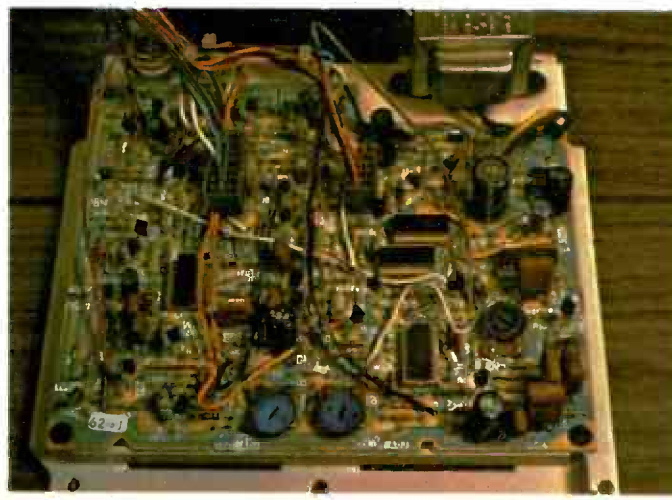
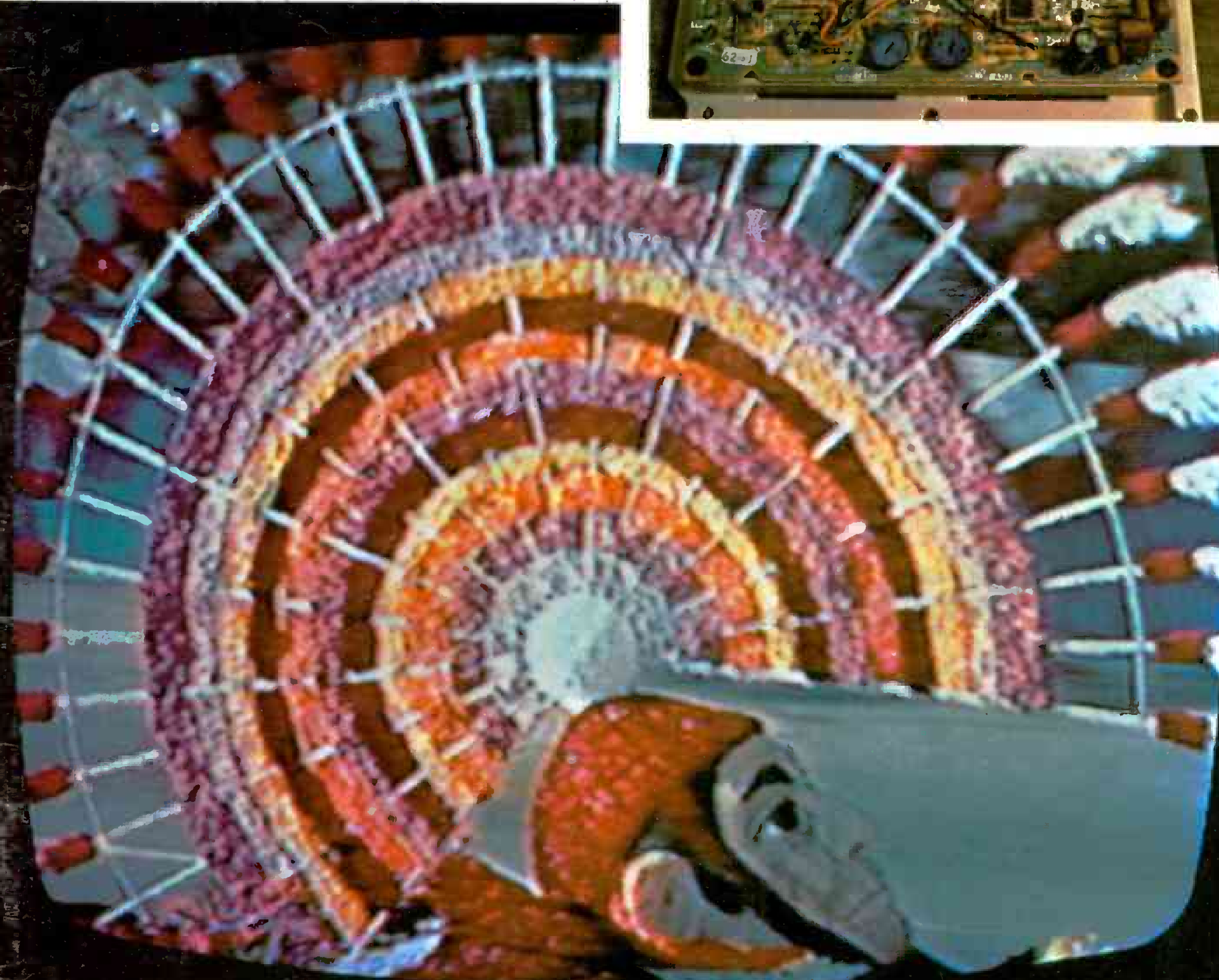
March, 1977 ☐ 75 cents

Electronic Servicing

A HOWARD W. SAMS PUBLICATION

VIR-CONTROLLED COLOR





PLL—New Brain for CB

Convergence Facts and Tips

March, 1977 ☐ Volume 27, No. 3

Electronic Servicing®

in this issue...

ABOUT THE COVER

This picture, photographed from the screen of a color-TV receiver, illustrates the operation of the General Electric module (see inset picture) which automatically corrects the color and tint according to the condition of the VIR signal.

DEPARTMENTS

Second class postage paid at Shawnee Mission, Kansas and additional mailing offices. Published monthly at 9221 Quivira Road, Overland Park, Kansas 66212 by Intertec Publishing Corp., 9221 Quivira Road, Overland Park, Kansas 66212. Send Form 3579 to 9221 Quivira Road, P.O. Box 12901, Overland Park, Kansas 66212.

Electronic Servicing

Editorial, advertising and circulation correspondence should be addressed to: 9221 Quivira Road, P.O. Box 12901, Overland Park, Kansas 66212 (a suburb of Kansas City, Missouri). (913) 888-4664.

ELECTRONIC SERVICING (with which is combined PF Reporter) is published monthly by Intertec Publishing Corp., 9221 Quivira Road, Overland Park, KS 66212.

ELECTRONIC SERVICING is edited for technicians who repair home-entertainment electronic equipment (such as TV, radio, tape, stereo, and record player), and for industrial technicians who repair defective production-line merchandise, test equipment, or industrial controls in factories.

Subscription Prices: 1 year—$6.00, 2 years—$10.00, 3 years—$13.00, in the U.S.A. and its possessions. All other foreign countries: 1 year—$7.00, 2 years—$12.00, 3 years—$16.00. Single copy 75 cents; back copies $1. Adjustment necessitated by subscription termination to single copy rate. Allow 4-6 weeks delivery for change of address. Allow 2-3 weeks for new subscriptions.

INTERTEC PUBLISHING CORP.
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electronic**scanner**

news of the industry

The first legal sale of a 40-channel CB radio in the United States was credited to Chick Whitfield, owner of the Radio Shack dealership in Tamuning, Guam. On January 1, 1977 at 12:01 A.M. (13 hours before midnight in the continental United States) Whitfield sold the first Realistic 40-channel model CB to Fritz Heiss. The event took place at a New Year's Eve party.

GTE Sylvania has received a contract from the US Army to explore applications for fiber-optics technology in future electronic communications equipment. A team of specialists is studying how hair-thin strands of glass called optical fibers can replace conventional cable and copper wire in tactical defense communications systems. Optical fibers are particularly well suited for defense communications, because of their immunity to electromagnetic interference.

The RCA Service Company recently began a new consumer program to increase customer satisfaction with television set repairs, by making certain that service is provided on the day promised. "When we make a date to visit a customer's home, we'll keep that date. If we fail to keep it, the customer will pay no labor charge," says Sigmund Schotz, Vice President of Consumer Affairs.

Many television manufacturers are "looking at, but keeping away from" video games, according to **Retailing Home Furnishings.** It is feared that building simpler nonprogrammable games into sets will result in immediate obsolescence because of the rapid production of new video games.

Increased federal regulation must be used to prevent self-destruction of the consumer-electronics industry, according to statements of Raymond Spence, Jr. (chief engineer of the FCC), which were quoted in **Retailing Home Furnishings.** Many new products radiate signals. Examples are radio-controlled toys, light bulbs of higher efficiency, and video games. Also, the radiation specs of TV receivers and CB radios might require tightening to minimize the RF pollution. Here at ELECTRONIC SERVICING, we are receiving more reports of CB stations being heard on stereo systems and electronic organs, so these concerns about RF interference seem to be justified.

Television sets with permanent VHF antennas must also have permanent UHF antennas as of January 1, 1978. According to the **Wall Street Journal,** the FCC acted on this ruling in answer to complaints from UHF broadcasters who claim they are placed at a disadvantage. Manufacturers usually ship loose UHF antennas with the set, but if the buyer fails to attach it, UHF channels will not be received.

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Johnson Educational Training Packages (JET PACS) are available for in-home or in-shop training on E. F. Johnson CB and two-way communication radios. The JET PACS, costing about $25 each, come in a variety of audio-visual formats, including film strips with tape cassettes, 3M soundpage 35-MM slides with synchronized audio, and video tape with sound. The subject matter includes circuit analysis, alignment procedures, product familiarization, and digital synthesis. For more information, contact Daryl J. Thompson, E. F. Johnson Technical Education Center, Waseca, Minnesota 56093.

Forest Belt illustrates a point at his first CB Training Workshop in Indianapolis, where he introduced the new **Easi-Way™** Servicing Method. A dozen more Workshops are scheduled around the country during 1977, ending with a two-week combination vacation and seminar in Hawaii! For details, write to Forest at Box 68120, Indianapolis, Indiana 46268.

Sony Corporation of America has announced a new schedule of National Video Production Workshops. Seven workshops are scheduled for video users in business, industry, education, government, and medicine. Additional information on the availability and costs of the services can be obtained from Jeff Glasser at Sony, 700 West Artesia Boulevard, Compton, California 90220.

Raytheon has completed the acquisition of Switchcraft, whose 1976 sales totalled $27 million. Switchcraft manufactures switches, jacks and plugs, audio connectors, and related equipment. The company will be operated as a wholly-owned subsidiary of Raytheon.

A tiny Micro Switch solid-state sensor now used in 1977 Oldsmobile Toronados improves both gas mileage and performance. The Delco Remy Division of General Motors developed the sensor for Honeywell. At the heart of the pressure transducer is a sensor chip of 0.110-inch size. Pressure changes inside the intake manifold of the engine flex the thin membrane of the sensor chip, causing the embedded resistors to change value. Other circuitry changes the resistance variation into a varying voltage, which through the microprocessor adjusts the firing of the spark plugs. It's said that the sensor operation increases the gas mileage by about 1.3 mpg and gives cleaner combustion for less pollution.

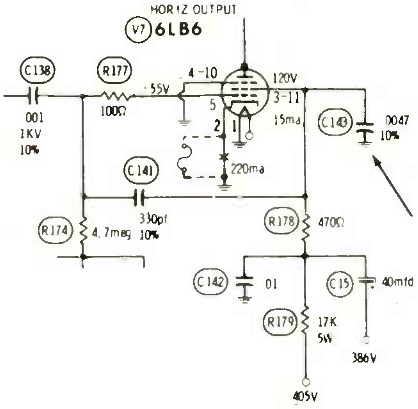
troubleshooting tips

Send in your helpful tips—we pay!

No Raster, no HV
Zenith Chassis 12A12C52
(Photofact 1120-3)

For the first test, I used my B&K Model 1077B Analyst to supply plate drive to the flyback, and found the raster and HV were restored. Next, the DC voltage at the control grid of the horizontal-output tube was measured and found to be within tolerance. From this, I assumed the horizontal oscillator was working okay.

My conclusion was that the trouble must be in the wiring or components of the horizontal-output tube, since the circuit appeared to be normal on both sides.



Finally, I checked the DC voltage at the screen grid (should be 120 volts), but found only about 25 volts. I tried three separate output tubes, but with no change of symptoms. However, an ohmmeter test showed only about 1,000 ohms from the screen (pins 3 and 11) to ground. Of course, that's much too low. I removed the output tube from its socket, and short was gone.

Although I didn't really understand the full implications of that last test, I tried to find the short by disconnecting all of the components from the screen grid pins, while monitoring the voltage at the screen. The voltage did not rise properly until I disconnected **C297**. Yes, **the capacitor checked very leaky.**

The thing that fooled me was that C141 and R178 were soldered to pin 3, while C297 connects to pin 11. I was checking the DC voltage at pin 3, so the internal jumper of the tube showed a short with the tube in socket, but no short with the tube removed.

The moral is to watch out for internal jumpers in the tubes.

Richard Sanderford, CET
Raleigh, North Carolina

Dean Johnson and Pete Childers,
Joliet, Ill.

Ben Hyek,
Edna, Texas.

John Buckner,
Lyndon, Ky.

Vic Hyek,
Nada, Texas.

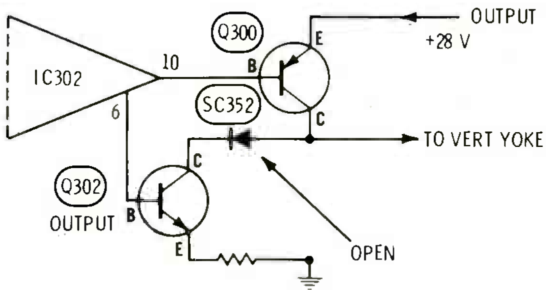
Bill Hughes,
Niceville, Florida.

Andy Winters,
and Don Boogar,
Palmyra, New Jersey.

symcure

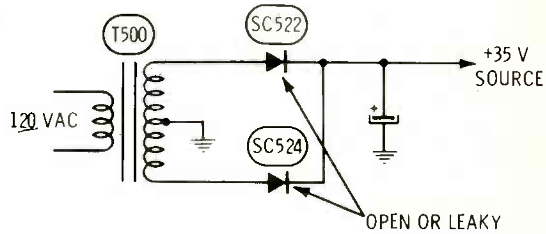
Symptoms and cures compiled from field reports of recurring troubles

Chassis—Sylvania E08
PHOTOFACT—1481-2



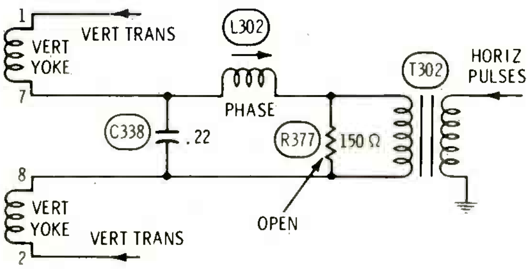
Symptom—Drive to IC302 okay, but no vertical sweep
Cure—Check diode SC352, and replace it if open

Chassis—Sylvania E10
PHOTOFACT—1477-3



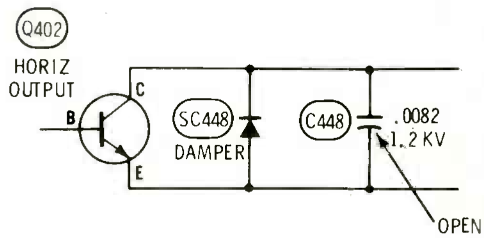
Symptom—Single hum bar in picture
Cure—Check SC522 and SC524, and replace them if leaky or open

Chassis—Sylvania E02
PHOTOFACT—1324-3



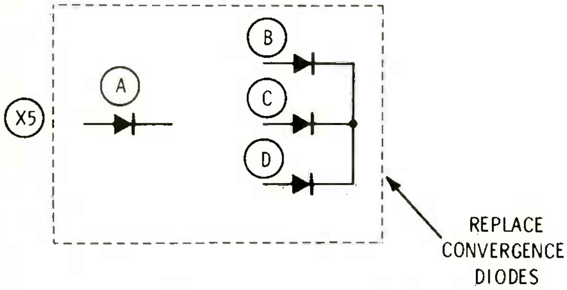
Symptom—Excessive height near center of picture
Cure—Check R377, and replace it if open or increased

Chassis—Sylvania E06, etc.
PHOTOFACT—1432-3



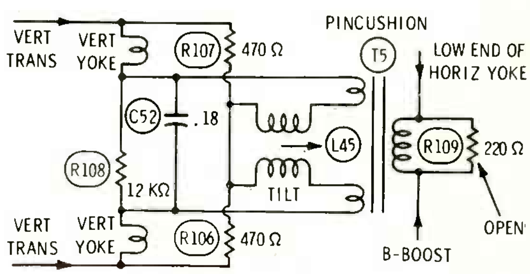
Symptom—HV arcing, or excessive HV
Cure—Check C448, and replace it if open (part #45-33037-13)

Chassis—Sylvania D05
PHOTOFACT—905-3



Symptom—Erratic height, or bottom foldover
Cure—Replace assembly of diodes on the convergence board

Chassis—Sylvania D06
PHOTOFACT—1072-2



Symptom—Rounded vertical bars at left edge of picture
Cure—Check R109, and replace it if open or increased

reader's exchange

There is no charge for listing in *Reader's Exchange*, but we reserve the right to edit all copy. If you can help with a request, write direct to the reader, *not to Electronic Servicing*.

Needed: *Service manuals for electronic organs, all makes and models. Quote price, and conditions of sale.*

Bill Cushing
630 NW 11th Avenue
Boca Raton, Florida 33432

Needed: *Schematic and/or service manual for Sencore CG10 color bar generator. Will buy, or copy and return.*

Lloyd Stoops
RT 3 Box 127-B
Foxworth, Mississippi 39483

Needed: *Schematic or owner's manual for RCA six-band radio. Model RLM-77A, Serial #80550012.*

John Brouzakis
RD 2 Box 602B
Charleroi, Pennsylvania 15022

Needed: *For my antique-radio library: old text books; old Rider, Gernsback, Supreme, and factory manuals; magazines from the '20's and '30's. Please describe what you have and price wanted.*

Lawrence Beitman
1760 Balsam Road
Highland Park, Illinois 60035

Needed: *Two 6N6G tubes; also Sentinel radio Model 344, part number 35E34-pointer.*

K. W. Hamilton
Route #1 Box 66-3
Friendly, West Virginia 26146

Needed: *"Electronic Organs, Volume 2" written by Norman Crowhurst, Sams book number 20754, now out of print.*

M. W. Scheldorf
835 First Avenue, Box 84
Marseilles, Illinois 61341

For Sale: *Back issues of Electronic Servicing from 1970 to present, 20 cents per copy, or 10 cents per copy for all.*

Louis J. Kozelsky
115 Iroquois Lane
Liverpool, New York 13088

Needed: *E. H. Scott radios, parts and literature. Would like correspondence with owners.*

Robert Fabris
3626 Morrie Drive
San Jose, California 95127

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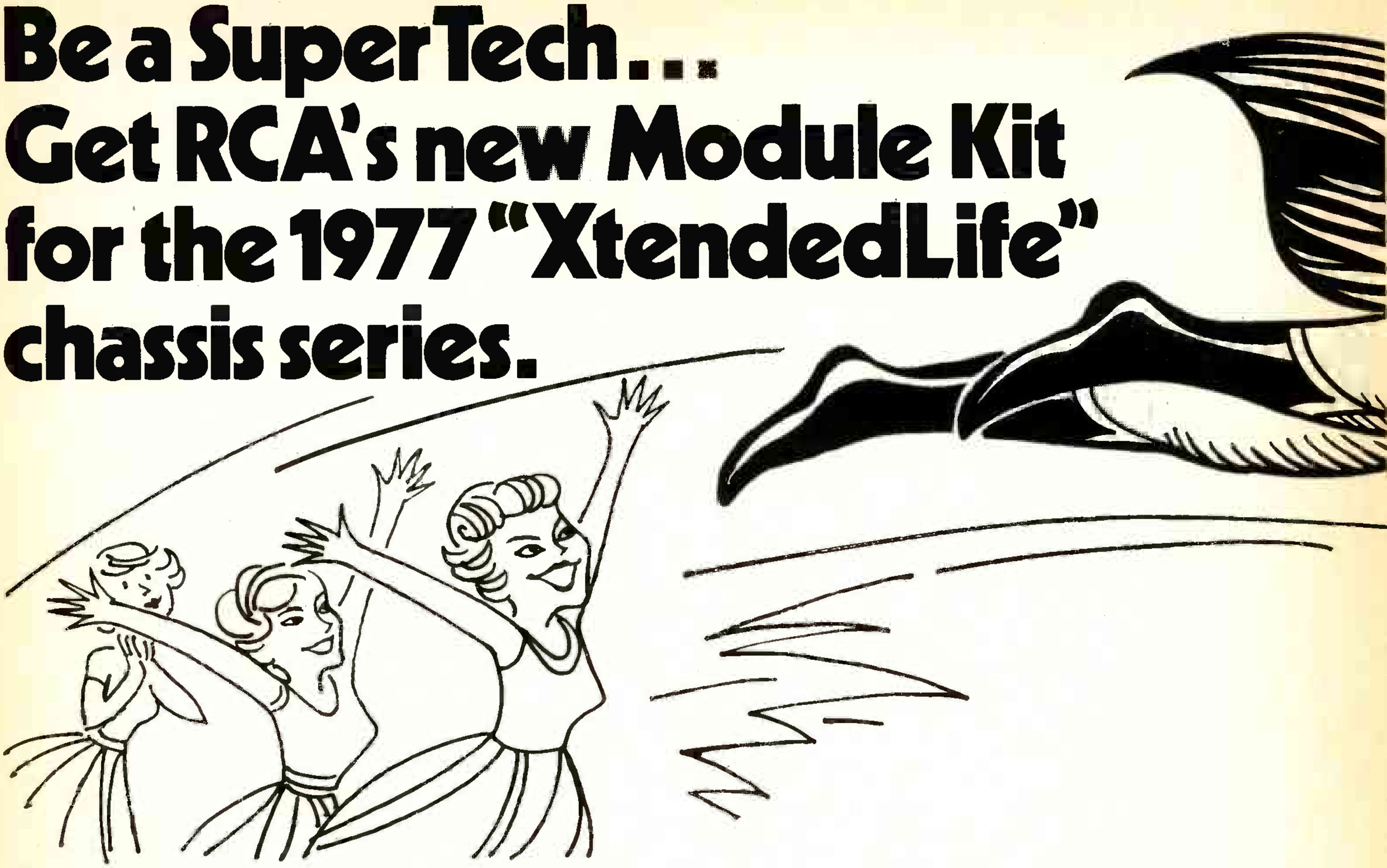


Readers' Exchange continued from page 15

Needed: *A good, used 440MB4 B&W CRT. Also, a source for other used CRT's.*
M. B. Danish
Mike's Repair Service
P.O. Box 217
Aberdeen Proving Ground,
Maryland 21005

Needed: *Schematic for Dumont stereo Model 511, Series B.*
E. W. Dennis
3830 Bernard Place
Columbus, Ohio 43224

Needed: *189-KHz crystal, plug-in type for a Precision color-bar generator, Model E-450.*
E. W. Dennis
3830 Bernard Place
Columbus, Ohio 43224

Needed: *Schematic for Shield VOM, TE-97. Will buy, or copy and return.*
William B. David
209 Fir Avenue
Montgomery, Minnesota 56069

Needed: *Horizontal-output transformer for a Waltham portable color TV, Model CP15W. Part can be new or used, but good.*
Maurice M. Bolin
2315 El Toro Circle
Hemet, California 92343

For Sale: *Most issues of Electronic Servicing and Radio-Electronics for the past 25 years. Any reasonable offer.*
Paul Smith
44 West Drive
New York Mills, New York 13417

Needed: *A schematic of Stromberg-Carlson AU-29 amplifier. Will buy, or copy and return.*
Martin H. Cecil
5305 Sheffield Drive
Owensboro, Kentucky 42301

For Sale: *Two B&K 1076 analysts, $150 each; RCA audio signal generator WA44B, $25; RCA RF signal generator WR49B, $25; Eico 460 scope, $75; Eico 324 VTVM (new probe), $50; and B&K 360 VOM, $25. Most equipment with cables and manuals.*
Duane M. Gage
Box 202
No. Truro, Massachusetts 02652

Trade: *One manual for S-54 and S-54/AR telequipment scopes to trade for an S-52 manual. Or, send price for S-52 manual.*

R. P. Frohwerk
TV Industries
4330 SE Woodward Street
Portland, Oregon 97206

Trade: *B&K Model 415 solid state sweep/marker generator for B&K Model 1077B television analyst.*

Ronald Olcott
7616-4 Sewells Pt. Rd.
Norfolk, Virginia 23513

For Sale: *RCA Model WO535A DC-10 MHz scope, $185. Lectrotech Model TO 50-MHz triggered sweep scope, $195.*

Ronald Olcott
7616-4 Sewells Pt. Rd.
Norfolk, Virginia 23513

Needed: *Schematic and alignment information for Knight Kit, Model #83Y102000 radio receiver. Will pay reasonable price.*

Herbert Naugle
1792 Finch Court
Hayward, California 94545

Needed: *A complete set of original manufacturer's test leads in new condition for an RCA Model WV-97A.*

Paul Capito
637 West 21 Street
Erie, Pennsylvania 16502

Needed: *Schematic for a Curtis Mathis B&W TV Model 55M 2733.*

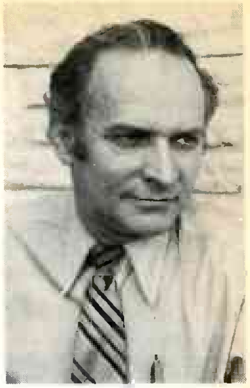
Peter J. Golumbus
64 Coolidge Street
Irvington, New Jersey 07111

For Sale or Trade: *PF Reporter and Electronic Servicing 1963 to 1977 for Sencore sweep-marker generator, Model SM-152.*

Steve Topley
145 Quarry Street
Mt. Pleasant, Pennsylvania 15666

Needed: *Manual (or copy) for MITS sweep marker MG-1K.*

M. W. Scheldorf
835 First Avenue Box 84
Marseilles, Illinois 61341



Servicing GE Modular Color TV

Part 7/By Gill Grieshaber, CET

VIR-Controlled Color

The editor strongly suggests you carefully study these articles about the new General Electric system of automatic color that's controlled by the condition of the VIR signal from the station. Not only is it a unique circuit that all technicians need to understand for purposes of servicing, but also it is the forerunner of many other digital circuits. We need to understand practical digital circuits, and how to troubleshoot them. This first article covers the counter for identification of Line 19, where the VIR signal occurs, and the so-called "slicers" that produce the keying pulses of the correct width and phase.

