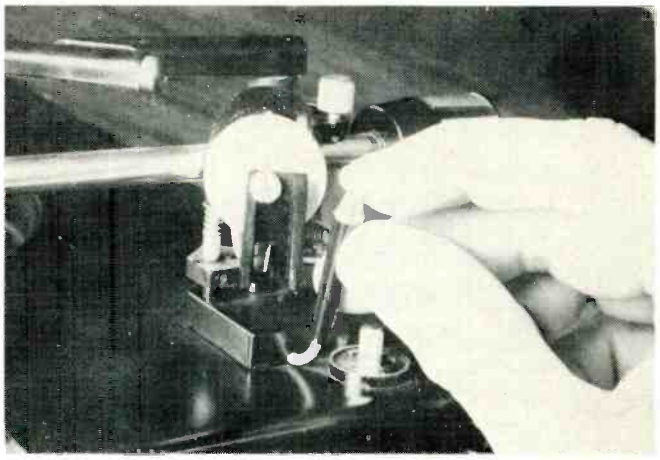


B

Fig. 2 Assembly that raises tone arm. (A) Pencil points to small spring that encloses pushrod, which rests on bent tab of cycling slide. (B) Small platform pushes upward on adjustment screw. (C) Cue lever lets you raise tone arm manually.

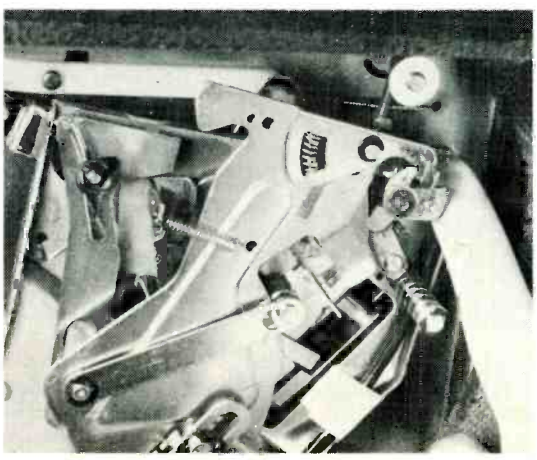


C

Troubles with dropping are more often in the spindle than anywhere else. The spring for the push-off tab gets weak. The tab and pushrod may get sticky, particularly if some misguided soul tried to oil them. Or the tab gets bent. Or the guides get sticky. The cure is a new spindle —usually inexpensive.

However, if that isn't the problem, inspect motions in the rest of the dropping linkage assembly. That includes the drop-slot, the dropping linkage itself, and its relationship to the cycling slide. Watch as it goes through a cycle. You'll spot the difficulty.

Fig. 3 Spring-loaded finger is part of cycling slide. Tab on it fits into V of lever at bottom of tone-arm pivot. It moves tone arm out of way of dropping record, and back after record has dropped.



Index Tone Arm

The idea of indexing is to set the tone arm down so the needle enters the lead-in groove of whatever size record has been selected. Some turntables, and most older changers, index automatically. With the BSR in these examples, and with several other high-quality turntables, tone-arm indexing is by a lever you set manually.

The plastic index linkage from the lever to the rest of the assembly is almost hidden by the on/off/reject linkages in Fig. 1D. It goes to a shorter link that moves a blocking pawl (Fig. 5A). As the cycle begins, an indexing bar is snapped against the blocking pawl by a spring. The position of the pawl limits how far the indexing bar moves.

Later in the cycle, as the tone arm is swinging back toward the record, the other end of the indexing bar engages serrations in the tone-arm lever (Fig. 5B). It blocks travel. The arm stays there while the setdown operation takes over.

Indexing trouble can be complicated to track down if you haven't followed my explanation carefully. There are several parts and several motions in the assembly that perform this operation.

Start by working the indexing lever (atop the motorboard) back and forth. Watch whatever motions that portion of the assembly goes through.

Then, with the turntable removed, turn the cycling gear by hand through one full revolution. Do it slowly. Watch how the spring jerks the indexing bar against the blocking pawl. If it doesn't, there's a trouble clue. Follow through the other motions.

Shutoff Indexing

One thing to keep in mind at this point: The shutoff operation, after the last record, must find the tone arm still over its rest—not out over a record. That requires another indexing position.

The hold-down arm that rests on top of the record stack drops down after the last record is out of the way. After the last record plays, the change cycle starts just like always. The tone arm is lifted and swung out of the way just as if a record were going to drop. The dropping mechanism operates, but, of course, there's no record on the platform.