Stampede For The Vertical-Retrace Space

Of the 525 horizontal-scanning lines, just 504 have video, and the remaining 21 lines originally had nothing by vertical-sync pulses in this barren area set aside for vertical blanking and retrace. But only 9 lines are needed for the vertical sync of each field, leaving 12 empty lines. Lately, the trend is toward filling these lines.

A few years ago, an observant TV technician might have noticed some strange dots and lines just above the top of the picture (see Figure 1). On the face of a picture tube, these shapes are without meaning, for they are intended for viewing on special oscilloscopes. Figure 2 shows three different kinds of Vertical-Interval Test Signals (VITS), which at first were on lines 18 and 19 of each field. The patterns were selected to show any video defects (such as poor frequency response, ringing or poor transient response, and variations of amplitude linearity) occurring in the network lines. Similar patterns still are used today, but they have moved to lines 17 and 18. TV stations operating by remote control must use VITS to check the operation of the Studio-Transmitter Link (STL). Other uses are optional.

Another VITS blinks one time per second; I don't know its purpose. Also, serious proposals have been made to reserve other lines for subcaptions for deaf TV watchers. Yes, the retrace time is getting to be very busy. But the most important of these to the viewer is the Vertical-Interval Reference signal (VIR signal).

This VIR signal is very simple (see Figure 3), but it is intended to evaluate color quality only, and does not duplicate or replace the VITS.

In practice, the VIR signal is added to the program video immediately following the point in the originating equipment where the color parameters have been established. Then, the VIR remains with the program, through network lines, video-tape recorders, studio, and TV transmitter. It is never blanked out, as the VITS frequently is. At many stages of the system, the VIR can be observed on special scopes, and corrections made as necessary. In fact, equipment is now available that makes several corrections automatically at the TV transmitter, and shows by meter readout the extent of those corrections!

Perfection?

According to these facts, few or no color level or tint adjustments should be made at each individual TV receiver. Unfortunately, the VIR signal is not mandatory yet. Some programs have it; others do not.

continued on page 20

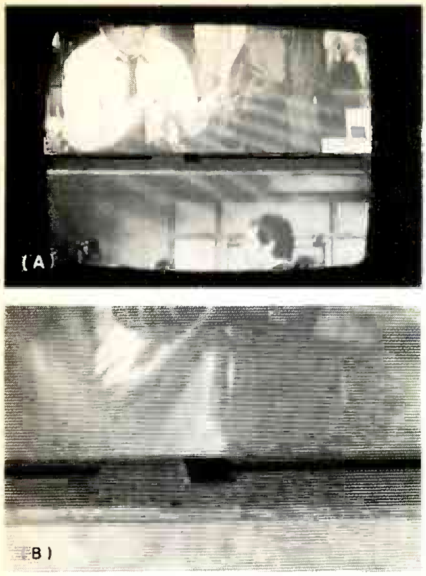


Fig. 1 Although the VITS and VIR signals can be seen at the top of a picture when you reduce the height, the only way to see the entire vertical-retrace area is to slowly roll the picture downward, with the brightness high and the contrast low. **(A)** The broad horizontal bar across the center is the 21 lines of the retrace period, including the black "hammer" (vertical equalizing and sync pulses), and the narrow white lines of the VITS and VIR signals down near the start of the picture. **(B)** This is a closeup of the hammer area. The hammer is useful for analyzing compression or poor vertical sync, but the VITS and VIR signals can't be analyzed profitably from the picture tube; they are intended for scope viewing.

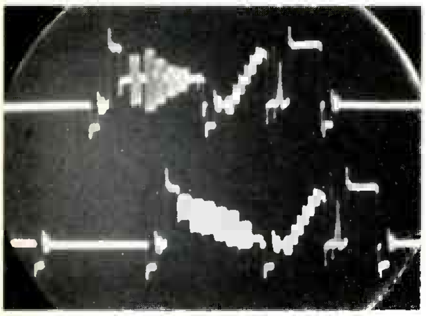


Fig. 2 Here is one of the best pictures I have made of the ABC network VITS waveforms, before the start of the VIR test signal. When a service-type triggered scope is used, the brightness is so low (only 6 lines out of 525 are shown on the screen) that analysis is difficult. (Broadcasting stations have specialized scopes which are better for this job.) Also, the roll-off of the receiver IF curve automatically reduces the high-frequency bursts of signal, as well as reducing the burst amplitude to 50% of what it is at the broadcasting station. These limitations prevent a scope analysis of receiver VITS and VIR signals from being very helpful.

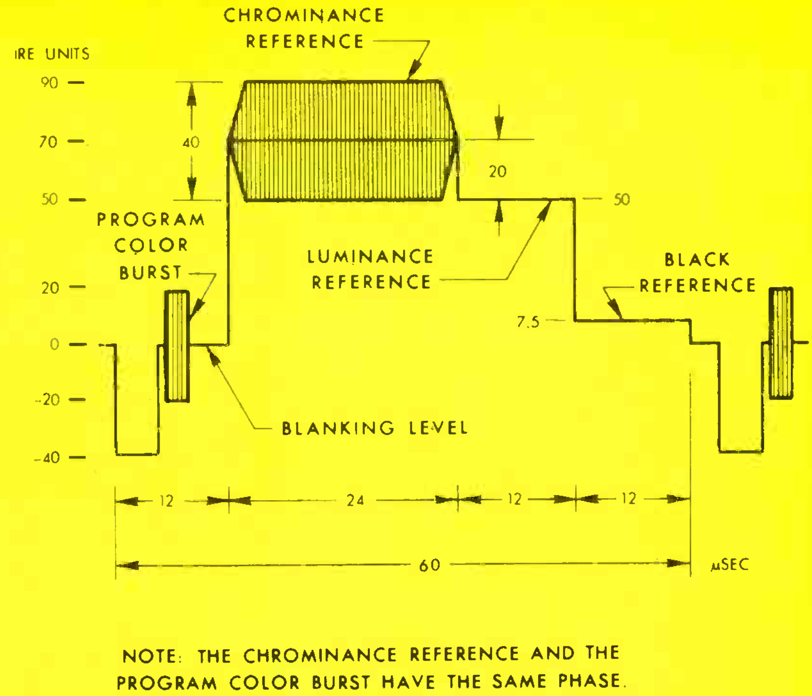
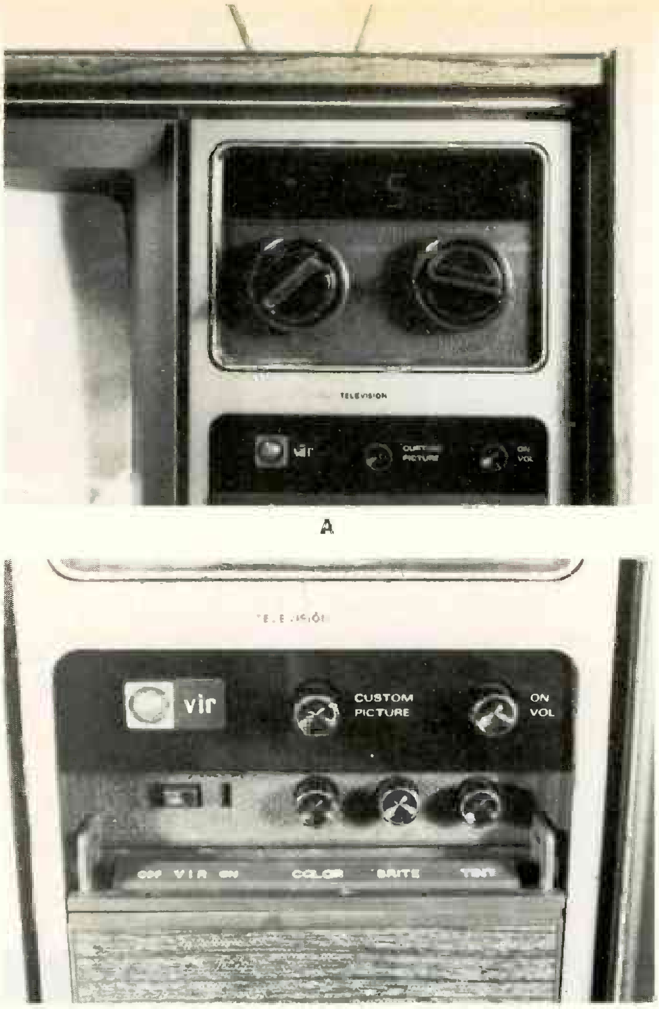


Fig. 3 The Vertical-Interval Reference (VIR) signal was designed to evaluate color TV parameters, only. Both the burst and the chrominance reference portions have the same frequency and phase. That's why the left half of the VIR line in the TV picture is greenish-yellow in color.

Fig. 4 Outwardly, a General Electric color portable appears similar to other new-generation modular TV receivers. The picture quality of our sample was excellent.



A

B

Fig. 5 Both VHF and UHF tuners share the digital channel readout. When the door over the seldom-used controls is closed, only the VIR LED light, a "custom picture" (combination color and contrast) knob, and the on/off knob can be seen **(A)**. An open door **(B)** reveals an on/off sliding switch for the VIR function, a brightness knob, plus manual color and tint knobs.

VIR

continued from page 18

And this brings us to the need for a unit in TV receivers that can correct color and tint by analyzing the VIR signal (which was intended for station use).

Just now, only General Electric has such a unit. The feature is called "VIR Broadcast-Controlled Color" and it is available in certain GE receivers using the YM and YC-2 color chassis. Although GE has an excellent training manual covering the VIR circuitry, we will present a slightly different viewpoint, based in part on my own measurements and scope patterns.

Digital circuitry is used extensively; however, you should not find it too difficult to understand. Even if you don't intend to service sets that have the VIR circuitry, the circuit analysis can serve as good practice for the digital circuits (such as digital video, etc.) to come.

General Electric With VIR Circuits

The picture of a GE 19-inch color TV receiver in Figure 4 does not seem to be very unusual. But if you look more closely, you find a VIR LED light, and an on/off switch for VIR (Figure 5).

When a color broadcast lights the LED a brilliant red, and the VIR switch is moved to "on", the color and tint controls under the door have no effect on the picture, when you turn them. Instead, the VIR signal on video Line 19 controls the color level and tint, subject to a minor amount of variation possible if you adjust the "color preference" controls that are located on the cabinet back, near the top. When the program has no VIR signal, the LED is dark, and the front-panel color and tint controls operate conventionally. Of course, you can slide the VIR switch to "off", leaving the VIR light glowing, and the color can be controlled manually by the front-panel knobs.

The first time you operate one of these models, you probably will switch back and forth often, trying the response of the controls, and watching curiously to see if the VIR system actually works effectively. I must confess that I certainly did!

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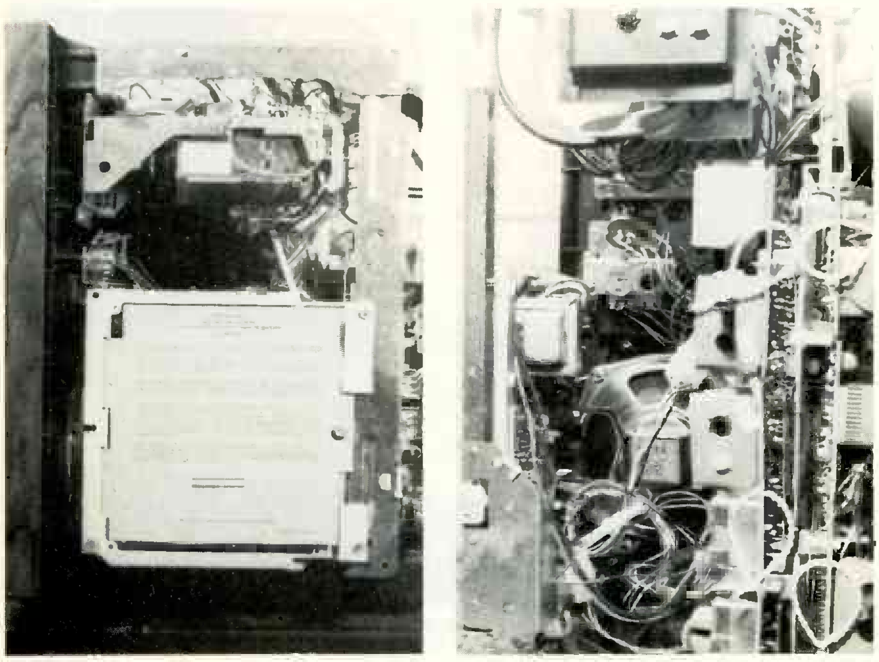

A

B

Fig. 6 A cardboard with instructions for using the VIR feature covers the VIR module **(A)** that's mounted below the tuners. Console models have the VIR module mounted horizontally, under the picture tube. You can see part of the VIR module **(B)** by looking to the left of the IF module.

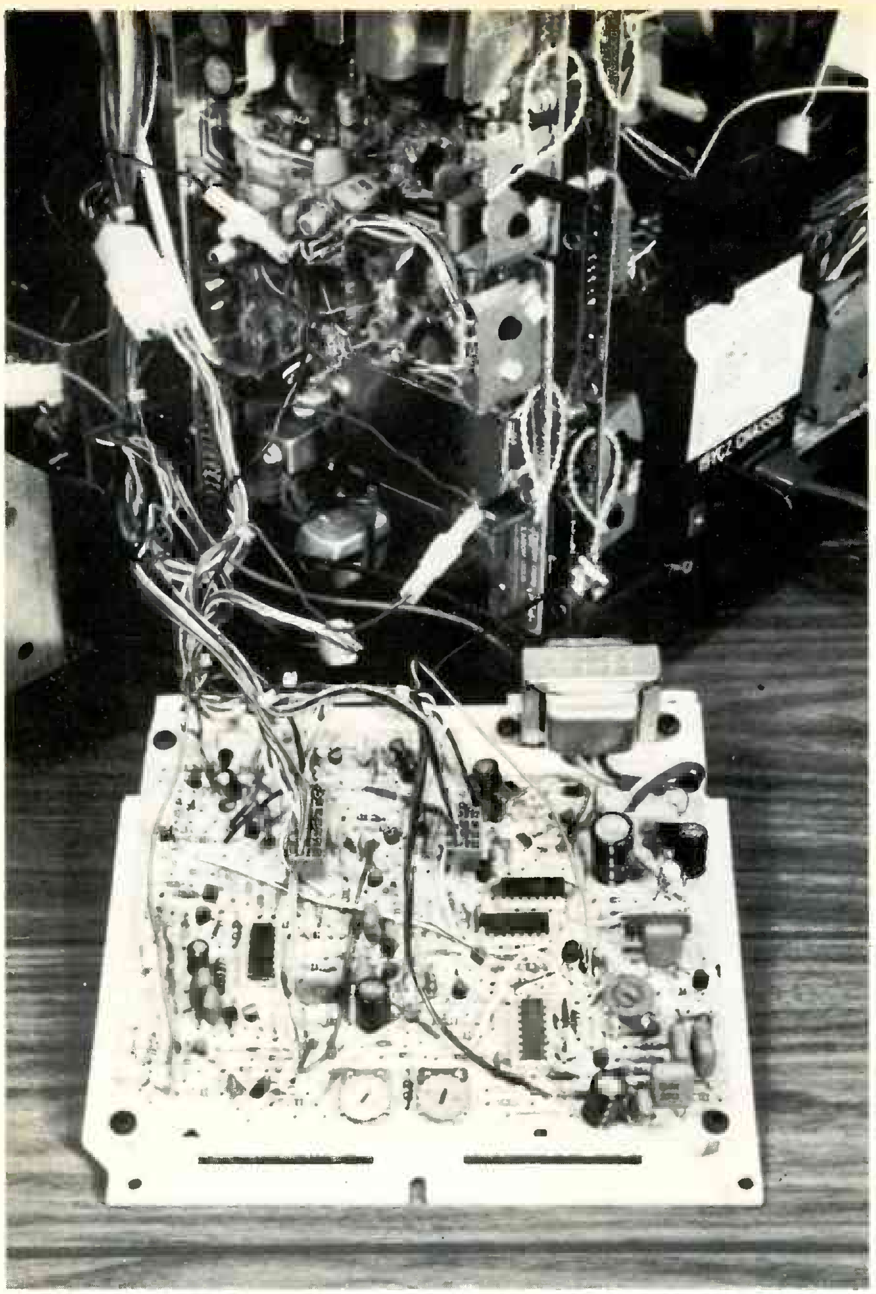

Fig. 7 Wires to the many plugs and connectors are long, allowing the module to be positioned behind the main chassis, when examination or testing is needed.

VIR

continued from page 20

After the back of the receiver is removed, you might not notice immediately any striking differences from a GE YC-2 chassis without VIR. However, on the side under the tuners is a piece of cardboard (Figure 6A) which says in part: "Read before servicing. Do NOT remove this label." The notice continues by giving a short course about how to operate the VIR controls.

If you peek between the IF module and the cardboard, you can get a partial view of some kind of circuit board (Figure 6B). Remove four screws, and the module can be removed for your inspection (Figure 7).

VIR Module

The General Electric EP93X101 module for controlling color and tint from the Line-19 VIR signal has 30 transistors and 5 IC's on a circuit board that's approximately 7-inches square.

Length of the connecting wires is sufficient to permit the module to be positioned behind the chassis, where you can examine it or make tests without being cramped for space. Speaking of the wires, it's possible to operate the receiver without the VIR module. Disconnect all of the cables to the module, then connect two certain chassis plugs together. Of course, there is no automatic color action, but the manual controls operate normally. This could prevent any interruption of the customer's TV entertainment while you repair the module or obtain a replacement.

Background theory

From mathematical formulas, the GE design engineers have determined these two facts:

- When the chrominance reference and the black-level reference of the VIR signal (see Figure 3) have identical amplitudes in the R-Y signal of a color receiver, **the tint matches that of the program at the time of origination;** and
- When the amplitudes of the VIR chrominance reference and the black-level reference are equal in the blue drive signal (for example, B-Y plus Y), **the color level (saturation) conforms to the original.**

Therefore, the VIR module operates to compare those important amplitudes. When they are **not** equal, an error-correcting DC voltage is produced to change automatically the color gain or tint phase until the amplitudes are matched. Also, other circuits switch from manual to VIR control when the program contains a VIR signal.

These basic objectives seem simple, until you remember that Line 19 occurs only twice in each frame of two fields! That means the circuit has only 60 chances in every second for making any needed corrections.