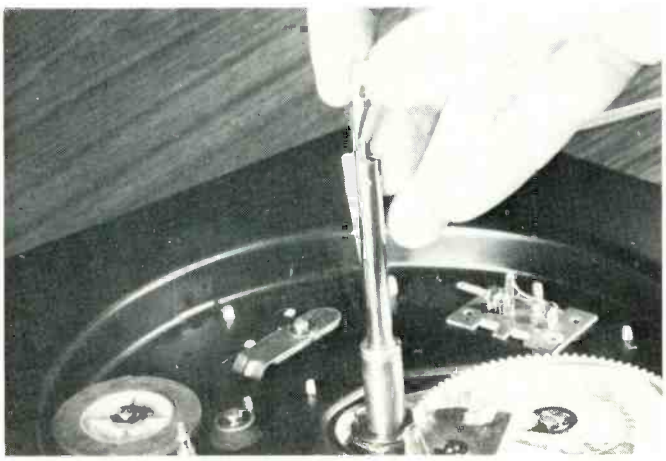
Then indexing starts. However, the bottom of the hold-down arm spindle is now pushing the index blocking pawl down out of the way of the indexing bar. The bar snaps all the way back because the blocking pawl doesn't stop it (compare Fig. 6A with Fig. 5B).

On the other side, the indexing bar now catches the very last serration in the tone-arm lever (Fig. 6B). The tone arm is held in its position over the rest. When the set-down operation takes over, the arm drops onto its rest.

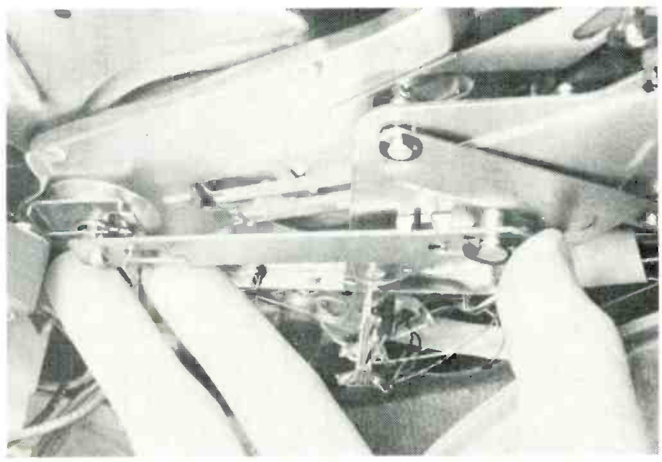
Set-Down

In light of what you already know about the change mechanism, this is probably the simplest operation to explain. It's merely a reversal of lifting the arm.

The cycling gear has almost gone

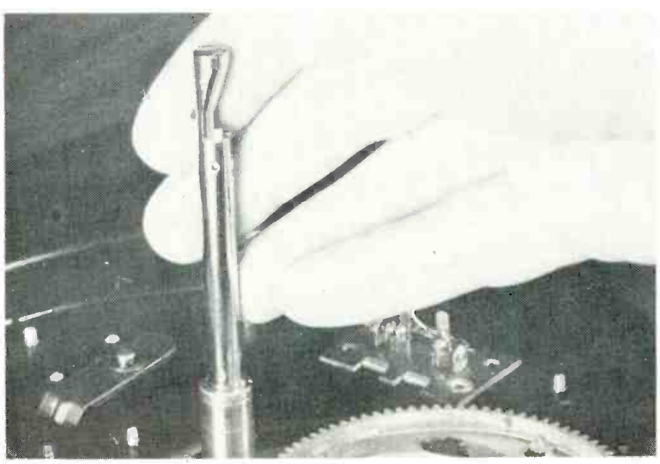


A



B

Fig. 4 Record-dropping assemblies. (A) Spindle has spring, pushrod, and push-off tab; also has guides to keep record stack in position. (B) Link from cycling slide has drop-slot at left end to engage spindle pushrod. (C) Push-off tab in position to push off record.



C

full circle. The cycling slide is moving back to its beginning position. As it does, the bent tab moves back from under the arm-lift pushrod and platform. The platform lowers to its resting position. If indexing is correct, the needle sets down in the lead-in groove of the record that just dropped.

Reset for Next Cycle

As the cycling cam or gear comes around, still driven by the gear teeth of the turntable, the open segment (where there are no teeth) reaches the turntable hub. With no teeth to engage, the turntable can't turn the cycling gear any further. A detent spring beneath the gear catches and holds the gear lightly, in readiness for the next cycle.