Basic circuits

Circuits of the VIR module divide naturally into five basic categories:

- The first circuit starts with the vertical sync pulse of each field and counts digitally up to Line 19. That "identifies" Line 19, then slicers produce the required pulses of partial line width;
- Next, the "VIR sensor" circuit checks to determine if Line 19 has a VIR waveform or not. If yes, DC voltages switch in the color and tint comparators and turn off the

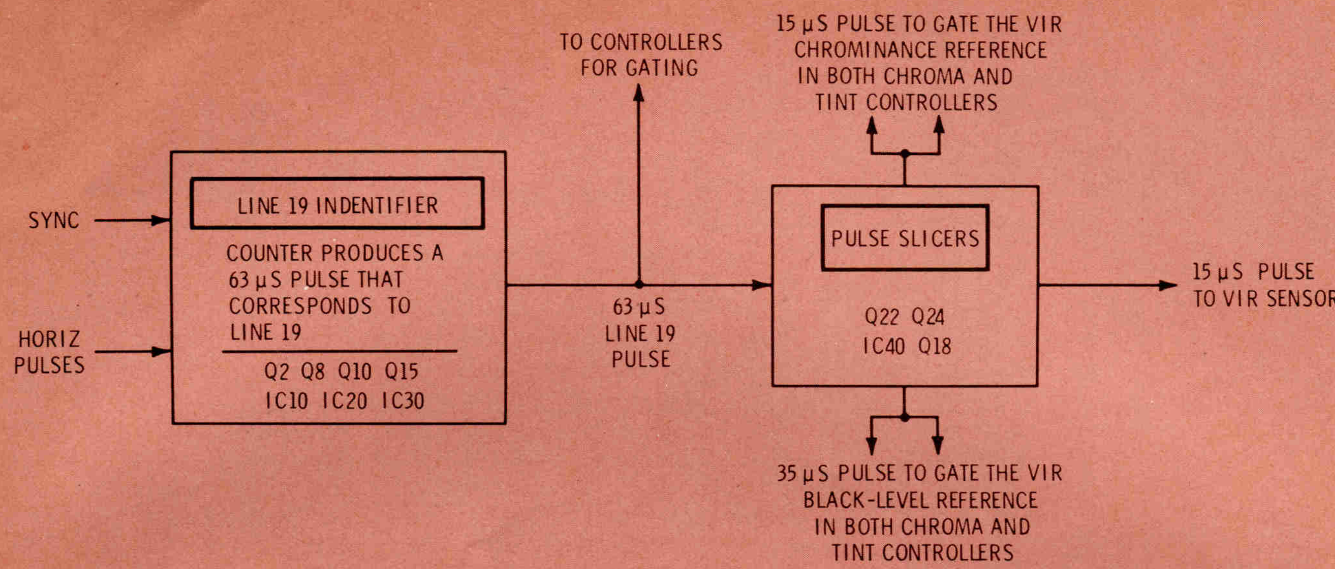

Fig. 8 The block diagram shows the stages we will examine this month. A combination of transistors and IC's, as well as both linear and digital techniques, are used throughout the VIR stages.

manual controls. If no, the DC voltages are reversed to switch on the manual controls and switch off the automatic color and tint controllers;

•In the "tint controller" section, the sliced pulses allow segments of the VIR waveform to enter a comparator at the proper time. From the amplitude comparison comes a DC voltage which determines the VIR automatic tint adjustment:

•Operation of the "color controller" is similar, but the input signal is different, and the output DC voltage determines the color level; and

•Some DC power-supply voltages come from the main chassis; others are developed by the power transformer and rectifier/filter/regulator system on the VIR module.

Of course, only the most important functions are listed here. The complete explanations show many refinements and details.

Identifier Of Line 19

Figure 8 shows a block diagram of the "Line 19 Identifier" and "Pulse Slicer" sections. Notice particularly the inputs and outputs. The identifier stages not only locate Line 19, but also they produce a 63-microsecond pulse that corresponds to the location of Line 19. (Remember that one horizontal line for color has a duration of 63.56 microseconds.)

From this pulse that has the width and location of Line 19, the slicer circuits produce 15-microsecond and 35-microsecond pulses to be used for keying-on the comparators.

Counting to line 19

Numbering of the lines of each vertical field begins with the 6 equalizing pulses that occupy lines 1, 2, and 3 just before the 6 serrations of the vertical sync pulse. This serrated vertical sync pulse (lines 4, 5, and 6) of each field is the start of the counting to Line 19. As we go through the following explanation, notice the similarity to the sync for vertical-deflection oscillators.

A complete schematic of the "Line 19 Identifier" and "Pulse Slicer" stages is in Figure 9.

Sync from the regular separator enters at R1, and goes to Q2, which is wired as an emitter follower, giving isolation and impedance matching. The incoming clipped sync has a DC component that provides the base bias of Q2. Following Q2 is a two-section integrating network (R3, C3, R4, C4) that forms a kind of triangular waveshape from the vertical sync, and this signal is passed along to Q8.

Q8 has a heavy forward bias so it operates completely saturated before the signal from the intergrator reaches the base. The negative-going vertical-sync waveform cuts off Q8's C/E current, forming a large positive-going pulse at the collector. The pulse is filtered a bit before it reaches the base of Q10. Q10 has no base bias except as provided by the Q8 collector voltage. So, Q10 is cut off, except during the sync pulse.

Both Q8 and Q10 are pulse generators, and they work together as a team to produce (at the collector of Q10) a negative-going 520 microsecond pulse (about 8 lines) that starts between lines 4 and 5.

Now, it is absolutely essential for the proper timing of Line 19 that the Q10 collector pulse start precisely at the end of line 4. Therefore, the bias of Q8 is adjustable by means of R7, which is called "delay". This is a factory adjustment, and should not be changed unless vital components are replaced in these stages.

(Because it is easier to describe as a single event, rather than many repetitions, we refer to the Q10 signal as a "pulse", as though there were only one. Actually, a 520 microsecond pulse is generated for every vertical field, or 59.96 pulses

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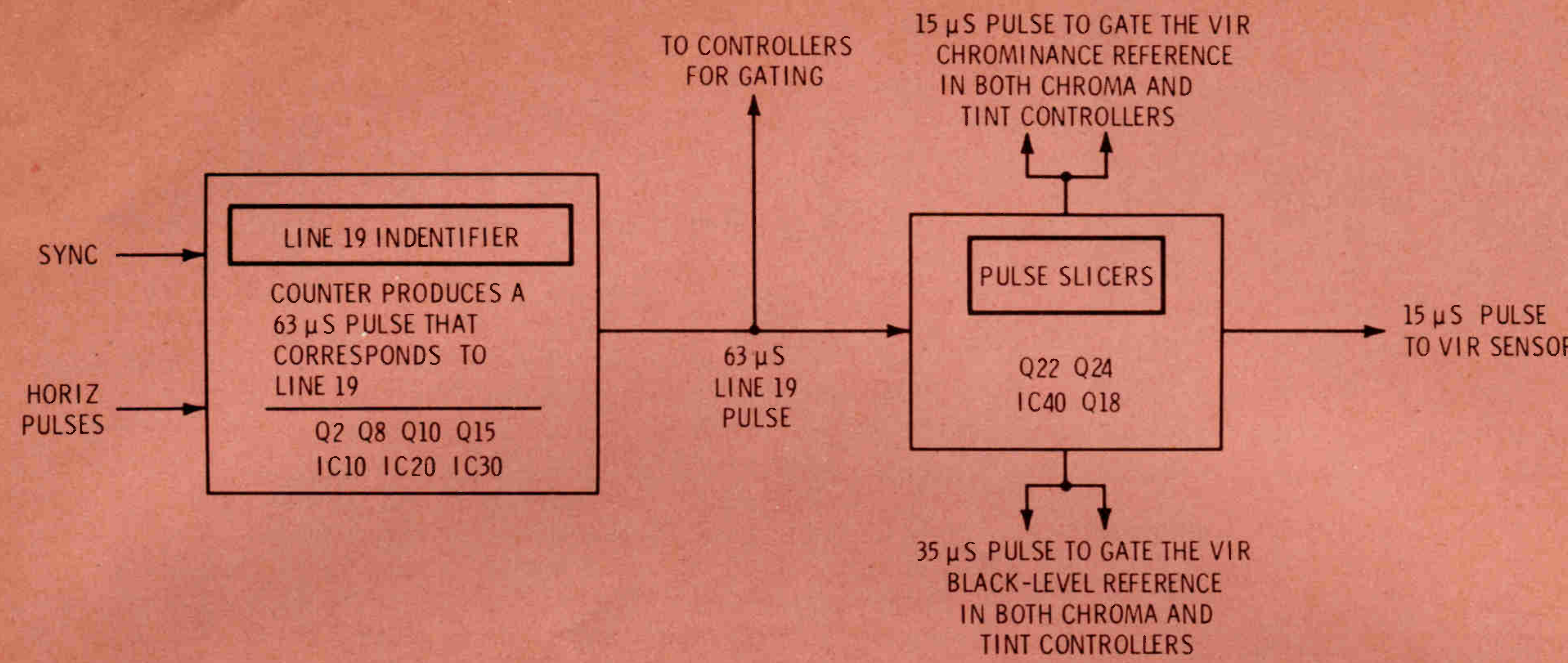

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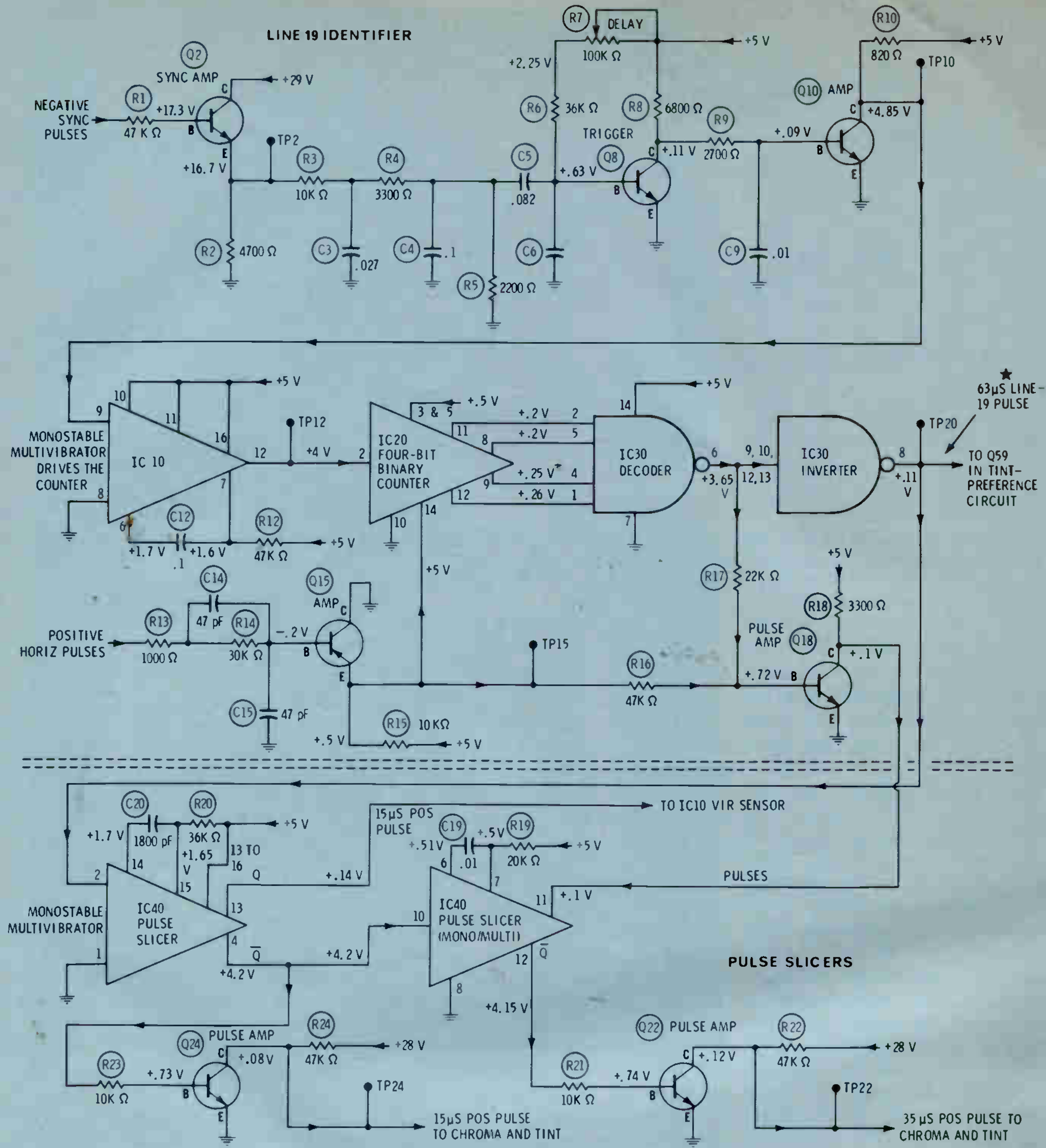

Fig. 9 The use of IC's, whose internal components are not shown on a schematic, makes this full diagram of the Line-19 Identifier and Slicer stages seem less formidable. Therefore, the circuit operation is not difficult to understand.

VIR

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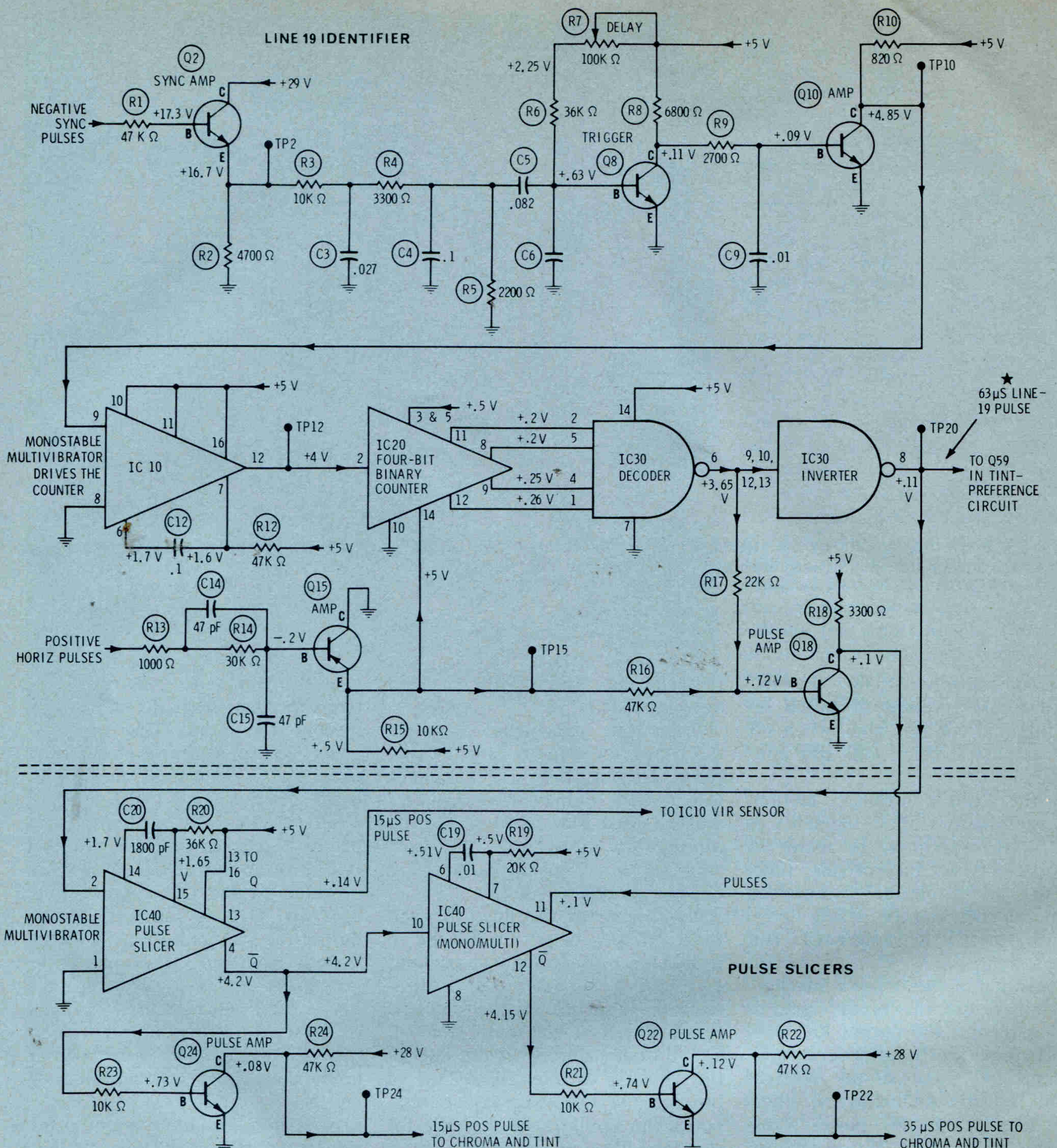
per second. Each pulse is triggered by the vertical sync.)

Figure 10 shows the composite video, sync pulses, integrated vertical sync pulse, and the 520 microsecond pulse at TP10.

One more condition must be established before the digital counting can begin: a negative-going pulse (wide enough to include all of the lines for the counter) must be produced. This wide pulse is generated by half of IC10, which is wired as a monostable multivibrator, and is triggered by the falling edge of the negative-going pulse at TP10. The width of the output pulse at pin 12 is determined by the values of the network C12 and R12 (they are a time-constant filter).

Although the width of the pulse at the output of IC10 is not critical, it must be slightly wider than 20



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Although the width of the pulse at the output of IC10 is not critical, it must be slightly wider than 20 horizontal lines (about 1300 microseconds), so the width usually is specified as 1400 microseconds.

The output pulse of this monostable multivibrator triggers (or enables) the digital counter which follows. Therefore, it is called a **"counter enabler".**

For the benefit of those of you who are not familiar with digital terminology, I will try to identify the stages and actions by both digital and more-conventional labels. For example, the space between the negative-going pulses is +5 volts DC (a "high" digital signal), and the tip of the pulses nearly reaches zero volts (or a digital "low").

Binary counter

IC20 is a 4-bit binary counter. When enabled, it counts up to 15, resets and counts up to 15 again, and repeats. At least, the counter would repeat endlessly if enabled all of the time. But the 1400-microsecond pulse both starts and stops the counting.

The IC20 counter has two inputs. Pin 2 has the enabling pulse, and pin 14 has a series of horizontal-sweep pulses.

When the 1400-microsecond enabling pulse at pin 2 of IC20 goes low, the binary counter begins counting the horizontal-rate pulses at pin 14. The count began at line 4 and the counter continues for its maximum of 15 counts, when the four output pins all are in a high state. (That corresponds to the start of video Line 19, as we shall see later.) However, the counter is still enabled, so it does not stop, but resets and begins counting up toward 15 again. Before it reaches maximum (actually just four more counts), the enabling pulse goes high (at about line 24), and the counter stops, with all outputs low.

The enabling pulse and the counting pulses at the four outputs are shown with the correct phase in Figure 11.

Those four outputs of the counter connect to four inputs of IC30, a **decoder.** The decoder is a four-input NAND gate, which has a low output **only** when all of the four inputs are high. Therefore, at the count of 15 horizontal pulses, the decoder has a low (negative-going pulse) that's exactly as wide as one video line.

Next, this low pulse goes through the IC30 inverter, which inverts the phase by 180 degrees. At the output pin 8, therefore, is a positive-going (high) pulse of the width of one horizontal line of video, and having the same phase as Line 19 of the composite video (see Figure 12 for the 520 microsecond pulse, the enabling pulse, and this Line 19 pulse).

Line 19 has been identified, since it corresponds with this pulse.

The drawing of Figure 13 shows all of the operation up to this point, plus the 15-microsecond and 35-microsecond pulses that will be made by "slicing" the 63-microsecond pulse that identifies Line 19.

Now, the question is: does Line 19 of the composite video from the station have the VIR waveform or not? But first, one more pulse must be produced.

Pulses Made By Slicing

Two other pulses, of narrower width and different phase, are made by "slicing" the "Line-19" 63-microsecond pulse previously described.

Slicer #1

To be honest about it, those slicers don't actually "slice" anything. But, that's just a simple way of saying what **seems** to happen. Slicer #1 is another monostable multivibrator. It's set to trigger on the **rising edge** of the pulse at pin 2, and this pulse is the 63-microsecond **positive-going** Line-19 waveform. So, **the pulse from slicer #1 begins with the start of Line 19.**

The time constant filter, C20 and R20, determines how long the slicer functions. Thus, the RC values give the desired pulse width of 15 microseconds. This is not a critical specification; normal parts tolerances are sufficient.

Actually, there are **two** 15-microsecond output pulses. The positive-going one at pin 13 (marked Q) feeds the VIR sensor circuit; and the negative-going one at pin 4 ($\overline{Q}$) drives the next pulse slicer and Q24.

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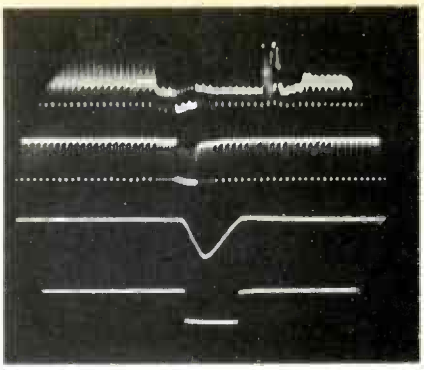

Fig. 10 These waveforms (top to bottom) are: composite video; sync pulses (negative-going) at TP2; the negative-going pulse at C4 after the serrated vertical pulse is integrated; and the 520-microsecond pulse at TP10. The falling edge at the left triggers the IC10 counter at the end of video line 4. Labeling a pulse with a microsecond rating refers to the horizontal width. All of these waveforms repeat 60 times per second (that is, once for each field of video).

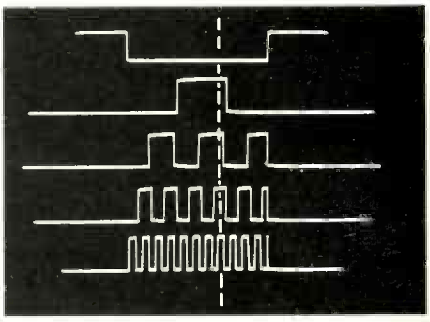

Fig. 11 Here are the waveforms at input and the four outputs of IC20, the four-bit binary counter. From top to bottom they are: the 1400 microsecond "enabling" pulse that keeps the counter running; pin 11; pin 8; pin 9; and pin 12. Compare these waveforms to the digital truth table in Figure 13. Notice that when "highs" occur in sequence, they form wider pulses, and do not show as separate pulses. Since the counter continues operating past the Line-19 pulse that's wanted, Line 19 is about one-third from the right, as shown by the dotted line. Vertical lines have been drawn in for clarity.

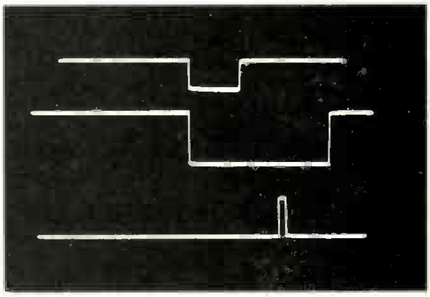

Fig. 12 From top to bottom are: the 520 microsecond pulse at TP10; the 1400 microsecond pulse at TP12; and the 63 microsecond Line-19 pulse.