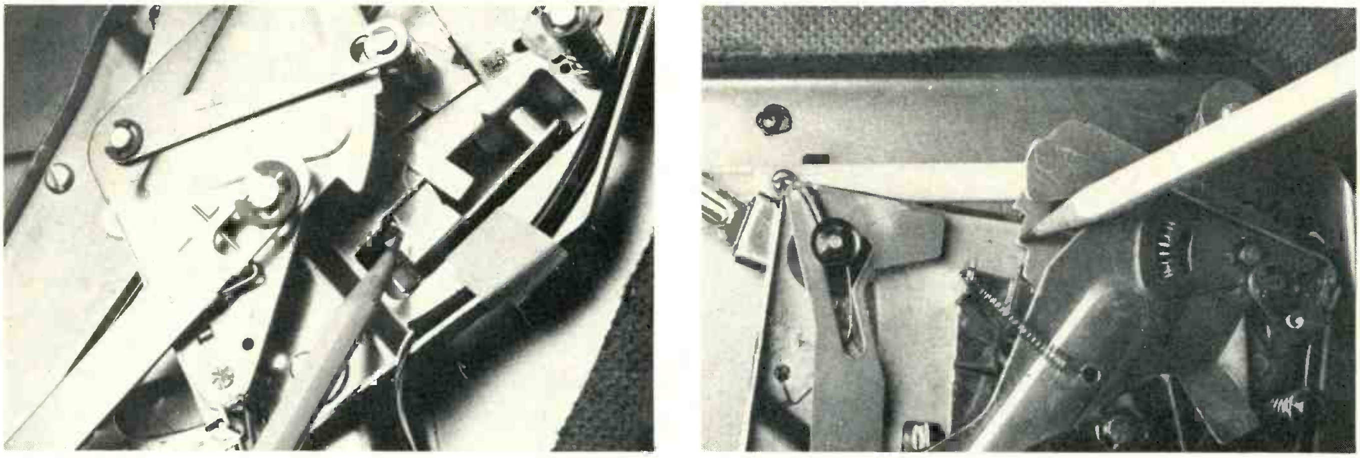
Meanwhile, as the cycling cam comes around to finish its cycle, the turntable hub has pushed the trip pawl inward. There it stays until the tone arm or reject lever pushes it out to initiate another cycle.

And So . . .

That's the logic of servicing automatic turntables. You also now have the information you need to make a troubleshooting method like this work. I've told you how each operation, assembly and motion fits into the overall scheme. Finding any defect should be duck soup from now on.

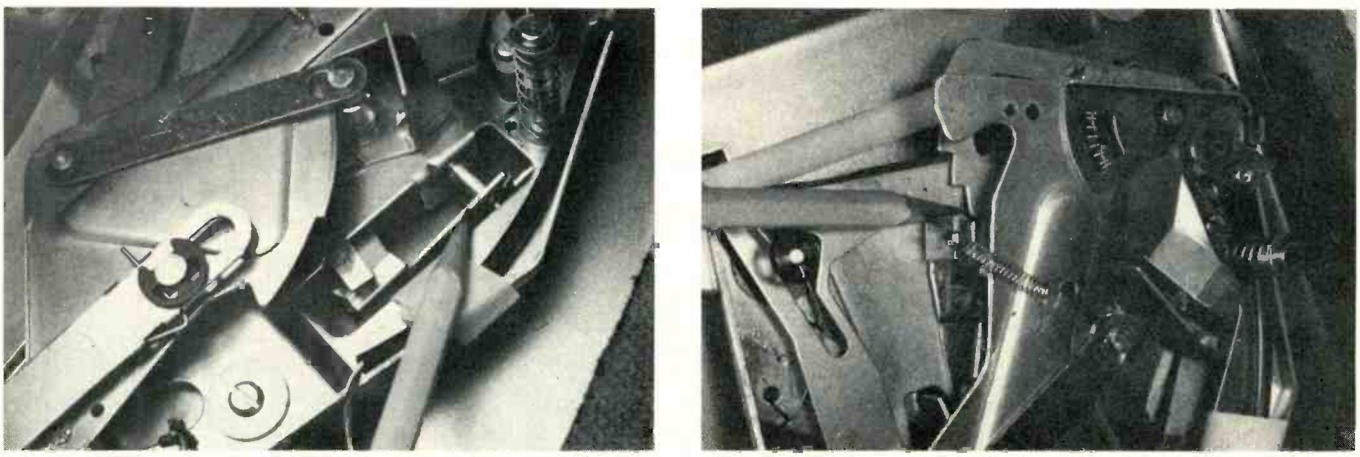
Next in Service Bench

Next month I go into something you've written to ask about. Guys who work on Citizens-Band gear sometimes worry about modulation. The law requires it be kept below a certain percentage. Yet the transmitter must have **enough,** or the user complains he can't be heard. Striking that happy medium is my next subject. ▲



A B

Fig. 5 Indexing mechanism consists of (A) blocking tab and indexing bar. (B) At other end of indexing bar, serrations in tone-arm lever catch on index-bar tab, preventing tone arm from moving further inward than lead-in groove of record size chosen.



A B

Fig. 6 For indexing at automatic shutoff, (A) record-support arm pushed trip pawl out of way. Indexing bar snaps all the way back and (B) stops tone arm swing by catching last serration.

Circle 35 on literature card

test equipment report

Field-Strength Calibrator

A solid-state calibrator for checking the accuracy of field-strength meters has been introduced by Measurements, Division of Thomas A. Edison Industries, McGraw-Edison Co.

Model 950 provides a continuously monitored and constant voltage reference traceable to the National Bureau of Standards. Frequency coverage is from 54 to 250 MHz, but special frequencies can be supplied on request.

The frequency dial is calibrated in MHz and segmented by TV channels 2 through 13. According to the

manufacturer, a wave-guide-below-cutoff attenuator permits accurate measurements from .1 volt down to .3 microvolt.

The unit can be used not only for checking the accuracy of field-strength meters used for antenna pattern surveys, but also for checking amplifier gain and measuring cable loss. Accuracy of output voltage is stated to be ±.75 dB over the entire frequency range.