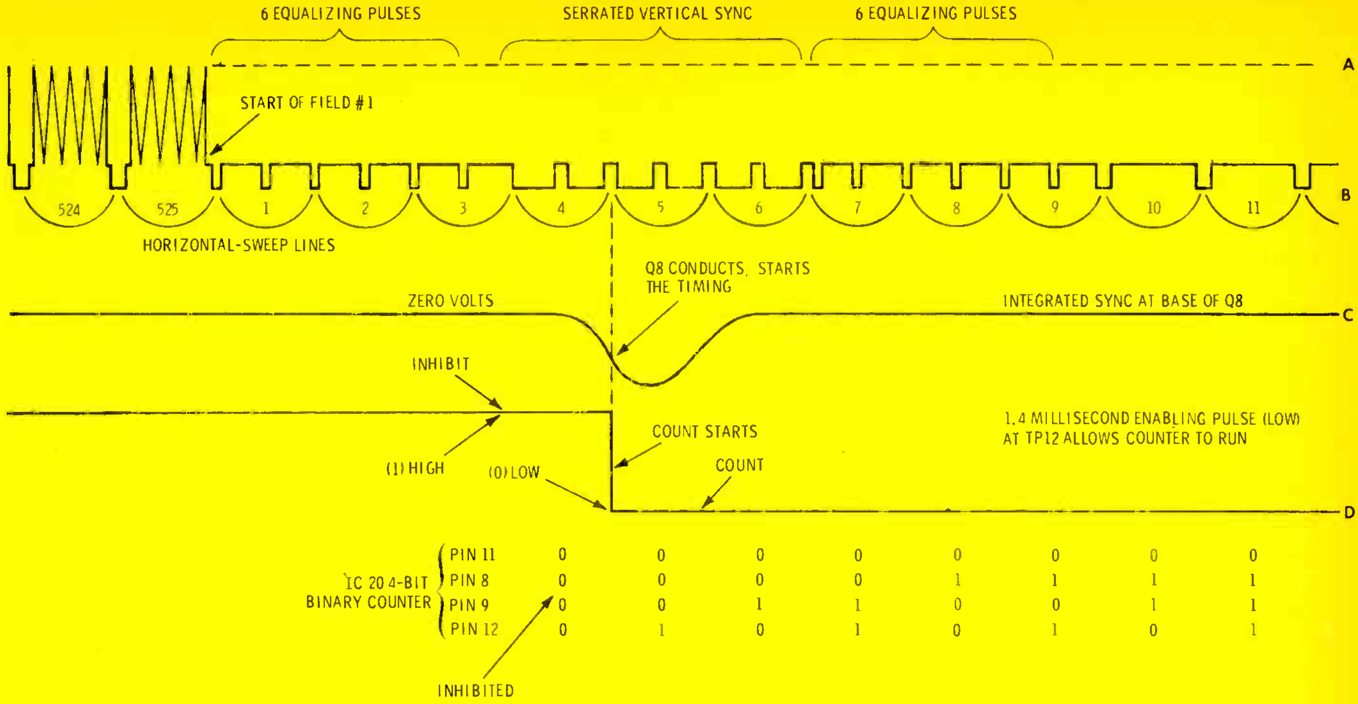

Fig. 13 Many useful facts can be learned from this drawing. Lines "A" and "B" represent the video of Field #1; "C" is the base voltage of Q8, including the negative pulse formed by integration of the vertical sync; "D" is the 1400 microsecond "enabling" pulse at TP12 (the counter runs only when this pulse is "low"); below line "D" are the columns of the counter truth table (also see Figure 11 for the actual waveform); "E" shows the 63-microsecond Line-19 pulse; "F" is the 15-microsecond pulse from slicer #1 at TP24; "G" is the 35-microsecond pulse from slicer #2 at TP22; while "H" and "I" show the DC switching voltages that change the operation from manual to VIR-controlled.

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Slicer #2

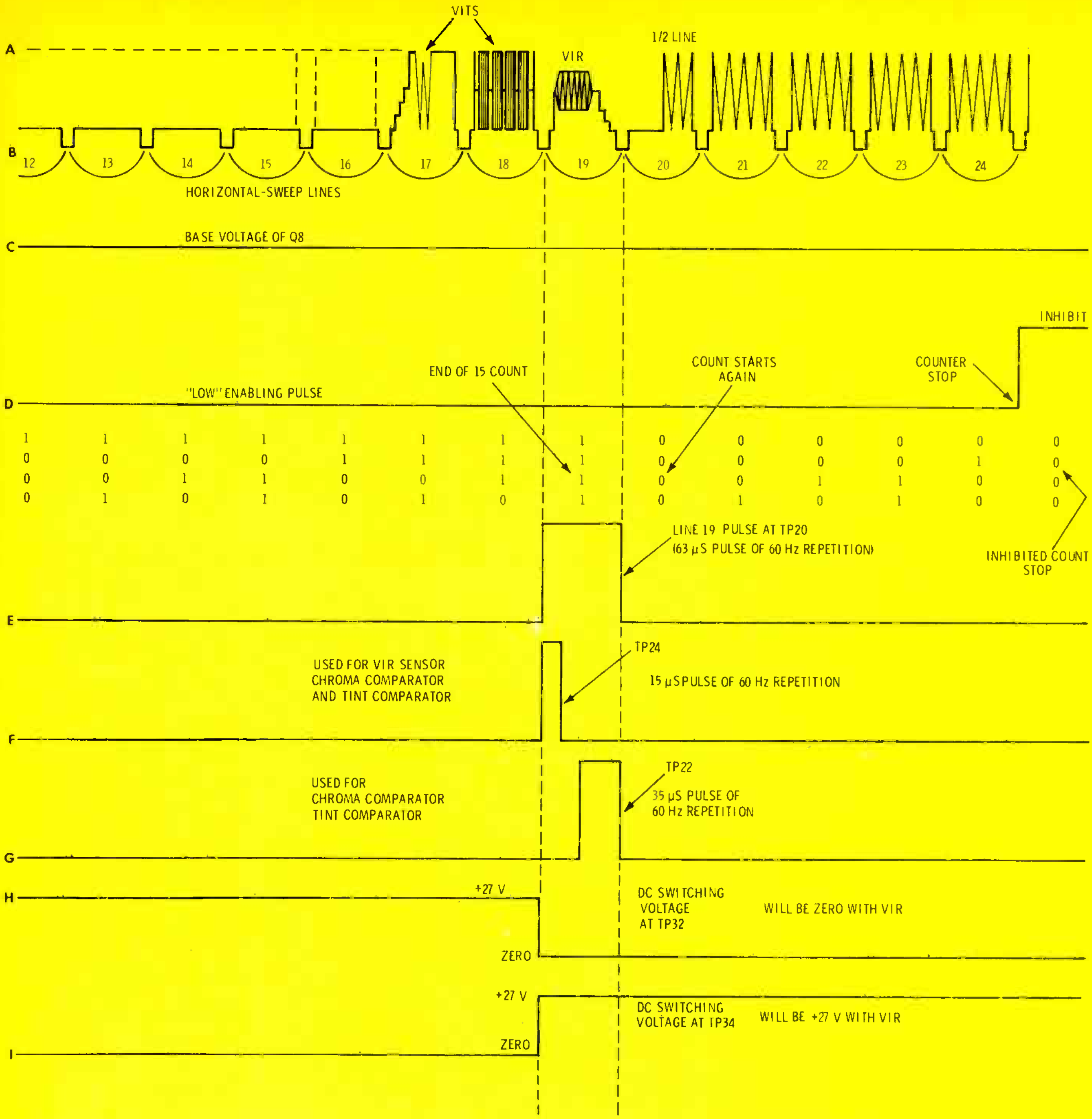
Pulse slicer #2 is similar to #1, except for a wider output pulse, and an additional important input waveform. More about that later.

Slicer #2 also is triggered by a **rising** pulse edge. But notice carefully that the input waveform at pin 10 is a 15-microsecond **negative-going** pulse, whose beginning (falling) edge marks the **start** of Line 19. So, the **first** rising pulse edge is the **end** of the 15 microsecond pulse. In other words, **the output pulse from slicer #2 starts 15 microseconds from the beginning of Line 19.**

This tells us why the output pulse can't be allowed to exceed 35 microseconds: it would extend into line 20, if so. Both pulses (plus the skew time to reach full amplitude) use up the whole 63 microseconds of Line 19. The tolerances of C19 and R19 can't provide such accuracy.

Therefore, C19 and R19 are selected to give **more** than 35 microseconds, then the second waveform at pin 11 terminates (clears) the pulse with high accuracy at the end of Line 19. That's the job for Q18 and other components.

Now, Q18 appears to be merely a simple amplifier of horizontal pulses, but a second source of input signal comes from the negative-going Line-19 pulse from the de-



coder output at pin 6.

The General Electric explanation says Q18 functions similarly to a 2-input NOR gate. Q18's output can be high (transistor cut off) **only** when both signal inputs are low (zero—no input bias). That's understandable, even without digital theory. Anyway, the "clear" input at pin 11 **must** go "low" (zero) to "reset" (terminate) the pulse at the output, pin 12.

Unfortunately, the GE explanation implies that the two input signals at the base of Q18 both are strong pulses. Yet, scope waveforms (see Figure 14) prove the narrow horizontal pulses have an amplitude of only 0.02 volts PP, while the broad Line-19 pulse measures 0.65 volts PP. So, when it's stated, "The R16 input from Q15 couples a positive-going horizontal retrace pulse (HIGH state) to the base of Q18 just prior to the end of Line 19. This pulse saturates Q18, pulling the collector back to 0 volts (LOW state) and resetting Pulse Slicer number 2", **I must disagree.** There is **no** way a pulse of 0.02 VPP can saturate the base of a transistor that also has more than 0.6 VPP of opposite-polarity pulse! At the most, the tiny positive-going base pulse speeds up the rising side of the negative Line-19 pulse, making more rapid and precise the resetting of slicer #2.

Waveforms

Figure 15 shows the Line-19, the

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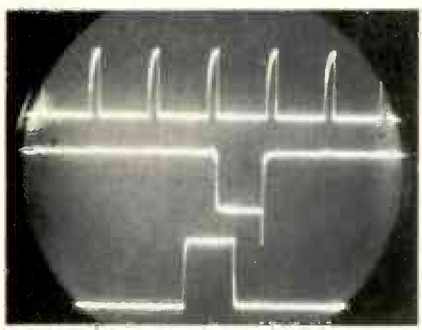

Fig. 14 The two upper waveforms have correct phase; the bottom one should be to the right, under the other broad pulse. From top to bottom, the waveforms are: horizontal sweep pulses at the emitter of Q15; the base waveform of Q18 (the broad pulse has an amplitude of 0.65 VPP); and the 4.8 VPP positive pulse at the collector of Q18. No trace of the horizontal pulses can be seen in this latter waveform. No touchup of the waveforms was done.

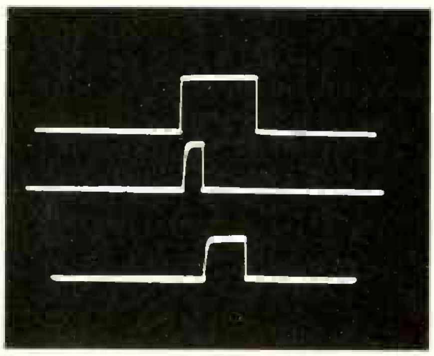

Fig. 15 These are the actual waveforms, in the correct phase, but with the vertical lines drawn in. From top to bottom, the pulses are: The Line-19 pulse at TP20; the 15-microsecond pulse at TP24; and the 35-microsecond pulse at TP22. Notice that the two lower pulses add to equal the Line-19 pulse (except for the slight gap required for the 35-microsecond slicer to begin). Although the two narrower pulses were produced individually by monostable multivibrators, the fact that they seem to be parts of the Line-19 pulse probably is the reason the pulse generators are called "slicers".

15-microsecond, and the 35-microsecond pulses, all in the correct phase.

Q22 and Q24 invert the polarity and amplify the 35-microsecond and 15-microsecond pulses, respectively, before they go to the controllers.

Next Month

Composite video is examined for the falling side of the Line-19 blanking during the life of the 15-microsecond pulse. A falling blanking side indicates that Line-19 **has** the VIR waveform. If the falling side is not there, that's proof of no VIR signal. Reception of the VIR signal reverses the switching voltages, allowing the automatic circuitry to control color and tint. Watch for these interesting explanations.

Also, instructions will be given telling how you can use your own triggered scope to look at the VIR waveform in the composite video. □

Convergence Trouble Symptoms And Repairs

By Robert L. Goodman, CET and Carl Babcoke, CET

Defects in convergence components are rare, so it's possible for us to become rusty in this kind of troubleshooting. Here is a refresher course in the fundamentals and methods of servicing both old and new convergence systems.

Convergence repairs admittedly are not interesting to most technicians. You won't hear this topic of conversation when the men gather after a service seminar, or relax in a bar. But, there was a time when convergence **adjustments,** and how well they could be done, were a worry to many color-TV technicians. Of course, the receiver circuits were not so effective as they are now, and more work was required to attain a "good" job of set-up. Finally, we developed methods that worked very well, and the subject faded away.

Before we give troubleshooting methods, and illustrate some of the new solid-state variations of circuitry, let's recap a few of the reasons why convergence is necessary, and how it's accomplished.

What Is Convergence?

Convergence (sometimes called merging) refers to anything done to bring the three colored pictures into register with one another. When

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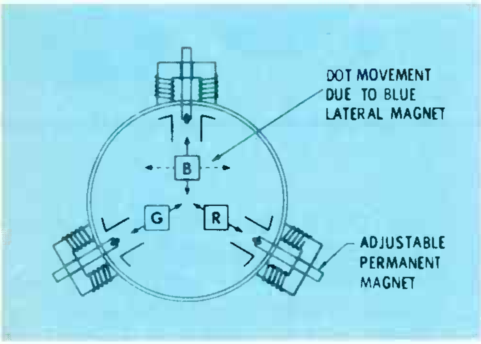

Fig. 1 The center-convergence permanent magnets of delta-gun picture tubes are mounted with the dynamic convergence coils. Rotating or sliding a magnet in its holder varies the magnetic field, which moves the entire picture of that color. Red and green can only intersect at one point near the center; then blue is moved up or down and sideways to converge.

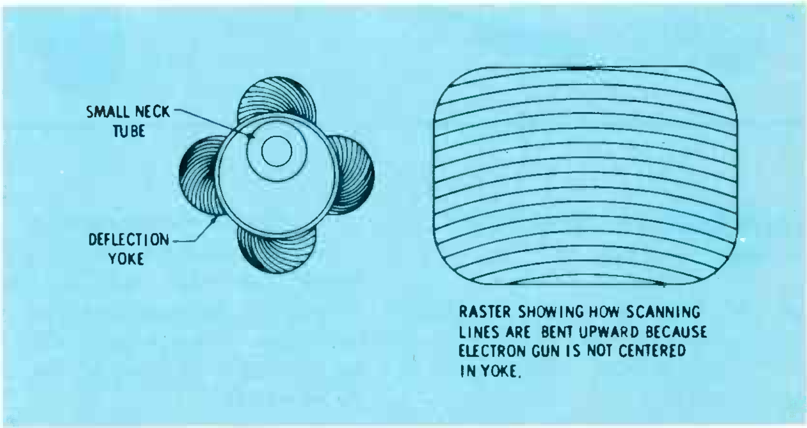

Fig. 2 An experiment made with a deflection yoke that's too large for the picture-tube neck will prove that the crosshatch lines bend according to the position of the electron gun in the yoke. Only in the center will straight lines be produced. Although the flat face plate of a color tube causes somewhat the same bending effect, it is a much smaller distortion.

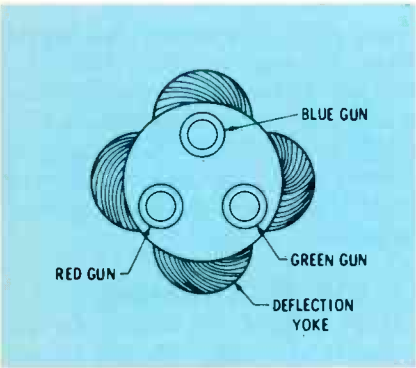

Fig. 3 Each gun of the delta tube is off-center in the yoke. Therefore, the crosshatch lines will be curved.

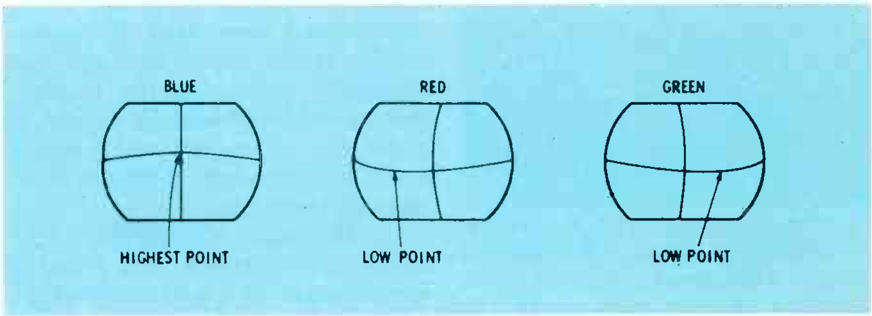

Fig. 4 Viewed on the screen, all of the crosshatch lines are curved, except for the blue-vertical lines. They are not bent, because the blue gun is midway between the vertical yoke coils (which are at the right and left sides).

The drawings of Figures 1 through 4 are from "Color TV Servicing Made Easy, Volume 1" (book 20135) by Howard W. Sams.

Convergence Trouble

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this is done properly, a B&W picture will not have red, blue, or green lines around the objects in the scene.

Actually, there are two basic types of convergence. (These first descriptions apply to the original "delta" arrangement of the guns.)

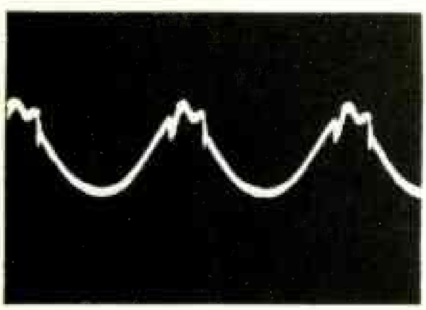

Fig. 5 Theoretically, a perfect parabola of current is necessary through the dynamic-convergence coils for total correction of the bent lines. In practice, the horizontal-correction current waveforms range from near-sine-waves to distorted parabolas. This waveform from a GE is better than most.

Center Convergence

Center convergence often is called "static" or "DC", and it means a moving of the complete red, blue, and green pictures until they overlap perfectly, at least in the center of the raster.

Originally, the moving of the three rasters was done by running an adjustable DC current through a coil of wire located "over" each gun. (In this case, "over" refers to the location relative to the gun and the center of the picture-tube neck, and does not mean up.) Later models used some kind of permanent magnet, whose strength was adjustable by moving the magnet. One system is shown in Figure 1, where the permanent magnets are mounted on each dynamic-convergence assembly.

In all cases, a magnetic field moves each complete red, blue, or green picture as a unit, without affecting the straightness of the lines, or changing the linearity of the sweep.

Viewed on the face of the picture tube, the blue picture moves up and down; the red picture moves diagonally along the south-west to north-east line; and the green picture moves diagonally along the north-west to south-east line.

With only these three movements, it would be possible for the pictures to not converge exactly at the center. So, an extra magnet is given to the blue gun, allowing adjustment horizontally (laterally).

With four adjustments, the three pictures always can be made to overlap perfectly, near the center of the screen. Without these adjustments, which compensate for minor errors of electron gun locations, very few picture tubes would have satisfactory center convergence.

Also, without the next type of convergence, the B&W picture would still not be converged around the edges.

Dynamic Convergence

If you were to eliminate all dynamic convergence, almost all lines of a crosshatch pattern would be curved. Only the blue vertical lines are straight when there is no correction.

Most textbooks and color courses say the lines are curved because the faceplate of the picture tube is not a section of a ball, but is too flat. Well, the flat screen causes some problems with purity and edge focus, but it's **not** the cause of the bent lines.

You can prove the cause for yourself by placing the yoke of an old B&W TV over the smaller neck of a newer B&W picture tube, and then operating the receiver. Look at a horizontal-lines or crosshatch pattern. If you hold the yoke so the neck is centered, the horizontal lines are straight. When you allow the yoke to rest on the neck, the scanning lines and crosshatch horizontal lines are bowed up in the center (see Figure 2). The deflection power is unbalanced because the electron beam does not pass through the center of the yoke.

In Figure 3, notice that **all** guns of a delta picture tube are off-center in the yoke. Accordingly, you would expect **all** crosshatch lines to be curved. That's almost right, but there's one exception. The vertical-deflection coils are located at the right and left sides of the picture-tube neck. Therefore, vertical lines of the blue gun are straight, because the blue gun is midway between the coils. The bending of the lines in Figure 4 have been verified by operating a color tube without convergence coils.

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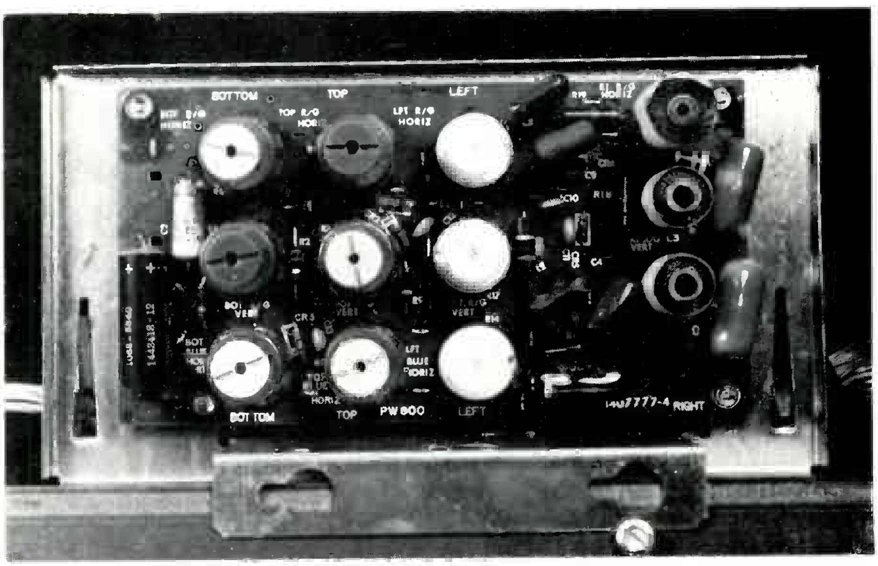
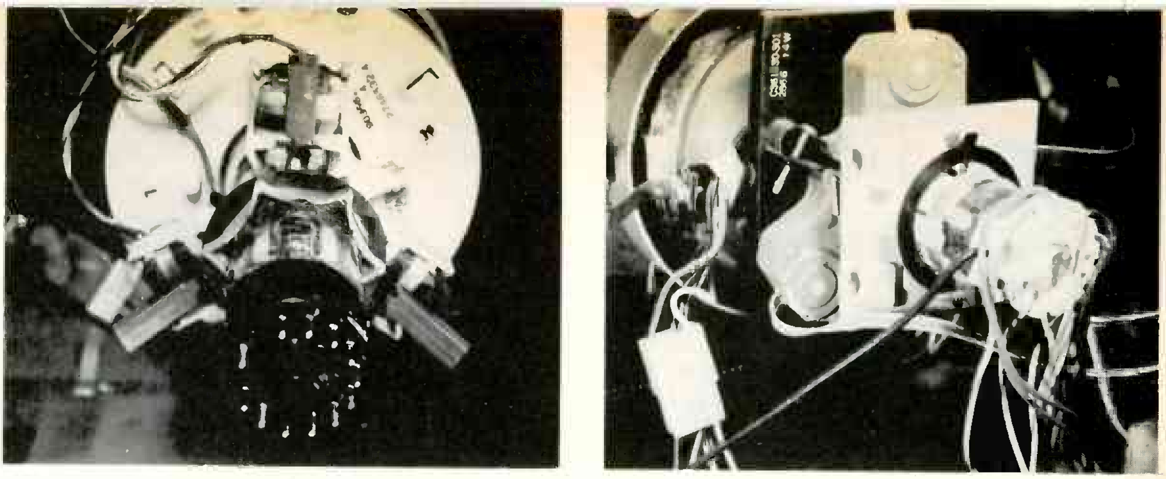


Fig. 6 This is the convergence circuit board of a 25" color tube. The six controls on the left are for vertical convergence. The three controls and three coils on the right are for horizontal adjustments.



A B

Fig. 7 On 21" round color tubes, the convergence coils and sliding magnets were part of a separate assembly mounted on the picture-tube neck behind the yoke (A). Rotary magnets and enclosed coils were used in the convergence assembly of this old 23" tube (B).