The Model 950 requires a power supply of 115 or 230 volts, 50-60 Hz, 12 watts. It measures 7 inches X 12¾ inches X 7½ inches and weighs 13 lbs. The unit sells for $360.00.

Circle 56 on literature card

Solid-State Volt-Ohmmeter

A battery-operated, solid-state volt-ohmmeter has been introduced by Electronic Measurements Corp.

Model 116 has a DC input impedance of 11 megohms and an AC input impedance of 1 megohm. Using four silicon transistors and two diodes, the unit reportedly has a sensitivity 500 times that of a standard 20,000 ohms-per-volt volt-ohmmeter. Its 4½-inch, 200-microamp meter and solid-state circuitry are protected against burnout.

Specifications include: four p-p AC voltage ranges—0-3.3, 33, 330, 1200 volts; four rms AC voltage ranges—0 to 1.2, 12, 120, 1200 volts; four DC voltage ranges—0 to

1.2, 12, 120, 1200 volts; four resistance ranges—0 to 1K, 0 to 100K, 0 to 10 megohms, 0 to 1000 megohms; four dB ranges— −24 dB to +56 dB.

Model 116 measures 6¾ inches X 5¼ inches X 2⅞ inches, and weighs 3 lbs. It is housed in bakelite, with the handle usable as an instrument stand. Both versions are shipped complete with batteries, test leads and step-by-step instructions. The kit version is priced at $29.95 and the factory-wired and tested model sells for $39.95. ▲

Circle 57 on literature card

GET COMPLETE DETAILS

about the products advertised or described in this issue.

Use Free Reader Service Card.

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Accu-Tint: RCA's answer

How it functions.

by Carl Babcoke/ES Technical Editor

The RCA **Accu-Tint** (A-T) system produces three basic changes when the A-T switch is turned to ON:

- The phase of the 3.58-MHz color subcarrier applied to the B-Y chroma demodulator circuit is changed so that it is nearer the phase of the subcarrier supplied to the R-Y demodulator.

- The output of the B-Y demodulator circuit is reduced about 33 percent.

- The screen color is changed from the normal blue-white to a brown-white, or sepia. (This "warming" of the screen color "temperature" occurs only when a colorcast is received (killer inoperative) and the A-T switch is ON.)

The result of these A-T actions is to increase the level of red and decrease the level of blue and green in the color picture.

Fig. 1 shows the demodulator and —Y amplifier circuits of the new RCA CTC39X chassis, which is similar to the CTC38X except for minor changes in the video amplifiers, and the addition of the A-T circuit.

B-Y Phase Change

The 3.58-MHz subcarrier for the R-Y demodulator is taken directly from the secondary of T703, while the phase of the 3.58-MHz carrier for the B-Y demodulator is made "leading" by a high-pass filter. When the A-T switch, S106, is in the OFF position, this high-pass filter consists of C732, L703 and R735. With this arrangement, the normal (A-T off) B-Y phase leads the R-Y phase by about 105 degrees.

When the A-T switch is turned to ON, L712 and R797 are added in series with L703 and R735. This reduces the lead of the B-Y phase to 90 degrees or less (RCA has not announced the exact figures). R-Y carrier phase is changed slightly by the difference in loading on the secondary of T703, but most of the shift is in the phase of the B-Y chroma subcarrier.

B-Y Amplitude At The CRT Blue Grid

Skin coloring that is acceptable to many people can be obtained with only an R-Y color signal, so logically the next step is to reduce the amount of blue and green in the color picture.

The second section of S106 performs a double function. One of these, when the A-T is ON, is to ground R795. This decreases the output of the B-Y demodulator so that the signal at the CRT blue grid is reduced from the normal 120 percent of red to about 80 percent of red.

R-Y amplitude is unchanged, but because G-Y is made from R-Y plus B-Y, it also will be reduced.

Change in CRT Screen Temperature

When the A-T is ON, the junction of R793, R794 and R178 no longer is grounded through terminal 4 of S106. The negative-going horizontal pulse originating at the center lug of the **kine bias** control is reduced by a voltage divider consisting of R793, R178 and R795, and then is applied through the .047-mfd coupling capacitor to the grid of V704B, the B-Y amplifier. After amplification and phase reversal (180 degrees) by the tube, it becomes a small, positive-going pulse at the plate, which is fed through the .01-mfd capacitor to the anode of diode CR707 and the blue grid of the CRT. On the cathode of CR707, a large negative-going pulse from the kine bias control is applied to the cathode of CR707 and turns it on, resetting the charge on the .01-mfd capacitor every cycle, and thus maintaining the CRT grid DC voltage constant regardless of the chroma waveform.

The positive-going pulse at the anode of CR707 and the negative-going pulse at the cathode **add** together to produce a larger pulse. Because the DC voltage on the CRT grid is "clamped" to the negative tip of the pulse, the DC voltage on the CRT control grid is made less positive (compared to the CRT cathode), and the current of the CRT blue gun is reduced.