Convergence Trouble

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Dynamic Convergence—In General

Straightening of the curved lines must be done with AC signals. So, it's called "dynamic" convergence, to prevent any confusion with center convergence, which operates from steady magnetic fields without AC signals.

Studies of crosshatch patterns, without correction for the bent lines, indicate that a parabolic correction is required. And because the correction signal is applied to electromagnetic coils, it follows that **the convergence CURRENT should have a parabolic waveform** (see Figure 5).

In all models of color receivers, samples of vertical and horizontal sweep signals first are filtered or mixed, and then are adjusted for amplitude, usually by controls and coils on a convergence board or panel, as shown in Figure 6.

Next, these red, blue, and green horizontal, and red, blue, and green vertical signals are sent to coils (with powdered-iron cores) mounted "over" the three guns (Figure 7). The coils act like individual non-linear deflection yokes, operating on the electron beams before the conventional deflection yoke. In a way, the action is similar to a stage that pre-distorts a signal to compensate for an opposite distortion that happens later.

Many years ago, before the circuits were improved, a control that regulated the amount of parabolic current was called "amplitude". And others that increased the current at the beginning and decreased the current at the end of each parabola (or the opposite) were called "tilt". Usually, one amplitude and one tilt control for horizontal, plus one amplitude and one tilt control for vertical were supplied for each of the three colors.

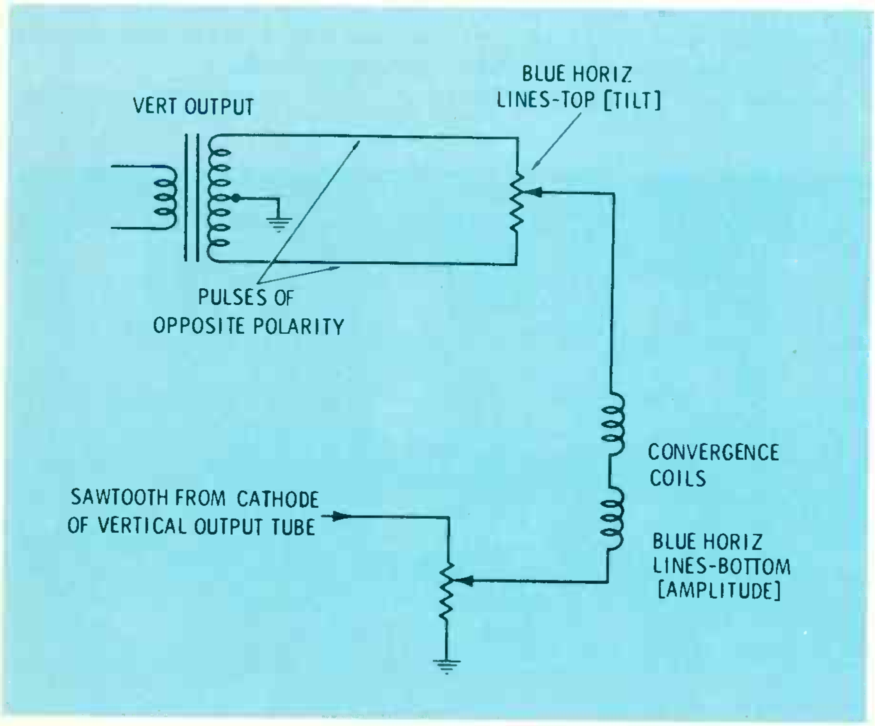

Fig. 8 Tube-powered chassis often used a vertical tilt and amplitude circuit, with the pulses for the tilt obtained from separate windings of the vertical-output transformer.

Later, after the adoption of some controls that affected two colors simultaneously, the controls were labelled to show where the main correction was located on the crosshatch. One knob might be marked, "TOP R&G VERT LINES", or "BOT BLUE HORIZ LINES".

Problems Travel Both Directions

One reason for telling these basics is to illustrate the interconnections between sweep and convergence.

For example, a defect in the convergence circuit might cause a change of linearity or vertical height. Or, other defects might

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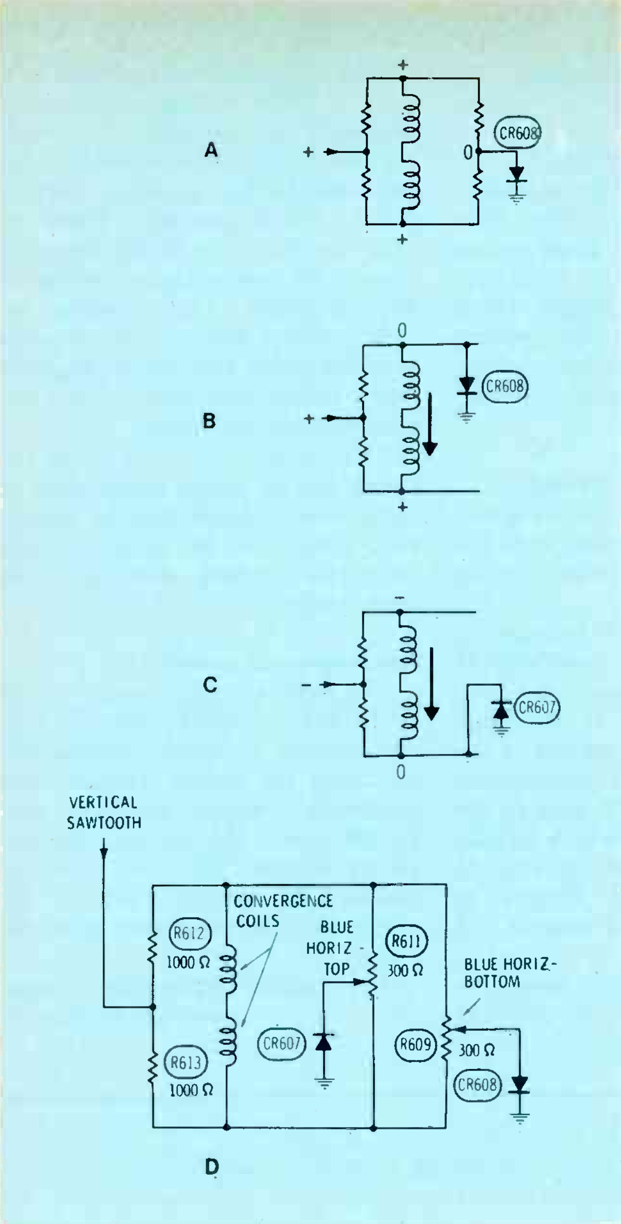

Fig. 9 Solid-state vertical-sweep circuits without output transformers demand convergence circuits with only one input from the deflection. Operation of the Zenith 19EC45 blue-vertical convergence is illustrated in several steps for clarity. (A) When a variable control (shown here by two separate resistors) is adjusted to the exact center of its resistance, the positive peak of the sawtooth forces the diode CR608 to draw current. However, the same positive voltage appears at both ends of the coil assembly; therefore, the coil has no current. During the negative peak, CR607 conducts in the same way, and both ends of the coil are negative, so again no coil current flows. (B) When control R609 is rotated to place CR608 at the R612 end of the coil, the positive peak causes CR608 to conduct, grounding that end of the coil. The positive input voltage appears at the R613 end of the coil, causing electron current to flow, as shown by the arrow. (C) When control R611 is rotated to place diode CR607 at the R613 end of the coil, the negative peak forces CR607 to conduct, grounding the R613 end of the coil. The negative input voltage at R612 causes electron current to flow in the coil, as shown by the arrow. Did you notice that the current flowed in the same direction in both (B) and (C)? (D) Here is the complete blue convergence circuit. One control acts as an amplitude control at the top of the picture; the other acts as an amplitude control for the bottom lines of the picture. When one is advanced more than the other, the effect is the same as tilt.

Convergence Trouble

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affect the horizontal sweep.

And, of course, the dynamic convergence signals are taken from the sweep circuits, so many sweep defects **temporarily** can upset the convergence. That's a strong reason to obtain the best size and linearity of the sweep circuits before making any dynamic convergence adjustments.

Vertical Convergence

Figure 8 gives the convergence circuit for vertical correction of the blue gun in an old color receiver with tubes.

To obtain a **parabolic** current it's necessary to apply a **sawtooth of voltage** to the inductance of a coil. A sawtooth waveform is developed across an unbypassed section of the cathode resistor of the vertical-output tube. The sawtooth goes to the "amplitude" control, which adjusts the voltage fed to the convergence coil, and the circuit returns to ground through the tilt control and transformer windings.

If an amplitude adjustment is lopsided, a sawtooth of current should be added to the parabola. And a **pulse voltage** generates a **sawtooth of current.** A center-tapped winding of the vertical-output transformer provides vertical pulses of both polarities. When the "tilt" control is set to the electrical center, the pulses cancel, giving no tilt correction. Then turning the "tilt" control one way or the other provides either positive- or negative-going pulses, and also changes the amplitude of the pulses.

This circuit works fine, when the circuit has an output transformer to supply the opposite-polarity pulses. But, what can be done for the solid-state circuits that have no transformer?

Transformerless vertical

The vertical convergence circuit of the Zenith 17EC45 operates very well without an output transformer to supply the pulses. Instead, **two** amplitude controls are used, one for the top of the picture, and one for the bottom. The effect of tilt is obtained by operating one of the amplitude controls higher than the other.

The vertical-convergence circuit

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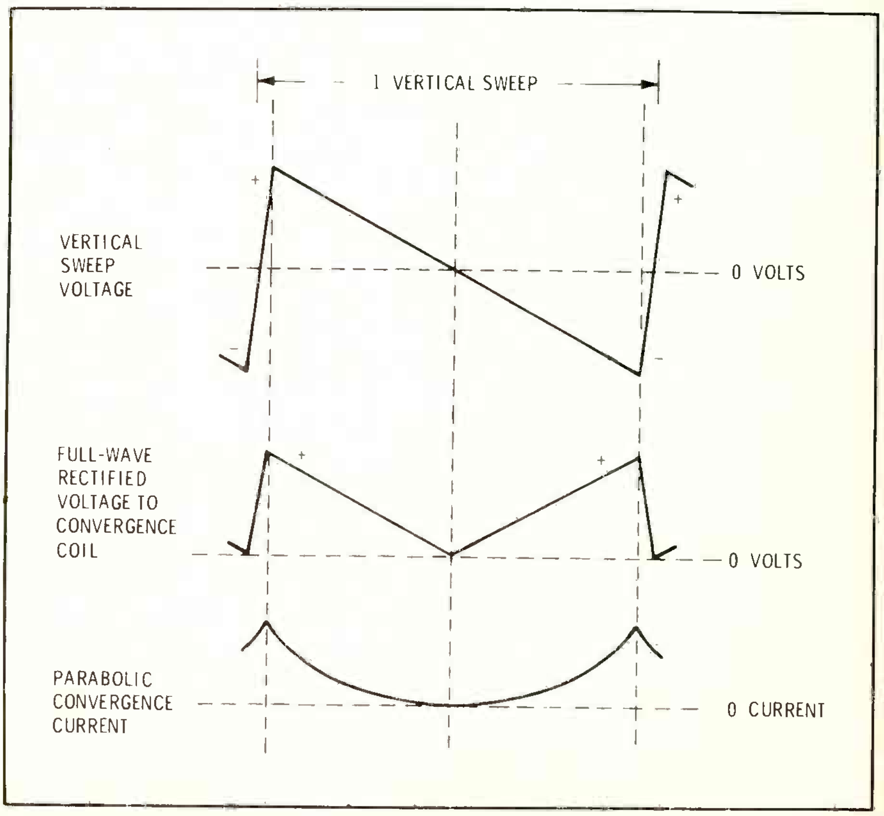

Fig. 10 These drawings show the operation of the circuit of Figure 9, explaining how one positive and one negative peak combine to make two positive peaks. In turn, those peaks produce a near-parabolic current.

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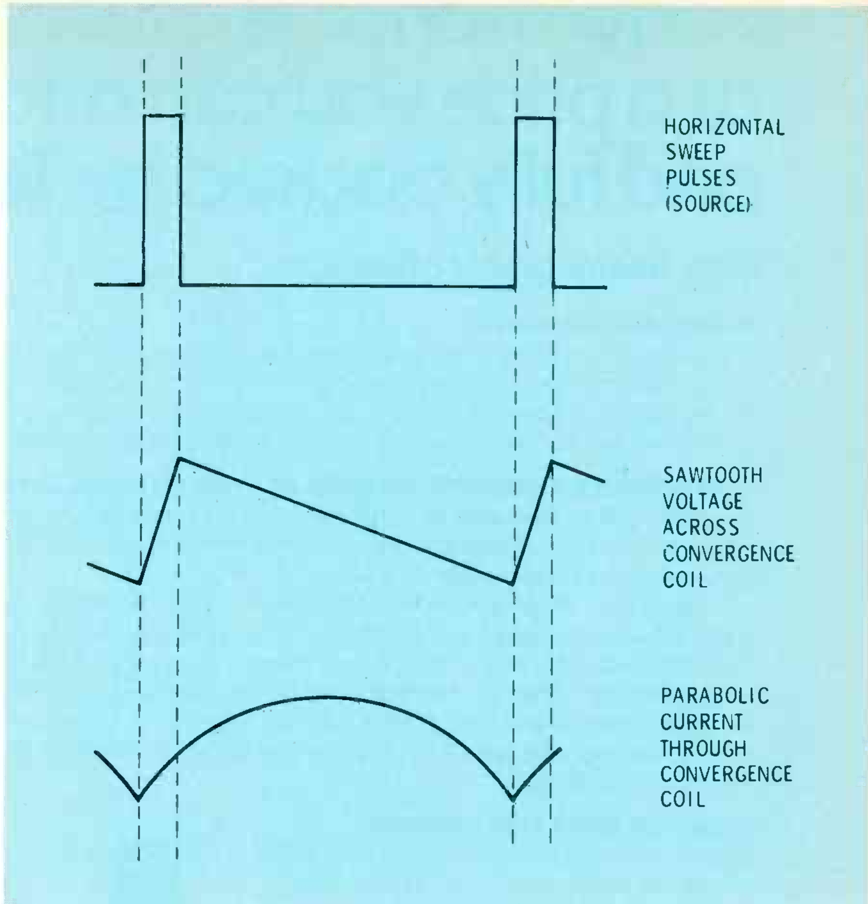

Fig. 11 Parabolic-shaped currents for horizontal convergence are produced by filtering (integration). Horizontal-sweep pulses (top waveform) are integrated by the inductance of a coil on the convergence board, forming a sawtooth of voltage (center). When the sawtooth of voltage is integrated by applying it to the inductance of the convergence-yoke winding, the yoke current has a parabolic waveform (bottom).

Convergence Trouble

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receives the full output power of the vertical-deflection module, as shown in Figure 9D. This circuit is not grounded, except through the two diodes, which act as voltage-controlled switches to conduct current at the proper times. Although the sweep waveform has some pulse amplitude, most of the amplitude is sawtooth. Therefore, we refer to it as sawtooth.

Several partial schematics in Figure 9 help explain the diode-conduction and convergence-coil currents, followed by the complete diagram of the blue vertical-convergence circuit.

The waveform drawings of Figure 10 show how switching by the diodes can change one positive peak and one negative peak into two **positive** voltage peaks that add together forming an approximate parabolic waveform of convergence current.

Horizontal Convergence

Parabolic current waveforms for horizontal convergence are formed by a different method. Figure 11 shows the progression from horizontal voltage pulses, integration by a coil into a sawtooth of voltage, and the parabola of current produced by the sawtooth of voltage. These parabolas are not classic waveforms—remember the actual waveform of horizontal-convergence current shown before.

The simplified schematic of a 1965 horizontal-convergence circuit (Figure 12) and another manufactured in 1974 show several similarities.

Pulses and waveforms

What should you check first, when the crosshatch pattern looks

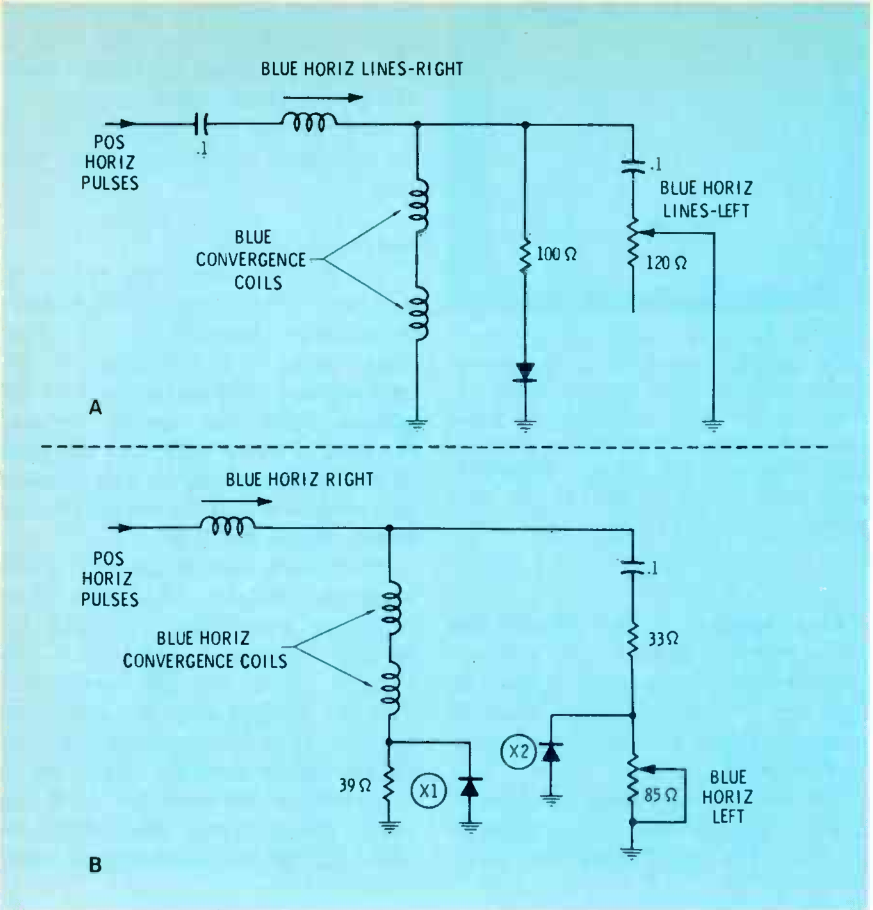

Fig. 12 The schematic of (A) comes from a CTC16 RCA TV. The adjustable coil and the .1 capacitor form a tuned circuit, while the control changes the tuning slightly. The diode is said to provide a small DC voltage to minimize changes of center convergence with adjustments, and also helps shape the waveform. The blue-horizontal convergence circuit of a newer model, the Zenith 17EC45, is shown in (B). There are improvements over the other circuit, but the similarities are obvious.

like the one in Figure 13? This appears to show a total loss of all convergence functions. Is that possible? Both horizontal sweep and vertical sweep samples (usually more than one kind) are brought to the convergence board, and the chances are slim of a defect eliminating all of them at the same time. But, an open in a ground wire common to both vertical and horizontal signals might do it. A loose or unplugged convergence connector is more likely.

However, when some functions work, but others don't, it's time to

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Convergence Trouble

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enlist your scope to see if all of the sweep signals are there. Figure 14 gives the amplitudes and waveforms of the four input signals of the Zenith 19EC45 chassis.

Try all adjustments

When the convergence is wrong in just one area, the best quickie test is to tune in a crosshatch pattern and attempt to do a complete convergence job. Then, notice which controls do not respond in the usual way. The problem often will be in the coil or control that does nothing, or operates incorrectly. Or, at least, the defect probably is in the immediate circuitry.

Think of the convergence board as the command post, telling the convergence yoke on the neck of the picture tube what to do. Now, are the proper signals leaving the convergence board? If so, perhaps the convergence coils are at fault.

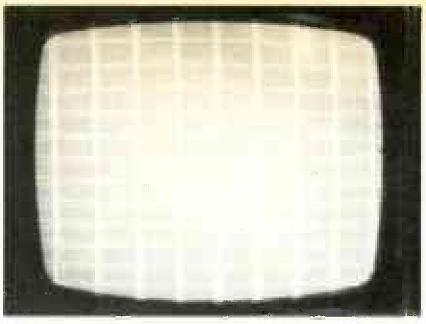


Fig. 13 When all convergence corrections are eliminated, all of the crosshatch lines (except blue-vertical), exhibit the parabolic bending. In addition, the vertical lines at the extreme right and left are moved sideways, with blue in the center of red and green.

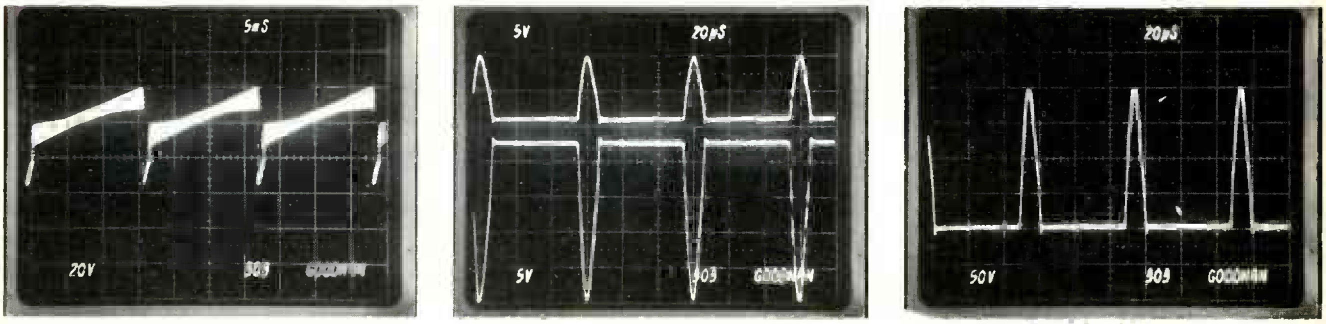
One method is to attach the scope probe **across** the coil or control that you suspect. Adjust it, and see if the waveform changes enough. Some examples are given in Figure 15.

Of course, waveform analysis is not an exact science in convergence circuits. The amplitudes and waveforms both change with the adjustments. And that's just the point of this test. You should expect **something** to happen, when you turn the knobs. If nothing happens this is an excellent place to start your search.