A small pulse also is applied through R793 and R794 to the cathode of V705, the R-Y amplifier. Since the signal is applied to the cathode, this pulse is amplified without phase inversion, and the negative-going pulse of a few volts appears at the anode of diode CR705.

A large negative-going pulse from the kine bias control is present at the cathode of CR705. The true voltage across the diode is the difference between the pulse voltage on the anode and the pulse voltage on the cathode. The effect is the same as a decrease in the pulse from the kine bias control, and causes the red grid of the CRT to become more positive by a few volts, increasing the red gun current.

During normal operation, small samples from the plates of both the R-Y and B-Y amplifiers are matrixed to produce a —(G-Y) signal at the grid of the G-Y amplifier. Because of phase inversion across the tube, a G-Y signal is developed at the plate and applied to the green grid of the CRT. Voltages in the G-Y stage are not affected by the addition of the extra A-T pulse voltages at the R-Y and B-Y amplifier plates; because the polarity of one is positive-going and the other is negative-going and the amplitudes of the two signals are nearly equal, they cancel at the G-Y amplifier grid.

to changing flesh tones

This method of using pulses to brighten the red, dim the blue, and leave green unchanged has another beneficial effect: When the color killer operates during b-w programs, the R-Y and B-Y amplifiers are biased to cutoff. Because of this, the A-T pulses cannot be amplified and, therefore, do not appear at the plates of the tubes or the anodes of the DC restorer diodes. Thus, the screen color is a normal blue-white, not sepia. (Of course, if the station leaves their color carrier on during a b-w commercial, or if the color killer malfunctions and does not operate normally during b-w programs, the screen color will be sepia if the A-T switch is in the ON position.)

Turning off the Accu-Tint circuit restores the B-Y demodulator phasing and amplitude, and restores the screen color to normal.

Conclusion

This RCA circuit prevents unwanted changes in skin coloration when the receiver is switched from channel to channel and/or when programing changes. Changes to the previous circuit are not extensive, and no critical or trouble-prone components have been used. Consequently, the circuit should be relatively service-free.

However, we must recognize that, despite excellent engineering and modern components, each basic type of automatic tint modifier is a stopgap emergency measure made desirable only by the continuing delay of the broadcasting industry in standardizing color hue. Also, it should be remembered that the circuits which most effectively eliminate green or purple faces also produce the most distortion of colors (except orange). ▲