Picture tube paths

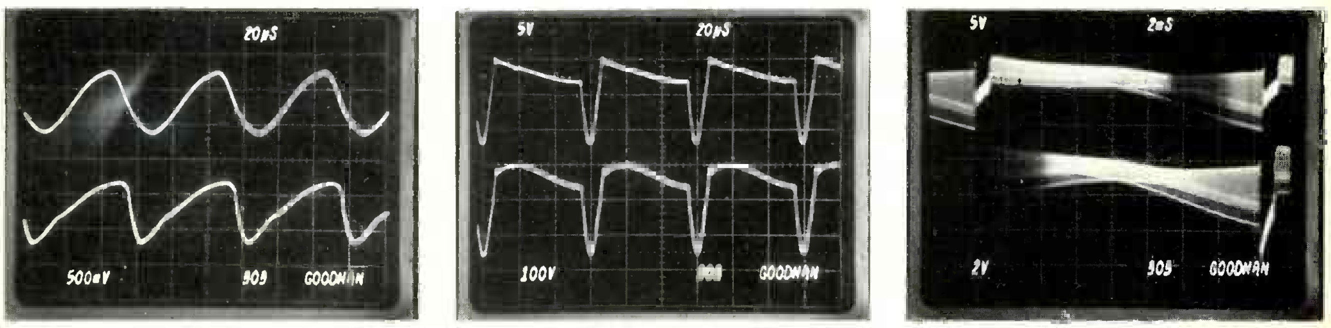
These last steps of the convergence system have fooled more technicians than all of the other stages have. I'm referring to: **the convergence coils on the neck of the picture tube; the spaces between the core of these coils and the glass of the tube; and the spaces between the neck and the convergence electrodes inside the tube.**

First, we'll look at the coils. Each assembly (Figure 16A) has four separate windings. Two are for vertical correction, and two (the smaller ones) are for horizontal. The two vertical coils are connected together by a twisting and soldering of the wires (usually the joint is then hidden between the coils and under the covering). Also, there are two lugs, or two connections where



A B C

Fig. 14 These are the four input waveforms to the convergence board of a Zenith 19EC45 chassis. (A) Vertical-sweep sawteeth (with butterfly wings from the pincushioning) of about 55 VPP enter at pin 6. (B) The waveform at top is the 8.8 VPP horizontal pulses at pin 7, while below are shown the 27 VPP negative-going pulses at pin 2. (C) More positive-going pulses of 200 VPP are found at pin 4 of the convergence plug.



A B C

Fig. 15 One test of a convergence control or coil is to attach the scope probes across the terminals and adjust it. The waveforms of (A) were found across T601 when R601 was turned from one end to the other. (B) shows the waveform of L601 at the two extremes of adjustment. The waveforms of (C) were taken at the end adjustment of R618, when the scope was across T601.

the wires to the convergence board are attached. The horizontal coils are connected in the same manner.

That makes a total of six connections with a possibility of opens or intermittents for each assembly (there's one assembly for each gun).

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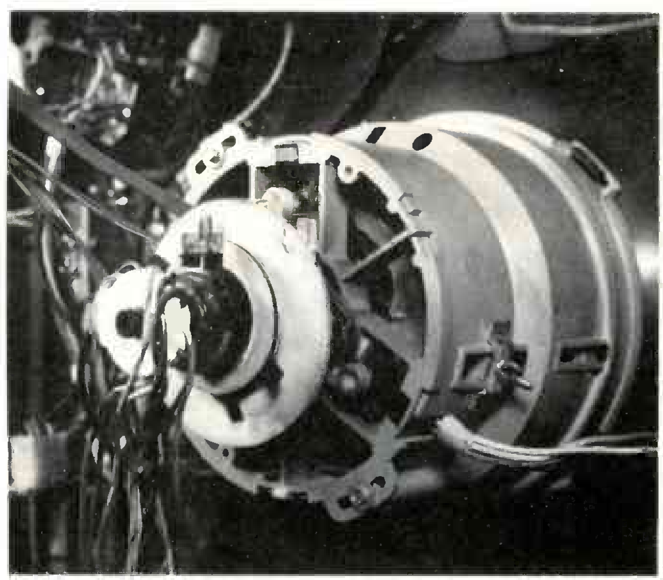
A



B

Fig. 16 Two convergence winding/magnet assemblies are shown in (A); one is complete. Notice the beveled tips that should fit tightly against the glass neck of the picture tube, and the spliced wires between the horizontal coils at the bottom. The disassembled unit shows the rotary magnet that should be clamped between the two core halves, by the complex spring. If the spring is weak, the magnet can move randomly, causing mysterious changes of center convergence. These convergence assemblies are mounted in the deflection-yoke housing (B) in many of the early rectangular models. Make sure the convergence cores are seated firmly against the neck of the picture tube.

Convergence Trouble

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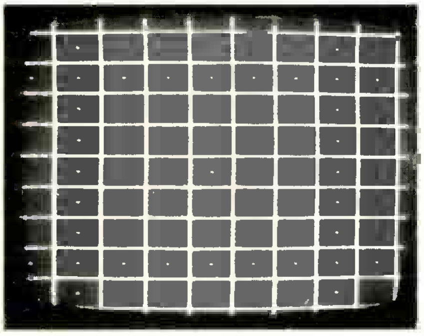
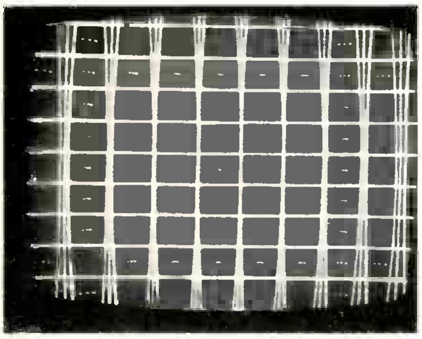
Even worse, the ends of the powdered-iron cores don't always fit snugly against the glass neck. Convergence systems usually have barely enough power for proper corrections; there is no reserve. So, a small gap between core and glass can reduce the correction for one gun.

Coil assemblies that fit tightly inside deflection-yoke covers, as pictured in Figure 16B, have been known to bind against the plastic, thus they were prevented from touching the glass neck.

But the worst problems of all can happen with those convergence-coil assemblies that are mounted separately on the neck of the picture tube. If the assembly becomes twisted in a circle (even a small amount), or is moved forwards or backwards a bit, the convergence coils no longer are "over" the metal pieces that conduct the magnetic fields to the gun. When these lengthened gaps appear in the magnetic paths, the field strengths are weakened, and the convergence adjustments are not sufficient to accomplish the usual correction.



A



B

Fig. 17 Picture (A) is a normal crosshatch pattern on a new General Electric receiver that uses an in-line-guns picture tube. When the convergence coil was shorted out, the horizontal lines of the crosshatch (B) were not affected.

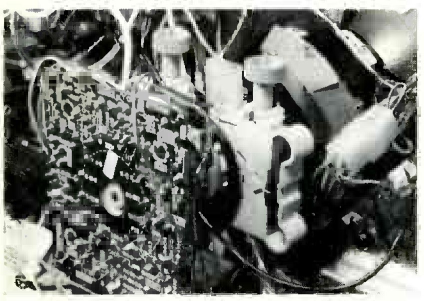


Fig. 18 Picture tubes with in-line guns typically have simplified convergence adjustments and components. This GE convergence assembly has four rotary magnets for center converging the red and blue with the green. Most of the dynamic convergence comes from a special winding inside the deflection yoke.

Tubes With In-Line Guns

Many of the new color TV's have picture tubes with all three electron guns in a horizontal line, rather than in a triangle. The convergence boards are less complex, and fewer adjustments are required.

Figure 17 shows a "hatchdots" pattern (from an ATC-10 American Technology generator) when the convergence was correct, and another pattern when the convergence coil was shorted out. Notice that the horizontal lines did not change. With this Chassis 19YC-2 General Electric, the "vertical" adjustments changed the spreading of the vertical lines **only** at the extreme top and bottom of the picture. The "horizontal" adjustments affected the **sideward** position of the vertical lines **only** at the extreme right and left edges of the screen. The green gun is the center one of the three guns, and it does not need any convergence adjustments.

Only two vertical and two horizontal center convergence magnets are on the convergence assembly (Figure 18), plus terminals for adding or removing a set of coils from the circuit. The small convergence board has only about six adjustments. One unique difference, compared to the delta circuits, is that **most of the convergence correction is applied to an extra winding** (or windings, it's difficult to see inside) **of the deflection yoke.**

Recommended Servicing Methods

These are the servicing methods we have found to be most effective for identifying convergence problems:

- Tune in a stable crosshatch pattern, which allows you to see all vertical and horizontal lines;
- Lock the TV vertical and horizontal to the crosshatch pattern, then check and correct (if necessary) any problems of improper width, height, and linearity;
- Check the purity of all three colors, and readjust it if necessary;
- Try all adjustment controls to determine if an average amount of line movement can be obtained (controls that do not respond, or the components connecting to them, should be suspected);
- Visually examine the board area around any coils or controls that do not control the lines correctly;
- If the core of a coil is stuck, or if turning the core doesn't produce the desired action, check the core for cracks in the powdered iron. Remove each suspected core and substitute one for another coil, as a test;
- Operate the receiver for a time (perhaps 10 to 15 minutes), turn off the power, and feel the coils, controls, and resistors for any excessive heat. **Coils having shorted turns often operate too hot;**
- Check in-circuit the forward and reverse resistances of the diodes. Remove any suspected ones for external resistance tests;
- Remember that multiple-diode assemblies have been known to cause hard-to-find intermittents. Replace the entire assembly, if there is any question;
- If all vertical (or all horizontal) adjustments of one color have little or no effect, check the resistance of the proper convergence coil on the neck of the picture tube. Some opens or intermittents have been found where the two halves of the winding are connected:
- Waveform analysis in convergence circuits is not very accurate, but a definite change of waveform or amplitude should be seen on a scope when it's connected across a coil or control, and the adjustment is changed; and
- When none of the adjustments are strong enough, suspect wrong positions of the convergence yoke. Remember that circular or front-to-back errors of more than ¼ inch can be important. □

TV TUBE STOCK

By Gill Grieshaber, CET

These were the fast-moving TV tubes during 1976 in my shop. We service all brands, but do few warranty repairs.

Local conditions, such as the number of carry-in portables, or any unusually-high sales of one brand in your area, can change these figures. Therefore, you should adjust your buying, just as soon as a trend becomes apparent. Larger shops should expect to stock multiples of these quantities.

An arrow pointing upward beside a quantity indicates the sales have increased recently, and a downward arrow shows decreased sales of the tube.

TUBE Type	Quantity	TUBE Type	Quantity	TUBE Type	Quantity	TUBE Type	Quantity
1G3/1B3	1 ↓	6BS3	1	6HA5	2	6LQ6/6JE6	10 ↓
1V2	1 ↓	6BW3/6DQ3	2	6HB7	1	6LR6	2
2AV2	1 ↓	6BZ6	1 ↓	6HF5	1 ↓	6LT8	1
2BV2	1 ↓	6CB6	1 ↓	6HQ5	2	6LU8	2
3A3	10 ↓	6CG3/6CD3/		6HS5	2 ↓	6LY8	2
3AT2	2 ↓	6CE3/6DT3	4	6HS8	1	6MD8	1 ↓
3AW2	1	6CG8	1	6HV5	4	6T10	1
3BS2/3BT2/		6CJ3	2	6HZ6	3	6U10	1
3BW2	1	6CL3	3 ↓	6J10/6Z10	2	6X9	1 ↓
3CN3	1	6CM3	1	6JA5	1 ↑	8FQ7	1
3DB3	1	6CS6	1 ↓	6JB5	2	8LT8	1 ↓
3DF3	1	6DS4	1	6JB6	1 ↓	10GK6	1 ↓
3DG4	1	6DQ5	1	6JC6	2 ↓	12AU7	1
3DJ3	3 ↑	6DW4	10	6JD6	1	12AX7	1 ↓
4BZ6	1	6DX4	1 ↓	6JF6	1	12BY7	2
4DT6	1 ↓	6EA7/6EM7	1 ↓	6JH6	1 ↓	12CL3	1
4EH7	1 ↓	6EA8	1 ↓	6JK5	1 ↑	12GW6/12DQ6	1 ↓
4EJ7	1	6EC4	1 ↓	6JS6	4	12HG7/12GN7	2 ↓
5GH8	2	6EH7	1	6JT8	1	12HL7	2 ↑
5U4	1	6EJ7	2	6JU8	2	17BS3	1
6AD10	1 ↓	6EN4	1	6JW8	1	17CT3	1 ↑
6AF9	1	6EW6	2	6JZ8	1	17JZ8	1
6AG9	1 ↓	6FM7	1 ↓	6KA8	2	17KV6	1
6AL5	1 ↓	6FQ7	5	6KD6	3	19CG3	1
6AQ5	1 ↓	6GE5	1	6KE8	2	21GY5	1 ↓
6AS5	1 ↓	6GF7	3	6KM6	1 ↑	21LR8	1 ↓
6AU4	1	6GH8	10 ↓	6KN6	1	23Z9	1
6AU6	1	6GJ7	1 ↑	6KT8	2	24LQ6	1
6AW8	1 ↓	6GM6	2 ↓	6KZ8	2 ↓	26HU5	1 ↓
6AX4	1	6GN8	1 ↓	6LB6	4	31JS6	1 ↓
6BA11	1	6GU7	6	6LE8	1	33GY7	1 ↓
6BE3	1 ↓	6GW6/6DQ6	1	6LF6	1	34CE3	1
6BK4	10 ↓	6GX6	use 6HZ6	6LF8	1	35LR6	1
6BL8	2	6GY6	use 6HZ6	6LH6/6LJ6	2	36MC6	1
6BQ5	1	6GX7	1	6LJ8	1 ↑	40KD6/36KD6	2

Note: ↑ indicates sales are increasing
↓ indicates sales are decreasing

PLL...A New Brain For CB Radios

By Marvin J. Beasley, CET

All of the new 40-channel CB radios have Phase-Locked Loops (PLL's) to generate the receive and transmit frequencies, using just a few crystals. These PLL's include both digital and analog circuits, and you need to understand the operation of this important development.

Will the diagnosis and repair of a defect in the circuit shown in Figure 1 be a "nightmare" or a "piece-of-cake"? You can keep it from being a nightmare, if you thoroughly understand the circuit operation.

This circuit is a Phase-Locked Loop, which is usually shortened to PLL. A quick look at a typical schematic will convince you that the circuit is complicated. Why, then, should the CB-radio manufacturers decide to use it in preference to other systems, such as the frequency synthesizer? The reasons can be condensed into these three words: cost, scarcity, and performance.

Even when the 23-channel radios required 14 crystals, a shortage of crystals had begun. Therefore, building millions of new CB radios for 40 channels, with each radio having perhaps 25 crystals, certainly is not practical, considering the cost and scarcity of good quartz crystals.

In contrast, a PLL circuit might have only one, two, or three crystals (depending on model and design) to generate the 80 frequencies (40 for transmitting and 40 for receiving) needed for the new allocation of 40 CB channels. The cost factor is obvious; we'll discuss the improved performance later.

Analog Plus Digital

One mental roadblock on our way to complete understanding of PLL's is the combination of analog and digital principles. Most analog stages amplify the signal, making good linearity desirable. The signal usually varies both in amplitude and waveform.

Digital circuits seldom amplify; unity gain is the norm. Waveforms of the signal usually are pulses or square waves, which are important only for the peaks, for these determine the "states". One peak is at supply voltage ("high") and the other is near zero ("low").

However, the digital circuits in PLL's either have DC switching voltages, or dividers which are self-contained inside IC's, so they are analyzed as "black boxes". Therefore, troubleshooting these circuits probably is easier than other types of digital devices.

Before analyzing the operation of PLL's, we'll take a short look at conventional heterodyne synthesizers.

Crystal-Controlled Heterodyne Synthesizers

A total of 46 crystals would be necessary for the original CB circuits which had one transmit crystal and one receive crystal for each channel. Figure 2 shows that a careful selection of crystal frequencies in a heterodyne-type of frequency synthesizer can reduce the crystal count to 14. If synthesizers were used in the new 40-channel CB radios, it's likely 25 crystals would be required. Of course, such a large number cannot be considered. This leaves PLL's as the only practical solution to the crystal problem.

PLL's Are Not New

Phase-Locked Loop circuits are not new, but many additional uses have been found for them lately. One example of an old PLL circuit is found in the horizontal locking of TV receivers (see Figure 3). Both the television and digital names for the stages are given on the block diagram, so you can become accustomed to the unfamiliar ones. The AFT action in TV receivers is very similar; however, the phase detector has only **one** input signal. When the frequency changes, a DC voltage is developed because of the changing **phase** of the signal.

Well-designed circuits such as these can be depended on to keep the output signal locked to the desired phase and frequency of the standard signal (horizontal sync, in one example). At least, they can over a narrow range of frequency. Broader pull-in and locking ranges require a DC amplifier between the low-pass filter and the oscillator. DC amplifiers in CB PLL's permit solid locking over a wide range of frequencies.

There's one serious limitation, if we want to adapt the circuit to other applications: the standard signal (sync) and the output signal (drive for the horizontal-output stage) have the **same** frequency.

For other applications it is desirable for the standard and output frequencies to be different. Sounds difficult, but it isn't.

Even with analog circuits, it's possible to fool the simple PLL of Figure 3 into locking at specific

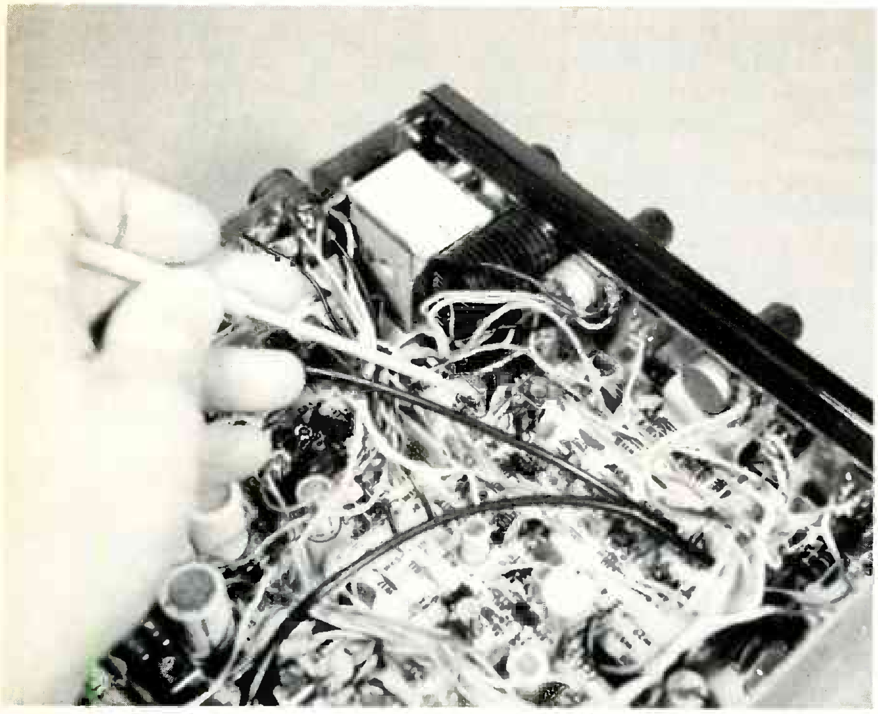


Fig. 1 The reference-frequency crystal of this Johnson PLL is pointed out by the alignment tool. Just to the right is the large IC, and beyond is the combination channel switch and digital readout.

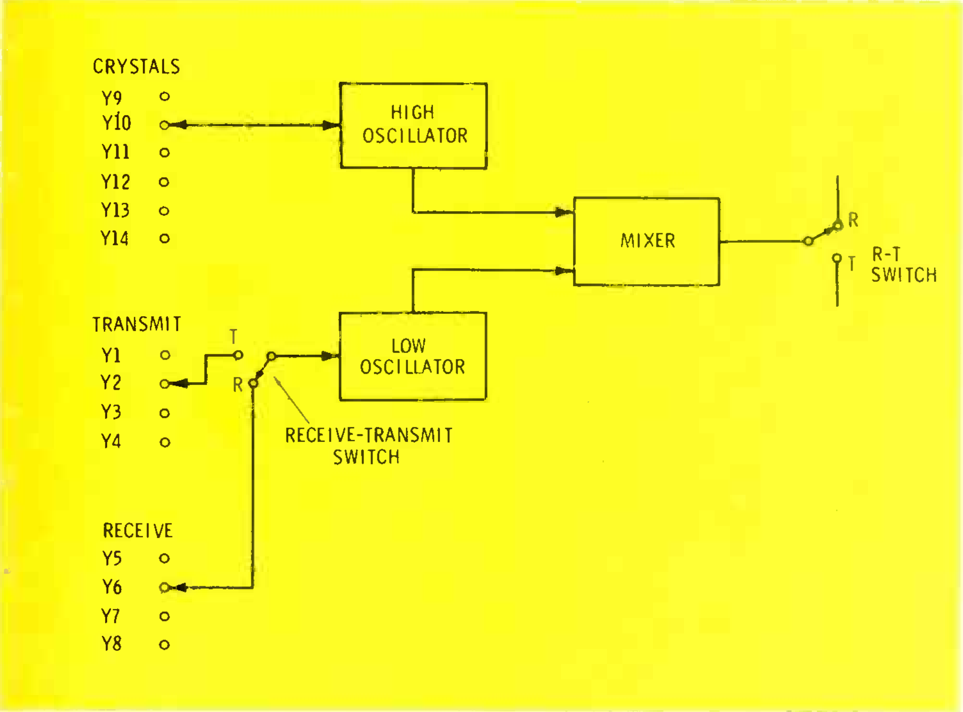


Fig. 2 Heterodyne frequency synthesizers were developed to reduce the number of crystals (46) that previously were necessary for 23 CB channels. By combining in a mixer stage the RF outputs of two crystal oscillators, extra sum-and-difference frequencies are produced. A proper selection of 14 crystals can supply the 46 frequencies necessary for receive and transmit of 23 channels.

multiples of frequency. A resonant circuit, tuned to the **third** harmonic of the standard signal and inserted at point "X" between the standard signal and the phase detector will cause locking at the third harmonic of the standard signal. **This is frequency multiplication;** the frequency of the output signal is three times that of the standard.

Alternately, adding a resonant circuit tuned to the **third** harmonic of the **desired** output frequency and inserting it at point "Y" will produce phase-lock with an output frequency that's one-third of the standard. **This is frequency division.**

Notice, in both cases, that when locking occurred, both signal inputs to the phase detector had identical frequency. So, **the secret of obtaining either higher or lower output frequencies** (relative to the standard) **is to add a frequency-changing device in series with one or both of the input signals to the phase detector, making the sample conform to the standard.**

Locking to harmonics doesn't give much choice of output frequencies, but by making some minor changes, it's possible to increase the number of phase-lock output frequencies. This is where digital circuits are far better than analog.

Include A Divider

Several changes are required to improve the simple PLL so it will operate over a larger range of output frequencies (Figure 4). First, the phase detector with the double diodes is replaced with a phase comparator, which might be a flip-flop multivibrator arranged so the widths of the output pulses vary with the differences of frequency and phase between the two signals coming into the comparator. After filtering, the output pulses become a DC voltage of a value determined by the width of the pulses. Incidentally, the filtering prevents locking at the **sum** frequencies. A tiny trace of the desired frequency fed into an oscillator along with the DC error-correcting voltage helps the locking. Without filtering, both the difference and sum frequencies would be present in the DC control voltage. This might tend to pull the oscillator to the wrong frequency.

An amplifier stage increases the amplitude of the error-correcting DC voltage. Higher gain in the loop increases the accuracy of the locking.