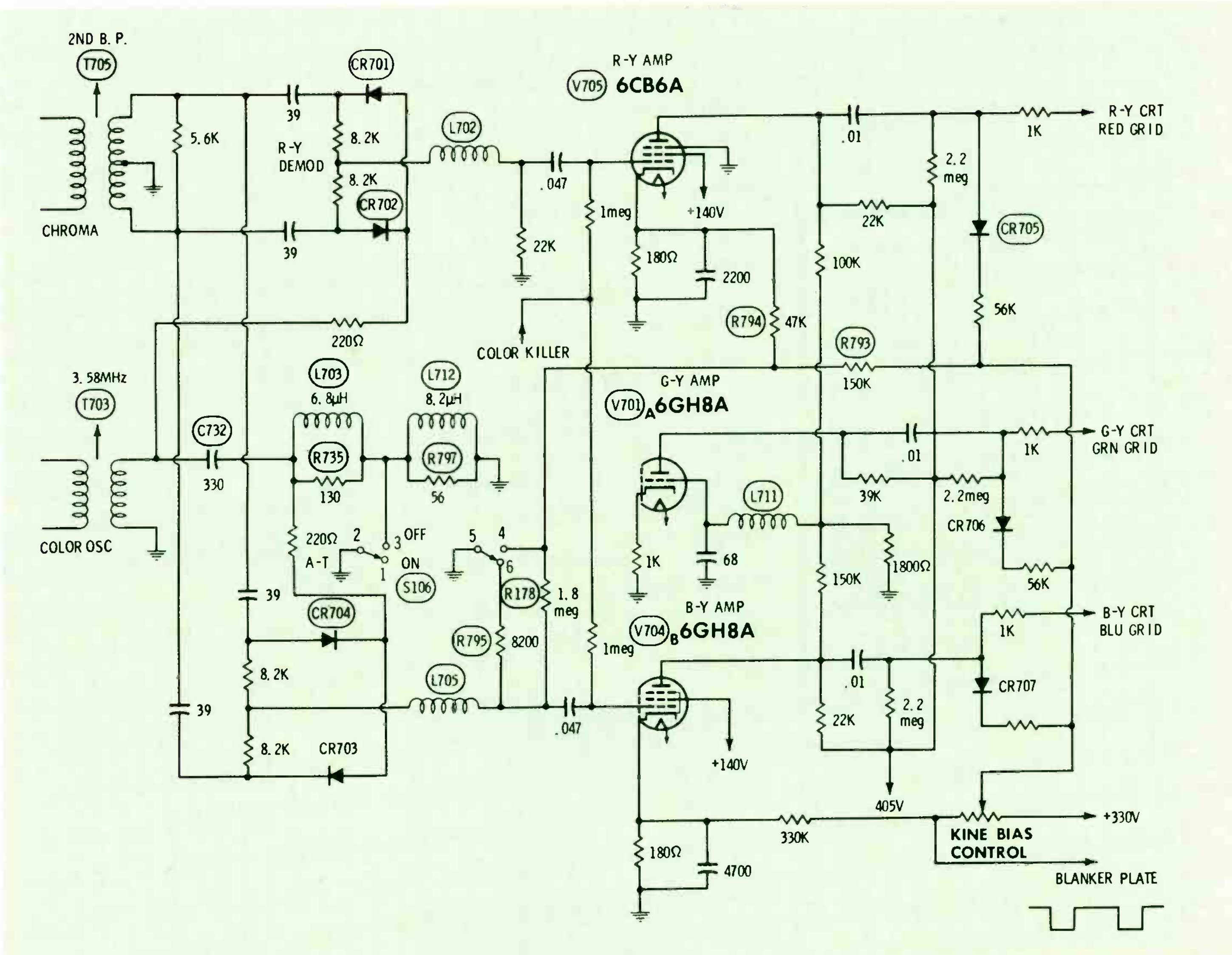


Fig. 1 Complete schematic of the demodulators and color-difference amplifiers in the new RCA CTC39X chassis. Notice especially the circuits connected to switch S106, the Accu-Tint OFF/ON switch.

productreport

for further information on any of the following items, circle the associated number on the reader service card.

Heat Transfer Compound

A new adhesive/heat-transfer compound has been introduced by the Vigor Tool Co.

Vigor Kool-It is reported to be one part adhesive for bonding electronic components directly to metal chassis and/or a heat sink for more effective heat transfer. The Vigor Tool Co. states that it has high

thermal conduction and high electrical insulation. Air-cured Kool-It is to be used at room temperatures and will adhear to clean metal surfaces.

The price of the heat device Kool-It ranges from $5.00 per 1-oz. tube in quantities of 1 to 9, to $2.50 per 1-oz. tube in quantities over 1000.

Circle 65 on literature card

Utility Cart

A new special-purpose cart to facilitate the transporting and marking of material as it is being put into stock has been introduced by Bay Products Division of American Metals Works, Inc.

Made of heavy gauge steel, the "Easy Marking" cart comes complete with two swivel casters with side brakes and two rigid casters. The main tray is 20 in. X 28 in. X

3½-in. deep and can be reversed to make a flat top working surface. The end tray is 12 in. X 20 in. X 1½-in. deep for carrying marking or other equipment.

The list price of Model 200-7474 is $49.75.

Circle 66 on literature card

IC De-Solder Kit

A five-piece de-solder kit, designed for use on small printed-circuit boards, has been released by Ungar, Division of Eldon Industries, Inc.

The kit, designated Model #6939, contains a 3-wire grounded "Princess"® handle, an 18-watt heat capsule and three de-soldering tips.

The No. 6948 slotted IC de-soldering tip reportedly is used to

release up to 16-pin in-line IC's in one operation. Another tip is designed for use on .375-in. "TO" packages and transistors, and is stated to release all leads simultaneously. The third tip melts and straightens bent tabs and leads.

Tool assembly is modular—tips thread into the heat capsule, which threads into the handle. All parts are replaceable, and additional tips are available for flat-pack removal and other "TO" diameters.

Prices range from $14.80 each for quantities of 1-3 to $11.30 each for quantities of 12 or more.

Circle 67 on literature card

Reversing Screwdrivers

Two double-insulated "D" handle reversing screwdrivers have been introduced by Skil Corporation.

Both models reportedly are rated at 750 rpm and are equipped with 10-ft. cords terminated in 2-prong plugs. Also, they both have $\frac{7}{16}$-in. hex drives and can run $\frac{3}{8}$-in. machine screws and nuts or No. 16 wood and self-tapping screws. Each weighs approximately 8 lbs. and measures less than 16 in. in length.

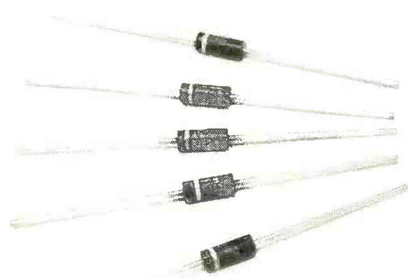
Model 444 is an adjustable clutch-reversing screwdriver, designed for precision driving of identical screws or nuts at uniform tension in materials of consistent density, according to the manufacturer. Skil also states that the clutch can be quickly and easily adjusted externally. Once the pre-set torque is reached, the clutch reportedly will ratchet. Other features include Skil's 6-amp "super burnout protected motor" with "safety stop brushes" and a 3-position auxiliary handle. Model 444 sells for $129.50.

Model 428 is a positive clutch-reversing screwdriver, reportedly designed for driving different size screws, and for jobs where torque requirements vary because of varying densities of materials. The operator maintains pressure to apply torque until the desired tightness is reached, then releases the trigger to stop the tool's action. A 6-amp "super burnout protected motor" powers the tool. The reversing lever is located above the trigger and the auxiliary handle can be positioned on either side or on top of the tool. It sells for $109.50.