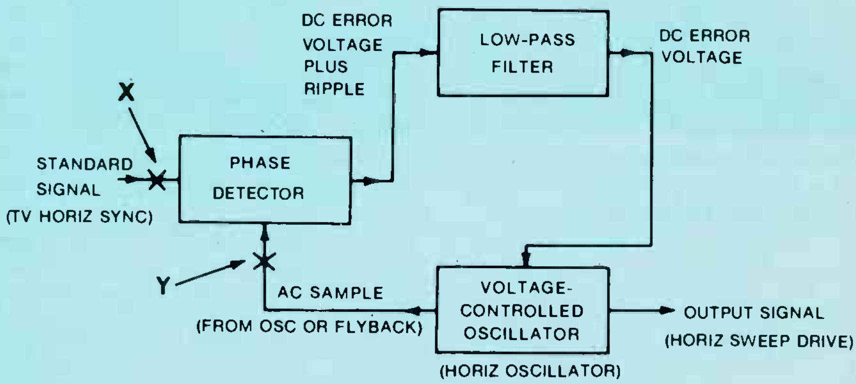
Controlling the bias of an oscillator transistor or tube (often the case with horizontal oscillators) cannot change the frequency as much as is desired in most PLL's. So, a varicap diode is used to provide a wide choice of frequencies when controlled by the error DC voltage.

Finally, a digital frequency divider is placed between the oscillator and the phase comparator. Closed-loop locking varies the frequency of the AC-sample signal at the phase comparator until it matches that of the standard signal (usually a crystal-controlled oscillator). That forces the frequency of the VCO (and the output signal) to be higher than the standard frequency by the same multiple as the division of the divider.

In other words, if the divider has a ratio of 15, the output frequency must be 15 times that of the standard. The number of possible output frequencies is limited only by the divider ratio. However, these are the limitations: the output frequency always is higher than the standard frequency; and the frequencies are in steps which are equal to the standard frequency. For example, if the standard frequency is 1 MHz, the output frequency might be 2 MHz, 3 MHz, 4 MHz, and so on, in 1 MHz steps, depending on the divider ratio.

CB channels are spaced every 10

Fig. 3 These are the stages necessary for frequency control by the Phase-Locked Loop (PLL) principle. Many AFC stages for horizontal oscillators in TV's are PLL's. The TV stages are listed in parentheses. The limitation of this circuit, when adapted to other applications, is that the standard and output signals have the same frequency.



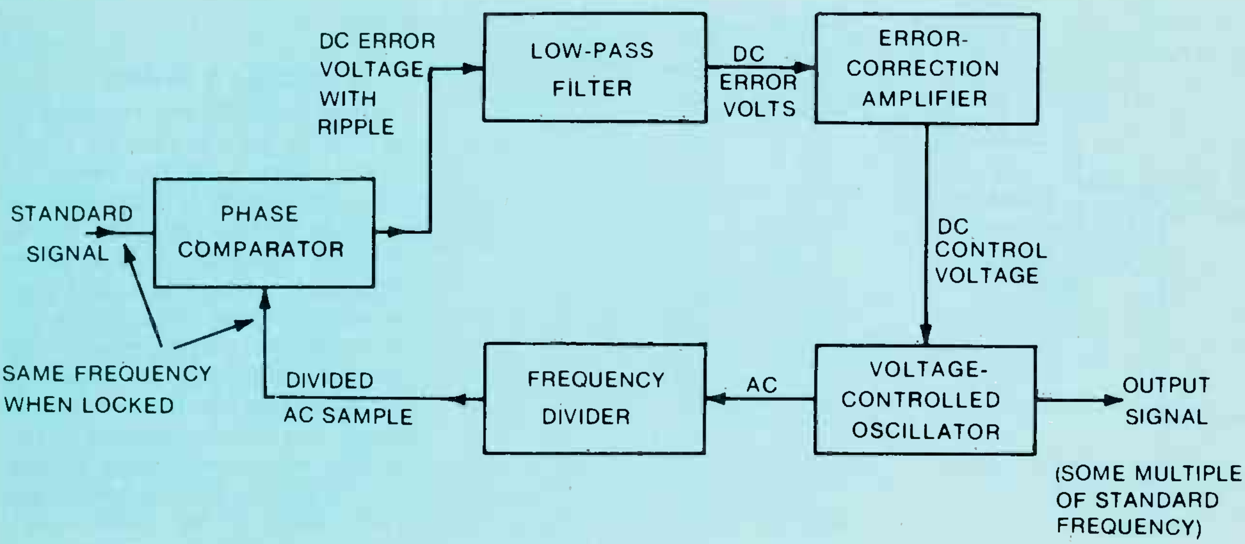


Fig. 4 Addition of a frequency divider to the sample signal before it reaches the phase comparator tricks the voltage-controlled oscillator (VCO) into producing multiples of the standard frequency. Notice that the two inputs to the phase comparator continue to have the same frequency when locked. **The output frequency depends on the standard and the ratio of the divider; it equals the standard frequency times the "divide-by" of the divider.** The limitation is that a fixed-ratio divider allows only one output frequency.

KHz, so the circuit of Figure 4 can work properly only when the standard signal measures 10 KHz. However, it's a long jump up to 27 MHz, and there are other problems. More circuit refinements are necessary.

At Last, 27 MHz

Figure 5 shows the block diagram of a practical PLL for CB transmitter use. Crystal oscillators for 10 KHz are difficult to build. Instead, a higher-frequency standard is chosen, with a following fixed divider to provide 10 KHz to the phase comparator.

Next, the fixed divider for the AC-sample voltage is replaced by a programmable-frequency divider. These dividers change ratio according to the switching of several control voltages in Binary-Coded Decimal (BCD) logic. Because the reference is 10 KHz, the VCO frequency changes by 10 KHz each time the divider changes one step. For example, dividing by 928 makes the VCO frequency 9.28 MHz; or dividing by 929 gives 9.29 MHz.

However, it isn't possible to divide even more and obtain the transmit frequency directly. Dividing by 2725 provides 27.250 MHz, and a division by 2726 gives 27.260 MHz, but Channel 23 is 27.255 MHz. The CB channel frequencies are **not** divisible by 10. The reference frequency could be 5 KHz, but this would require a division by 5451 for Channel 23.

Therefore, some models include another crystal oscillator, which, along with the VCO, feeds the mixer. Sum-or-difference frequencies from the heterodyne mixing can provide the correct channel frequencies.

The other reason for the additional oscillator is to provide the receive frequency, which always is above or below the transmit frequency by the frequency of the first IF in the receiver. Changing the PLL from receive to transmit could consist of switching-in the proper crystal.

Notice that the same two crystals are used for all transmit frequencies, so all channels will have exactly the same accuracy (or error). Likewise, all of the receive frequencies have the same accuracy.

We are ready now to examine the circuit actions of one PLL. There are many other variations, and our explanation does not necessarily apply to them. We will cover the other types at a later date.

Johnson PLL

The block diagram of an E. F. Johnson 23-channel Phase-Locked Loop digital synthesizer (originally developed for the Messenger Model 191) is given in Figure 6.

This PLL is nearly the same as the example in Figure 5, although it doesn't appear that way at first.

The drawing is turned around from the example, because several of the basic circuits of the Johnson PLL are inside one IC (U101).

The oscillator for the standard frequency (crystal Y101 and part of U101) does double duty, supplying the comparator, and also furnishing a signal to the offset mixer. The oscillator labeled "high oscillator" is the one we mentioned as being necessary to solve the problem of the channel frequencies not being divisible by 10. In addition, the high oscillator has one crystal for transmit and another for receive.

Output from the VCO does not go directly to the programmable divider, but first goes through the "synthesizer mixer" and the Q106 amplifier before reaching the divider (which is inside of U101).

Now that you are oriented to the locations of the various stages, we'll start the circuit analysis.

Transmit Operation

When any circuit has a closed loop, it's difficult to know where it all starts. Where is the beginning, and where is the ending of a circle? Although the Voltage-Controlled Oscillator (VCO) can be considered as the heart of a PLL circuit, any explanation starting there gets very confusing. Actually, you need to know everything at once, so keep in mind the purpose of each stage, as we start with the channel switch and the frequency standard.

Crystal-controlled frequency standard

Crystal Y101 and part of IC U101 comprise the oscillator of the 5.120-MHz frequency standard, that's used as a reference for the VCO signal. Because a frequency of 10 KHz is needed at the phase comparator, the signal goes through a "divide-by-512" non-adjustable divider, and the 10-KHz output is sent to the phase comparator (the divider and the comparator both are inside U101). These conditions and frequencies do not change, regardless of the channel selected or the receive/transmit mode.

When the loop is locked, the other comparator input (from the programmable divider) also **must** have a 10-KHz signal. In fact, **the PLL will vary the frequency of the VCO until the 10-KHz frequency is obtained.**

Channel switching

The main duty of the channel-switch contacts, the switching-logic IC's (U102 and U103), and the programmable divider is to select the proper divider ratio so that the number on the channel dial and the transmit output frequency both are correct for the channel desired.

Up to Channel 23, the programmable divider operates from a hexadecimal code (six numbers). One section of the channel switch activates U102 and U103, which are connected as NAND gates. In turn, they determine the DC voltages at 4 divider pins of U101. Voltages at two other divider pins are controlled directly by the channel switch. (Above Channel 23, the 40-channel models also control two more divider pins, making a total of eight pins. More about that later.)

On Channel 1, the divider ratio is 81, for Channel 10 it's 92, and for Channel 23 the ratio is 110. All "divide-by" ratios are determined by the "high" or "low" state of the six inputs to the programmable divider.

Comparator and VCO

Inside U101 is the phase comparator. It is not a duo-diode type, but uses a type of pulse-width modulation. From the comparator, comes a DC voltage; a zero voltage when the two input frequencies are identical (phase locked), and a negative or positive voltage when the two frequencies are not the same. The polarity is such that it changes the VCO frequency in the direction necessary for phase-lock at the comparator. Major errors of frequency produce large voltages, and the voltage becomes smaller as the error is reduced.

However, the varicap diode (CR101), which determines the VCO frequency, requires a reverse

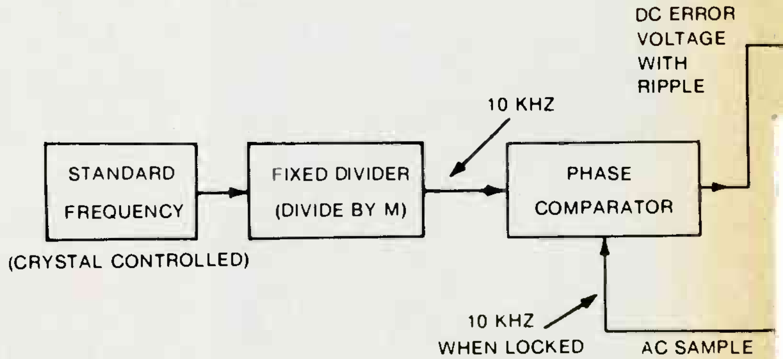


Fig. 5 The previous schematic plus changes and additions becomes a practical PLL for a CB radio. In order to produce 10-KHz steps, the phase comparator requires 10 KHz at both inputs. A fixed divider changes the standard frequency to 10 KHz. A programmable frequency divider replaces the one-ratio divider shown previously. It is controlled by switching circuits. Output of the VCO is in 10-KHz steps, but the channel frequencies are not divisible by 10 KHz, so another crystal oscillator is necessary to permit the channel frequencies to end in 5 KHz. Another requirement, not shown, is for a frequency change during receive.

voltage (positive to the cathode). Consequently, a fixed positive bias is added to the variable-polarity voltage from the comparator. Following filtering of the error-correcting DC voltage, the voltage at the varicap diode might swing from near zero to about 6 or 7 volts, according to the amount of frequency error, with phase-lock occurring at about +3.5 volts.

Of course, it is true that the varicap voltage **must** be different for each channel. When the operation is normal, the varicap control voltage (at TP1) should change slightly with each channel selected. If the circuit can't achieve phase-lock, the voltage will be too high or too low, and probably not change with each channel. This voltage can provide important clues during troubleshooting.

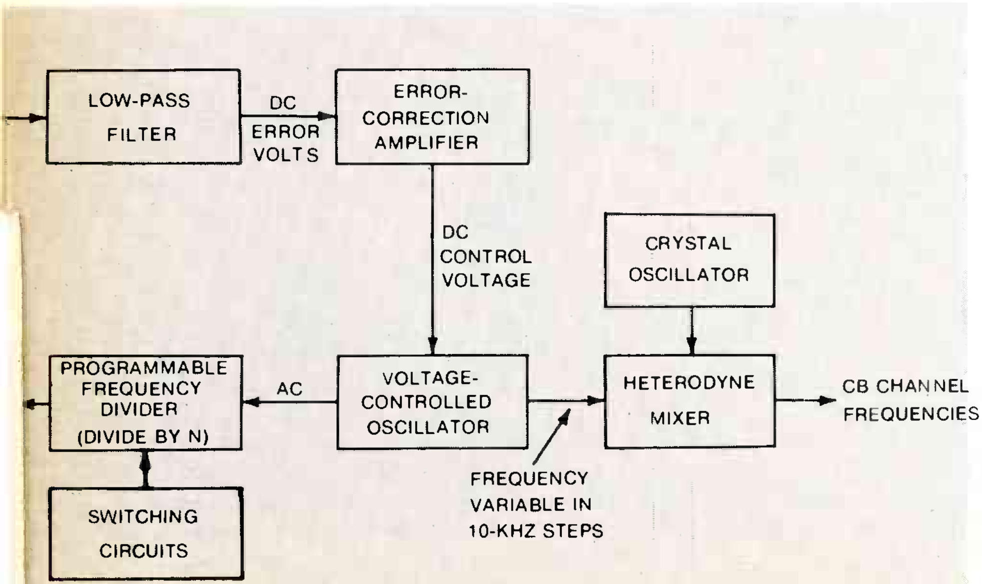
High oscillator and mixer

Output frequency from the VCO is not the final or desired frequency, either for the receive/transmit functions, or for the sample signal for the programmable divider.

So, the Q104 "high oscillator", Q105 "synthesizer mixer", and the Q106 "amplifier" stages have these **three** functions:

- They act as a strange kind of divider, giving a frequency reduction of slightly more than 34 for Channel 10, and more than 29 for Channel 23. The purpose is to obtain a lower frequency that can be handled by the CMOS programmable divider. The difference frequency between the VCO and the high oscillator ranges from 810 KHz at Channel 1 to 1.1 MHz at Channel 23. That is the sample signal at the output of the amplifier, Q106.
- The high oscillator supplies the extra carrier (having a frequency ending in 5 KHz, such as 31.275 MHz for Y103) that must be mixed with the output of any VCO which is controlled by this kind of divider (produces only frequencies that are divisible by 10). The problem was explained before.
- It's easy to obtain the necessary 455 KHz decrease of PLL frequency during the receive function by switching in quartz crystal Y103 for transmit and Y102 for receive. This switching is done with diodes. CR105 is forward biased into conduction by the transmit B+, thus grounding the low side of Y103 for transmit. Then for receiving, CR104 is made conductive by the receive B+ and Y102 is properly grounded. The diode switching eliminates any need for additional talk/listen contacts, for the two B+ supplies already are selected by the talk/listen switch.

Those are the stages and their functions in the Johnson PLL,



except for the "offset mixer" and the output switching.

Offset mixer and diode switching

At first, I could not understand why a sample of the 5.120-MHz carrier and a sample of the VCO output were fed to the "offset mixer". Of course, the VCO output frequency was not correct for any CB channel, but the divider **could** have been re-programmed to supply it. A Johnson design engineer gave me the answer: when the VCO operates on the same frequency as the RF 4-watt power output stage, there is a possibility of a few radios suffering a feedback between those two circuits. This would appear as a small amount of FM, and the transmitting carrier would be wider than usual. To prevent any chance of such a problem, the VCO is operated at another frequency, then the 5.120-MHz carrier heterodynes it to the correct channel frequency.

CR102 and CR103 are operated as voltage-controlled switches, routing the transmitter signal to the transmitter predriver, and the receiver signal to the receiver mixer. They are keyed by the two B+ supplies.

PLL for receive

Functions of the PLL are the same during receiving as for transmitting, except for the two circuits that are switched by diodes. However, many of the frequencies are different, so we have included a block diagram of the receive mode (Figure 7). The frequencies are for Channel 10, and the stars indicate the frequencies that are different for each channel.

Overall Operation

To make sure we have not gotten buried under a multitude of facts, let's briefly go through the basic operation, in slow motion.

Suppose the receiver is tuned to a channel, and all circuits are working correctly. Then, we turn to another channel, temporarily interrupting the phase-lock. For a split second, the VCO remains on the frequency of the previous channel. However, the programmable divider

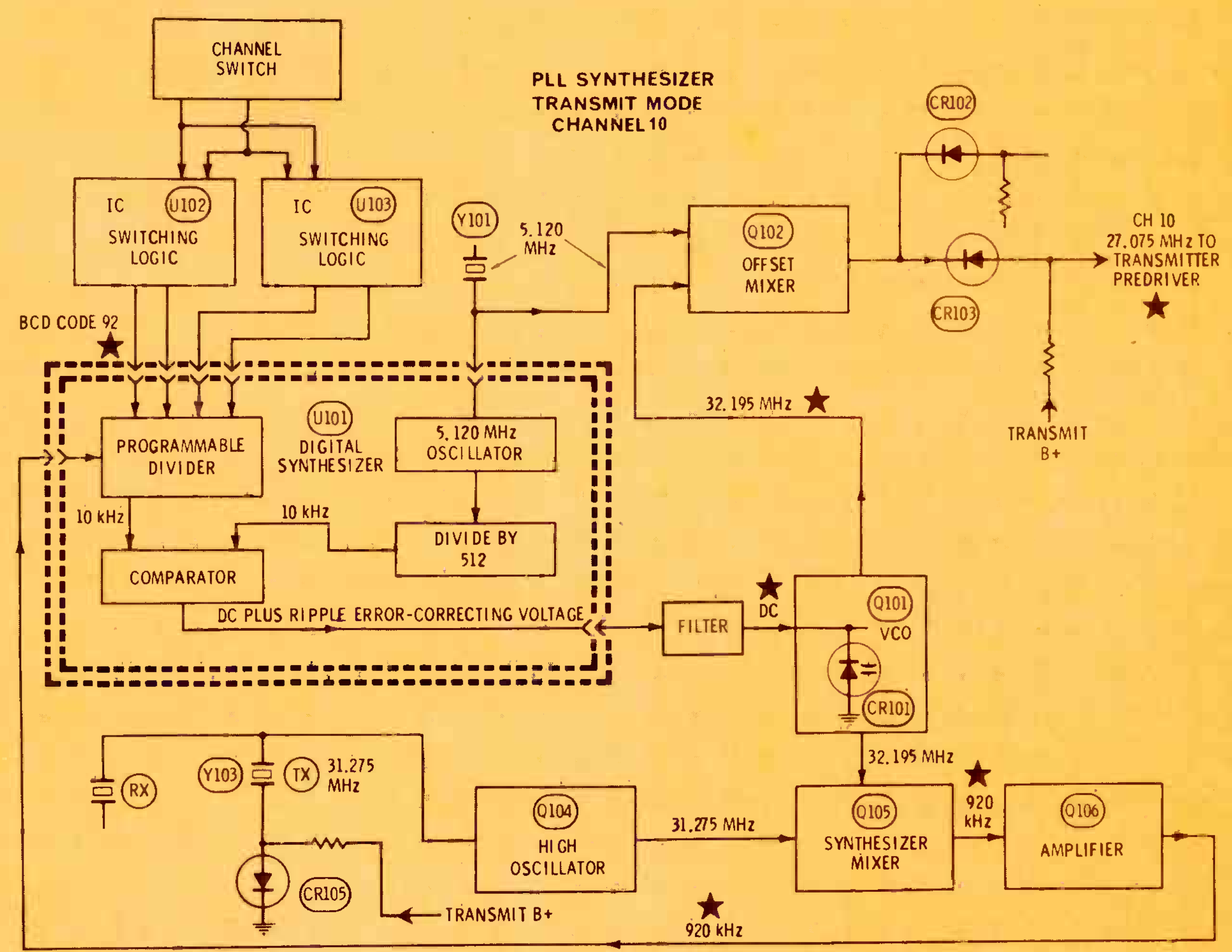


Fig. 6 This E. F. Johnson PLL has the same general circuit as the one in Figure 5. It is drawn differently because several basic stages are inside U101 Integrated circuit. The frequencies are the ones for transmit on Channel 10, and the ones with stars are different for each channel.

Chart 1

Johnson Phase-Locked Loop

Channel	Divide-By Number	12	13	14	15	2	3	4	5	Transmit Frequency
		U101 Pin State								
1	81	1	0	0	0	0	0	0	1	26.965 MHz
5	86	1	0	0	0	0	1	1	0	27.015 MHz
10	92	1	0	0	1	0	0	1	0	27.075 MHz
23	110	1	0	1	1	0	0	0	0	27.255 MHz
30	115	1	0	1	1	0	1	0	1	27.305 MHz
40	125	1	1	0	0	0	1	0	1	27.405 MHz

Note: The first number of two-digit "divide-by" numbers (or the first two numbers of 3-digit "divide-by" numbers) determines the binary code for U101 pins 12, 13, 14 and 15. The second number of the two-digit "divide-by" numbers (or the third number of the 3-digit "divide-by" numbers) determines the binary code for U101 pins 2, 3, 4 and 5.

Decimal-To-Binary Conversion

Decimal	Binary
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
10	1010
11	1011
12	1100

Chart 1 The "divide-by" number of the programmable divider applies to the Johnson PLL (other brands probably have different numbers), while the "pin state" uses conventional binary "high" and "low" states. Enough examples of decimal-to-binary conversion are given for you to check the programming. For example, the state for pins 12, 13, 14 and 15 are for the first divide-by number, and the second number gives the states for U101 pins 2, 3, 4 and 5. Channel 10 has divide-by 92. From the conversion, 9 is 1001, and 2 is 0010, for a total code of 1001/0010 for U101.