Circle 68 on literature card

Universal Silicon Rectifiers

Universal 2.5- and 3.5-amp silicon rectifiers, reportedly able to replace all diodes exhibiting voltage characteristics up to 1000 volts, are available from International Rectifier's Semiconductor Division.



The 2.5-amp rectifier, No. R250F, has a 50-amp maximum surge, and is reported to be suitable for TV, radio and communications applications. The 3.5-amp rectifier, No. R350F, has a 70-amp maximum surge, and is suitable for higher-power circuits in original and replacement applications as well as for industrial circuits requiring ratings up to 1000 volts PIV.

No. R250F sells for $1.50 each, and No. R350F is priced at $1.90.

Circle 69 on literature card

Temperature-Controlled Soldering Iron

A 2½-oz., temperature-controlled soldering iron has been introduced by General Electric's Industrial Heating Department.

This 135-watt maximum output iron has a thermocouple in the tip, which reportedly maintains precise control of tip temperature, and an adjustable set-point circuit that provides full-power response to load in seconds. It operates in the 100- to 1000-degrees (F) range.

Tip temperatures are maintained within closely defined limits by the controller and the built-in tip thermocouple, according to the manufacturer. When the desired temperature is reached, the controller maintains it by cycling power to the tip as required. As the tip is ap-

Circle 33 on literature card

Circle 29 on literature card

plied to cold work, the thermocouple instantly responds by applying full power. The tip continues to receive pulses of power to maintain it at or near the pre-set temperature. The control eliminates high tip operating and idling temperatures, thereby reducing tip replacement cost.

The complete unit consists of a small, balanced handle and cord set, tip, heater unit and controller. The controller measures 4 inches X 7½ inches X 5½ inches and chisel tips are available in either ⅛-inch or 3/16-inch widths.

The temperature-controlled soldering iron sells for $149.50.

Circle 70 on literature card

CRT Isolation/Brighteners

Isolation and isolation/boost brighteners are now available from the Telematic Division of the U.X.L. Corp.

The 2-1 color picture tube brighteners have a switch which can be set to either the "Normal" position for isolation or the "Boost" position for isolation with boost. Also featured is an oversized transformer for long life and cooler operation.

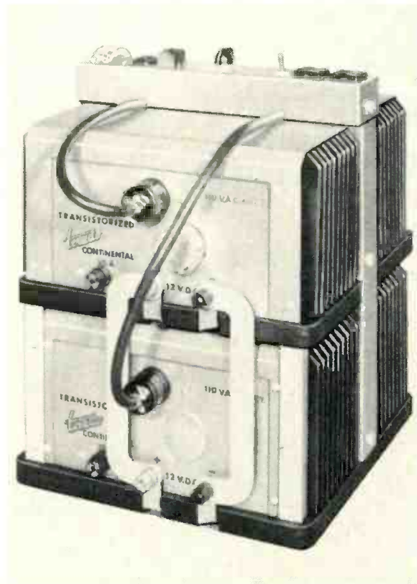
Two models are available—Model CR-300 for 70-degree tubes, and Model CR-350 for 90-degree tubes. Both models sell for $7.45 each.

Circle 71 on literature card

High-Power Inverter

A new high-power inverter for the operation of 117-volt 60-Hz AC equipment has been introduced by the Terado Corp.

The Quad-Continental inverter, Model 50-110, which has a 1000- to 1200-watt capacitance, changes standard 12-volt DC battery to 117-volt 60-Hz regular power while reportedly maintaining frequency within ¼ Hz, regardless of the input voltage on the load. It is completely filtered for operation of sound equipment and comes complete with control harness, solid-



state circuitry and uniform forced-air cooling.

The inverter weighs 120 lbs., measures 15 inches X 12 inches X 12 inches, and sells for $869.95. ▲

Circle 72 on literature card

Check "Index to Advertisers" for additional information.

catalogs literature

ANTENNAS

100. *Winegard Co.* — has released two new catalogs: Catalog #107 features commercial systems equipment for MATV, CCTV, ITV, ETV, CATV and NATV installations; and revised Catalog #710, a 32-page booklet, illustrates and describes Winegard's entire line of over 100 TV/FM outdoor and indoor antenna models and over 200 electronic products for home and commercial systems.

AUDIO

101. *Nortronics Company, Inc.* — has announced publication of a reference guide, which shows all the configurations and dimensions generally used for 1/4-inch tape and casette (.150-inch) formats, as well as Studio Series configurations for 1/2-inch tape, 1-inch tape and 2-inch tape. Also included are model numbers for the Nortronics recording heads applicable to each configuration.

102. *Stanford International* — is offering a booklet on the fundamentals of microphones, including characteristics of each type.

HARDWARE

103. *Birnbach Co.* — announces Catalog No. 2570, a 24-page, illustrated booklet covering their line of wire, cable, tubing and hardware.

SERVICE AIDS

104. *Chemtronics Inc.* — has made available two new illustrated booklets: "TUN-O-FOAM TECH TIPS" explains possible uses for TUN-O-FOAM spray lubricant/cleaner; and "HOW TO SPEED SERVICING WITH TUN-O-WASH" covers the use of this aerosol cleaner/degreaser.*

SPECIAL EQUIPMENT

105. *Bourns Security Systems, Inc.* — has issued a 4-page product brochure containing applications, features and specifications on their complete line of ultrasonic intrusion alarm equipment.

106. *Caddylak Systems, Inc.* — is making available a 16-page catalog featuring their line of magnetic visual control boards used for scheduling operations.

TECHNICAL PUBLICATIONS

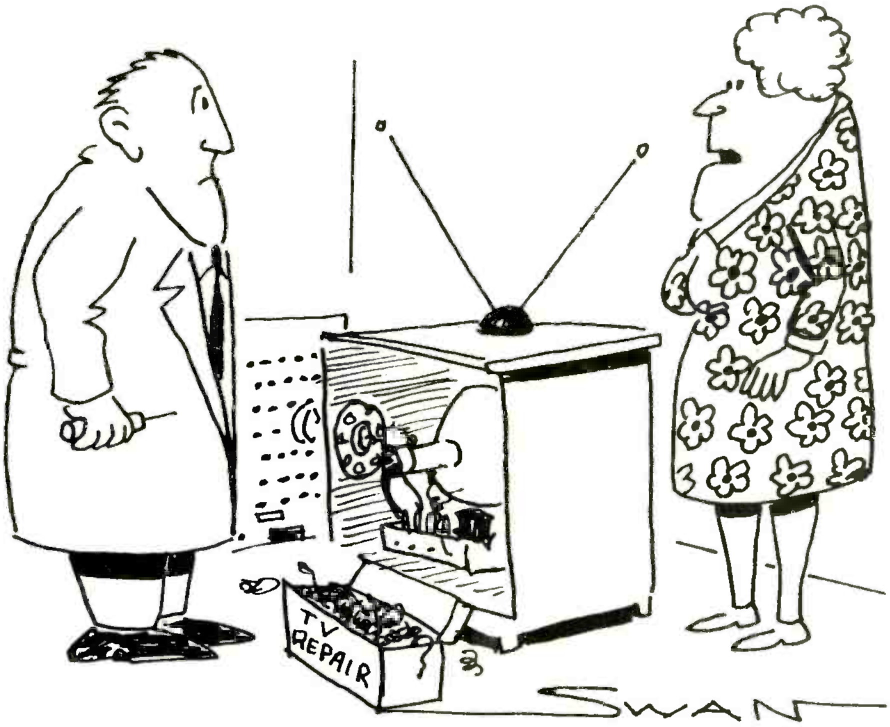
107. *Howard W. Sams & Co., Inc.* — literature describes popular and informative publications on radio and television servicing, communication, audio, hi-fi and industrial electronics, including their 1970 catalog of technical books on every phase of electronics.

108. *Sylvania Electric Products Inc., Sylvania Electronic Components Div.*—has published the 14th edition of its technical manual, which includes mechanical and electrical ratings for receiving tubes, television picture tubes and solid-state devices. The price of this manual is $1.90.*

TEST EQUIPMENT

109. *Sencore, Inc.* — has issued its 12-page 1970 catalog, Form No. 517, which describes the company's complete line of test instruments and features 5 new instruments, with performance data and prices included.*

*Check "Index to Advertisers" for additional information. ▲



"Well, how much will it cost to **lengthen** the circuit?"

advertisers' index

The brilliance of our new color replacement tube is matched only by the sharpness of its pictures

RCA MATRIX

Now it's easier to sell up to the best. RCA has added brightness without sacrificing sharpness!

Here's how and why:

To produce the brightest color picture tube in RCA's history, we developed a new phosphor-dot screening process that incorporates a jet-black matrix. But we didn't stop there. We wanted a tube that could deliver sharp, vivid pictures even in strong room light. So, we added the brilliance of new phosphors and deposited each red, green and blue phosphor-dot within the black matrix. Result: brighter pictures with no loss of contrast. Thanks to the matrix technique, combined with our new high resolution gun and greatly improved phosphors, the Matrix is also the *sharpest* color picture tube in RCA's history. Matrix owners can turn up brightness *without* "turning down" color!

Will your customers see the difference? You bet! What's more, they'll be pre-sold on the difference—every time they see the 1970 big-screen color sets people are talking about! So when they need a replacement tube, satisfy their appetite for brighter, sharper pictures. Give their sets new brilliance and more vividly detailed pictures with RCA Matrix. The Matrix Tube is 100% brighter than any previous color picture tube manufactured by RCA.

For complete details, call your RCA Distributor.

RCA Electronic Components, Harrison, New Jersey

RCA

The RCA 25BCP22 Matrix Tube can directly replace 25XP22, 25BAP22 and also the following types: 25ABP22, 25AFP22, 25ANP22, 25AP22, 25AP22A, 25AQP22, 25BMP22, 25CP22, 25CP22A, 25GP22, 25GP22A, 25SP22, 25WP22, 25XP22/25AP22A and 25ZP22.