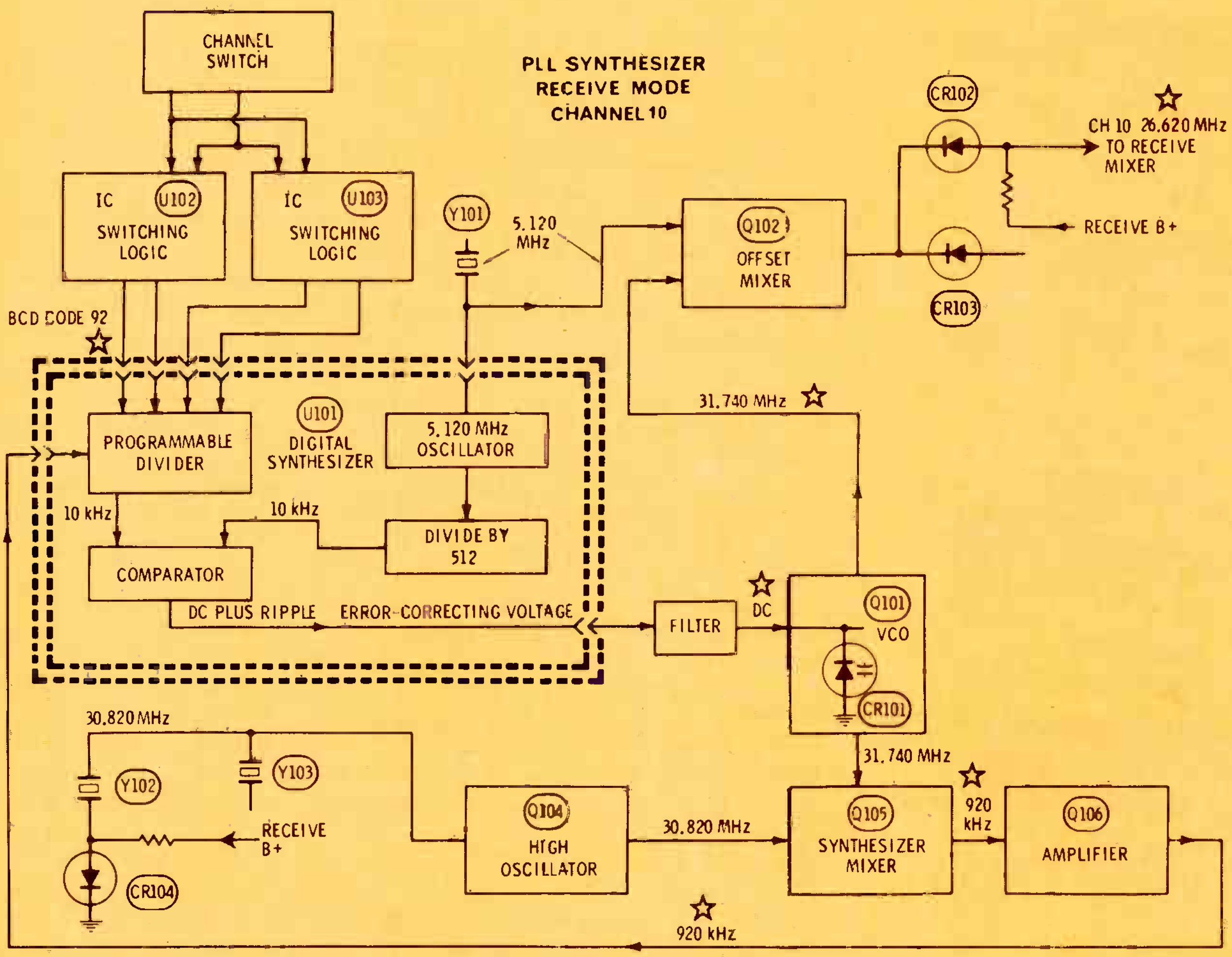


Fig. 7 The receive-function block diagram is the same except for the Channel 10 receive frequencies, and the diode keying of the high-oscillator crystal and the output from the offset mixer.

has changed to another code, so the signal sent to the phase comparator is **not** 10 KHz.

Because the two input signals at the comparator do not have the same frequency and phase, an error voltage is generated and sent toward the varactor diode in the VCO. However, the AC filter slows down the travel time of the DC voltage, thus making the correction a gradual operation.

The change of varactor voltage swings the VCO frequency slightly, forcing the slave frequencies (output of the synthesizer mixer, and output of the programmable divider) to follow in turn. This brings th PLL nearer to phase-lock, which reduces the amount of DC correction voltage. It is a gradual process, somewhat like a car braking to a stop at a certain point. When the phase-lock is accomplished, the correction voltage virtually is zero.

Main job of PLL

The PLL has just one automatic and single-minded purpose, to vary the VCO frequency until the two input signals to the phase comparator have the same frequency and phase. That's all! Then it's up to the other stages to take the phase-lock condition and produce the correct channel frequency.

Reverse look at PLL

Now, the VCO signal travels through the synthesizer mixer (which acts as a kind of divider) and the programmable divider to the comparator. Also, it's certain the signal can't retrace the same path back to the VCO. Yet, it helps us understand the PLL operation better, if we start with the 10-KHz sample signal at the comparator, and mentally trace the signal backwards through the divider, the synthesizer mixer, and to the VCO. Visualize these dividers as frequency multipliers, as you do this.

Refer to the frequencies in Figure 7. The sample signal at the comparator is 10 KHz (we're assuming phase-lock), and the divider is programmed for code 92. Multiply the 10 KHz by 92. The answer is 920 KHz. Mix this with the high-oscillator receive frequency of 30.820 MHz, taking the sum product. The frequency now is 31.740 MHz. That's exactly the value needed for Channel 10 receive VCO.

Go one more step by mixing the 5.120 MHz signal in the offset mixer, and taking the difference product. Now, the frequency is 26.620 MHz, the correct Channel 10 receive frequency, and just 455 KHz less than the transmit frequency multipliers as you do this.

Doesn't this reverse view of the PLL help clarify your overall concept?

Divider Programming

In the discussion of channel switching, we mentioned that the divider is programmed by selecting the proper "high" state (+10 volts) of the "low" state (near zero) for six pins of the internal divider.

However, the divider is capable of many more ratios, but two more pins of the IC must be switched. (In the 23-channel version, these two were connected to B+ and ground.) That makes eight logic control points.

Also, the switching logic IC's (U102 and U103) have been eliminated. The channel switch has been changed to include the extra switch contacts.

Most of the CB radio manufacturers include in the service manuals the programming tables for the PLL's, so you don't have to become a mathematician, when you need the information during troubleshooting.

Chart 1 lists just a few representative figures for the 40-channel Johnson PLL.

Another advantage of the digital programming is that it is compatible with digital readout circuits. LED channel numbers can be added at only moderate extra cost. This is a valuable feature; a dial with 40 numbers on it would hardly be readable; while the digital numbers can be read at a glance.

Comments

In future articles, we'll present some detailed troubleshooting procedures for PLL's. For now, here is this one tip: determine by tests and symptoms whether wrong frequencies are caused by a programming defect, or from a malfunction in one or the other of the oscillators. □

Reports from the test lab

By Carl Babcoke

Each report about an item of electronic test equipment is based on examination and operation of the device in the ELECTRONIC SERVICING laboratory. Personal observations about the performance, and details of new and useful features are spotlighted, along with tips about using the equipment for best results.

Fig. 1 The VIZ Model WD-750A Digital VoltOhmyst has the features most needed for TV and electronic servicing, including high accuracy of readings, auxiliary analog meter, low-power ohms, plus extra voltage and resistance ranges.

VIZ products probably seem familiar to you, although the name might not be. For many years, VIZ designed and manufactured test equipment that was marketed by RCA. Last December, VIZ also obtained the distribution rights for the entire line. Other items have been added since then. These are the reasons why the instruction books (and even a few of the instruments) have the name "RCA" on them.

VIZ Model WD-750A Digital VoltOhmyst

This new digital multimeter (Figure 1) seems to be a worthy successor to the famous VoltOhmyst VTVM.

Here are some of the basic specs and features:

- automatic polarity indication for DC volts and current;
- automatic zeroing for all functions;
- 3½ digits with bright 0.45-inch red LED's;
- the automatic overrange causes the digits to flash rapidly in a random reading;
- an analog meter, with an uncalibrated sensitivity control, gives conventional swings of the pointer for peaking and nulling readings;
- all ranges and functions are selected by push-buttons;
- one pushbutton selects either low-voltage or high-voltage for resistance readings;
- each range button positions the decimal;
- the AC and DC volts, AC and DC current, and resistance functions have five ranges. In addition, a separate 20-megohm button is provided; and
- provisions are made for internal Ni-Cad batteries, if desired.

The readout conforms to that of most 3½-digit meters. The highest reading is 1999. Above this figure, overrange occurs. For example, the 2-volt range reads up to 1.999 volts, but any increase of voltage does not produce 2.000 volts; overrange is triggered instead. It might be explained as a 1000 readout with a 100% overrange (less one count).

DC volts

Five DC-voltage ranges are provided: 0.2 volt (200 millivolts) and 2, 20, 200, and 1200 volts. The positive or negative polarity sign is displayed automatically. It's not necessary to reverse the test probes. Tests showed that the readings changed by no more than one digit, when the probes were reversed, thus forcing a change to the other polarity. That's good performance; not all analog meters can pass this test.

Accuracy of the DC voltage ranges is 0.1% of reading ±1 digit, and the input resistance is 10 megohms. Several test readings were almost identical to those of another brand of meter having similar accuracy ratings.

AC volts

Ranges of RMS AC voltage are the same as those for DC, and the input resistance also is 10 megohms. Typically, the accuracy of any meter is less for AC than for DC. The specs show ±0.75% ±2 digits between 45 Hz and 4 KHz, and ±2.5% ±2 digits between 4 KHz and 10 KHz. I believe the Model WD-750A exceeds that frequency accuracy.

These ratings bring up one characteristic of many digital meters that usually is buried inside many figures: frequency response. The desirable 10-megohm input resistance often costs two trade-offs. One is the loss of peak-to-peak readings (I don't know of any digital meter that offers such a calibration), and the other is the possibility of narrow-band frequency response. (One meter of another brand rolled off drastically above 4 KHz.)

I am happy to report that the WD-750A meter has excellent frequency response; as good as any similar meter I have checked. The variation in the usual hi-fi audio range between 20 Hz and 20,000 Hz was less than 1%; and, even at 100 KHz, the reading was only about -8%.

Think about that for practical audio measurements. One dB is about 11%, and few specs for hi-fi equipment demand any higher accuracy than about 0.2 dB. That's about 2%. Now, look at the previous paragraph again. For all except the most precise audio frequency-response or voltage measurements,

continued on page 54

Fig. 2 This photo shows the unretouched 0.45-inch LED display, and the pushbutton operated switches, including those for the separate 20-megohm resistance range, the "LP" ohmmeter voltage, and the low-range millivolt, microampere, and 200-ohm functions. (This instrument has the RCA name.)

Fig. 3 The small "analog ref. set" knob should be adjusted to give a useful reading on the "analog reference" meter, for those times when you want a pointer swing, of no particular value except to show maximum and minimum, for peaking and nulling operations.

Fig. 4 The VIZ Model WA-504B/44D Audio Generator has a Wein-bridge solid-state oscillator to supply the low-distortion sine waves, and a Schmitt trigger which reshapes the sine waves into square waves.

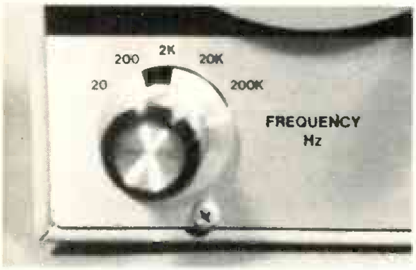
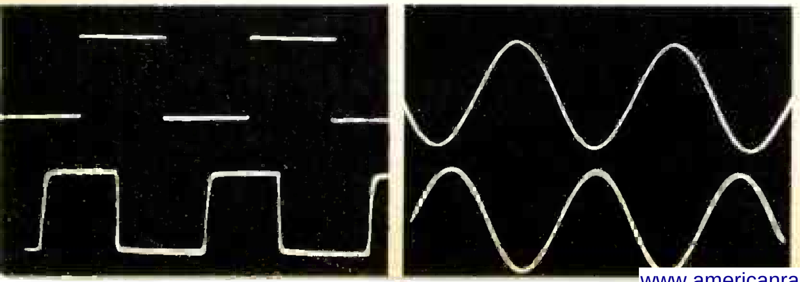


Fig. 5 Limits of each range are indicated by a slit in the knob which shows a black bar between the low and high frequencies.

Fig. 6 Waveforms of the WA-504B/44D are very good. The top waveform of **(A)** shows 20-Hz square waves; and below it are the 200-KHz square waves, which have slightly rounded corners and slower rise and fall times. Over the audio range, the square waves are perfect. In picture **(B)**, the top waveform shows 20-Hz sine waves, and the bottom trace has 200-KHz sine waves. At 1,000 Hz, the sine waves had only 0.22% total harmonic distortion.

A B



Test Lab *continued from page 53*

the readout can be taken as accurate, without any correction factor!

DC current

The DC current ranges are the same as those for DC volts, except they are expressed in amperes, instead of volts. Accuracy is rated at 0.3% of reading ± 1 digit, voltage drop across the meter is 200 millivolts, and a 2-ampere fuse gives overload protection.

AC current

Ratings for AC current readings are similar to those for DC, except the basic accuracy is $\pm 1\%$ ± 2 digits, plus some derating for high frequencies.

Resistance readings

Four of the resistance ranges are direct-reading in thousands of ohms. In addition, the 200-ohms range reads in ohms up to 199.9 ohms, and a separate pushbutton allows readings up to 20 megohms (actually 19.99 megohms).

Another excellent feature is the "LP" button which allows a choice of "high-power" or "low-power" operation (see Figure 2). When you **want** to read the resistances of diodes or transistors, select the high-power mode. At the high end of each range, about 2 volts is applied to the test leads. Near the low end, about 0.1 volt is applied. This is slightly more than that from VTVM's. With infinite resistance across the test leads, the voltage measured about 11 volts.

When you are measuring circuit resistances, and **don't want** the transistor conduction to give erroneous readings, select the low-power mode. Although the open-circuit voltage also is about 11 volts, the highest resistance not causing overrange produces about 0.1 volt across the test leads, and 0.006 volts near the low end of each range.

Only about 1 digit difference of reading was noticed when changing from low-power to high-power. The "hot" test lead is the positive one.

Analog meter

To the left of the digital display is the "analog reference" meter, which gives a conventional reading on the edge-wise scale that has lines for reference, but is marked only "min" and "max", without any calibration numbers. Adjustment of a small knob (without markings except "analog ref. set", as shown in Figure 3) determines how high or low the meter pointer moves.

The analog meter is very handy when you only

Fig. 7 An audio generator usually is thought of in connection with frequency response curves and distortion measurements. But, there are many more uses, such as the one shown here, where an adjustable tone is fed to an amplifier and speaker system to check for buzzes and rattles.

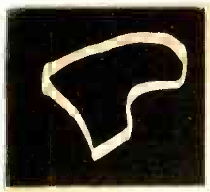


Fig. 8 Another good test, that's probably not done often enough, is to identify an unknown frequency by displaying a Lissajous figure on a scope. Connect the unknown signal to the scope's vertical amplifier, and the output of the audio generator to the external horizontal input. Adjust the gain controls to give approximately equal height and width. Then, adjust the generator frequency until some variation of a circle spins slower, and finally stops. (When the frequency is high, it's difficult to stop the rotation completely. In those cases, slow it enough that you can be certain it is a circle.) **The frequency of the unknown is the same as the generator frequency.** The waveform was made by a signal from a solid-state vertical sweep and a sine wave from the VIZ generator.

want to know minimum or maximum voltage points during certain adjustments, and don't need precise readings. This eliminates the minor irritation of a digital display that flashes when a reading varies.

VIZ Model WA-504B/44D Audio Generator

Four decaded ranges supply low-distortion sine waves or fast-rise-time square waves from 20 Hz to 200 KHz. The compact generator (Figure 4) has a large metal tuning dial with clear calibrations. For fast adjustments of frequency, the center knob can be turned, giving direct drive. Or, the smaller knob can function as a vernier, when accurate or critical adjustments are needed.

An unusual way of showing the tuning limits of each range is supplied by the frequency selector knob (Figure 5). A cut-out in the rim of the knob exposes part of a black area on the panel, showing a black rectangle between the low and high frequencies of the range in use. In the picture, the second range (from 200 Hz to 2 KHz) is in use. This range with other machines might be marked "X10", or 10 times the dial calibration.

Figure 6 shows waveforms of the lowest and highest sine and square waves produced by the generator. Total-harmonic distortion of sinewaves measured 0.22% at 1,000 Hz. Only the most expensive generators have lower distortion.

Two knobs determine the output level. The top one is a variable control, which should be turned to maximum, when exact calibration of the other is desired. The lower attenuator is a four-position switch giving 0.01, 0.1, 1, or 10 volts peak-to-peak.

The circuit provides a constant 600-ohms impedance at all attenuator settings. This unit checked slightly above 11 volts PP, without any external load (the waveforms do not change with or without a load).

No DC appears at the output banana jacks (it does with some square-wave sources), because a coupling capacitor is placed before the attenuator.

Do not connect the generator to a circuit that has DC voltage, unless you first add an external capacitor at the output of the jack. This is to avoid damage to the attenuator.

The operating manual shows and illustrates many uses for the audio generator in traditional audio applications (such as the one of Figure 7, where the generator is helping to find rattles in a guitar

continued on page 56

continued from page 55

amplifier/speaker). However, the generator also is useful in television servicing for finding and measuring the approximate frequency of vertical and horizontal sweep by the display of Lissajous figures (Figure 8).

Comments

The VIZ WD-750A Digital VoltOhmyst performed all of the usual digital functions very well. In addition, I especially liked the analog meter, the choice of ohms voltages, and the added very-low and very-high ohms ranges.

However, another thing that "sold" me on the equipment was the excellent way it passed a little test I made up for digital DC voltmeters. You see, some digital meters give high accuracy when the DC voltage under test is steady and pure DC. But, when used with DC having high ripple or pulses, the reading can be all wrong (one model had a 40% error). So, I try them using two kinds of DC voltage. One source is half-wave unfiltered DC from a rectifier. The other is taken from a vertical-output transistor. The VIZ meter gave very accurate readings from both of these difficult sources.

The operating manuals for the digital meter and for the audio generator contained a wealth of information about the instruments, and how to use them properly in service work. □

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bookreview

Solid State Electronics
Authors: Frank P. Tedeschi and Margaret R. Taber
Publisher: Van Nostrand Reinhold (A Division of Litton Educational Publishing, Inc.), 450 West 33rd Street, New York, New York 10001
Size: 202 pages plus index
Price: $8.95

The authors have compiled fundamental semiconductor and electronic principles into this introductory book to reflect the current state of the art in electronics technology. All information adheres to the IEEE Standard No. 260, Symbols for Units. The book sets out to provide a more comprehensive working knowledge of actual electronic components in practical circuits. Eleven self-contained sections concentrate on specific semiconductor components. Numerous example problems, laboratory experiments, and illustrative aids such as graphs, formulas and actual wiring circuits help bridge the gap between theory and practice.

test equipment report

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RF Generator

Hickok has introduced a general-purpose RF signal generator, having special features for CB radios. Model 256 has four bands for variable tuning of any frequencies from 100 KHz to 16 MHz. These cover the IF needs for AM, FM, and CB radios, plus other applications.

The fifth band is calibrated in CB channels, and gives expanded tuning from Channel 1 to Channel 40.

An internal 1 KHz oscillator provides modulation which is variable

from 0% to 100%, with calibration at 30%. Or, modulation can be produced from an external source.

The RF attenuator has 20-dB steps plus a 20-dB variable control.

Perhaps the most important feature for precision CB work is the extra signal-output jack for feeding a frequency counter. The level is not affected by the attenuator setting, so the accuracy can be as good as the counter that's used.

Model 256 sells for $199 to technicians or repair shops.

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Dry Dummy Load

Coaxial's Model 4260 dry, coaxial RF load contains no oil, so it can be operated at full rating in any position without any messy leaks. Rated at 50-ohms impedance and a maximum average power of 200 watts, the Model 4260 is a suitable dummy load during transmitter testing without RF radiation at frequencies from DC to 512 MHz. □

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CARTOON CORNER

"Next time you need car-radio service, **please** call my competitor."

"Your TV has conked out, Mr. Smith? Great! I'll be right there."

"Better keep that green thumb of yours under control!"

productreport

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Spray-Thru Caps

A new convenience for TV technicians is available in the "spray-thru" caps on **Chemtronics** aerosols. It has been said this is the first time non-removable caps of this type have been used in the electronics industry. Misplaced caps and accidental sprays are eliminated with spray-thru caps. Also, the extension tube can be left permanently in place, reducing any risk of loss.

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CB Converter

Sparkomatic has introduced Model CB-11 CB converter that is connected between a standard auto antenna and any AM or AM/FM radio for listening to any of the 40 CB channels. Some of the features include: an illuminated channel-selector knob; a switch to select either radio or CB reception; a noise silencer; a fine-tuning control, and a red LED that shows when the CB converter is on.

The converter retails for approximately $39.95.

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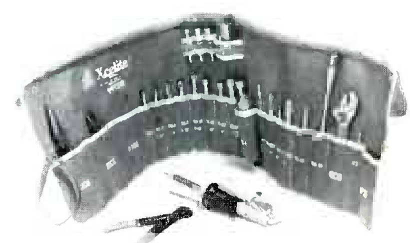
Tool Kit

The 99SMW service kit by **Weller-Xcelite** features the addition of a wire stripper/cutter and a 25-watt soldering iron. The tools fit into a roll-up, plastic-coated canvas case. The kit also includes long-nose and diagonal-cutting pliers, adjustable wrench, an assortment of regular and stubby screwdrivers and nut drivers, plus both regular and stubby handles, extension blade, and reamer.



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Shielded Power Wiring

Gold Line is offering a "Noise-Filtering Hookup Harness" Number 1106 which is said to reduce the noise picked up by the power wiring of CB or communications radios. Heavy-duty shielded coaxial cable with connectors, and an inductive filter are supplied to replace the unshielded power wires commonly used. An in-line fuse offers additional protection against shorts or overloads.

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DC Adapter Charger

Dynamic Instrument's "Auto-Vert" DC-to-DC adapter/chargers plug into a cigarette lighter, and reduce the 12 volts DC to other DC voltages as low as 3 volts, as required for lower-voltage devices. It also can be used to charge rechargeable-type batteries, such as lead acid or Ni-Cad.

Four interchangeable plug tips, called "Quadraplug", allows matching to various polarities and receptacles.

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audio systems report

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CB/Public Address Speaker

A CB/public address speaker that mounts in most places is available from **Audiovox.** Model CBS-20 is a

weatherproof horn speaker, having a horn length of 4½ inches, and a bell diameter of 3½ inches X 3 inches.

The speaker has a frequency range of 800 Hz to 6000 Hz, and a nominal input power rating of 5 watts.

A 12-foot cord with a 1/8-inch plug is furnished with the speaker, which lists for $11.95.

For More Details Circle (47) on Reply Card

Auto Speaker

Model KK-6069 "Kriket" auto speaker by **Acoustic Fiber Sound** is

designed for high-volume operation without damage. The 8-ohm speaker handles up to 30 watts, with an extended frequency response said to be from 35 Hz to 20 KHz from a dual-cone speaker with air-suspension and front-loading designs. Suggested retail price is $44.95 each.

For More Details Circle (48) on Reply Card

catalogs literature

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87. Mountain West—offers a 64-page catalog featuring over 900 intrusion and fire-alarm products, ranging from simple kits to the latest ultrasonic, radar, and infrared intrusion detectors. Product categories include burglar systems, fire systems, fire and burglar detectors, control instruments, telephone dialers, and lock specialties, among others. Products are described in detail regarding application, principle of operation and specifications, with connection diagrams and pictures.

93. Fordham—has released a discount mail-order catalog catering to radio and TV servicemen, electronic technicians, CB users, and hobbyists. 148 pages list test equipment, CB equipment, tools, tubes, antennas, speakers and microphones, phonograph cartridges and needles, and other items. Particular emphasis is devoted to test equipment.

94. Hewlett-Packard—has a 32-page publication which provides background on such subjects as thermal printing, testing, servicing, C-MOS, P-MOS, and N-MOS circuits and RPN language. A catalog section provides background on each of the hand-held and printing calculators, including an explanation of functions, physical specifications and accessories. The publication also includes a question and answer section and a collection of unusual case histories.

96. Lansdale Transistor and Electronics—offers 16 pages about their line of germanium power transistors with single and quantity prices. A selector guide is included for reference and selection of power alloy transistors with 3A to 60A ratings, diffused-base power transistors with 10A to 60A ratings, and low-current transistors for audio amplifier and switching applications. A cross reference guide also is provided.

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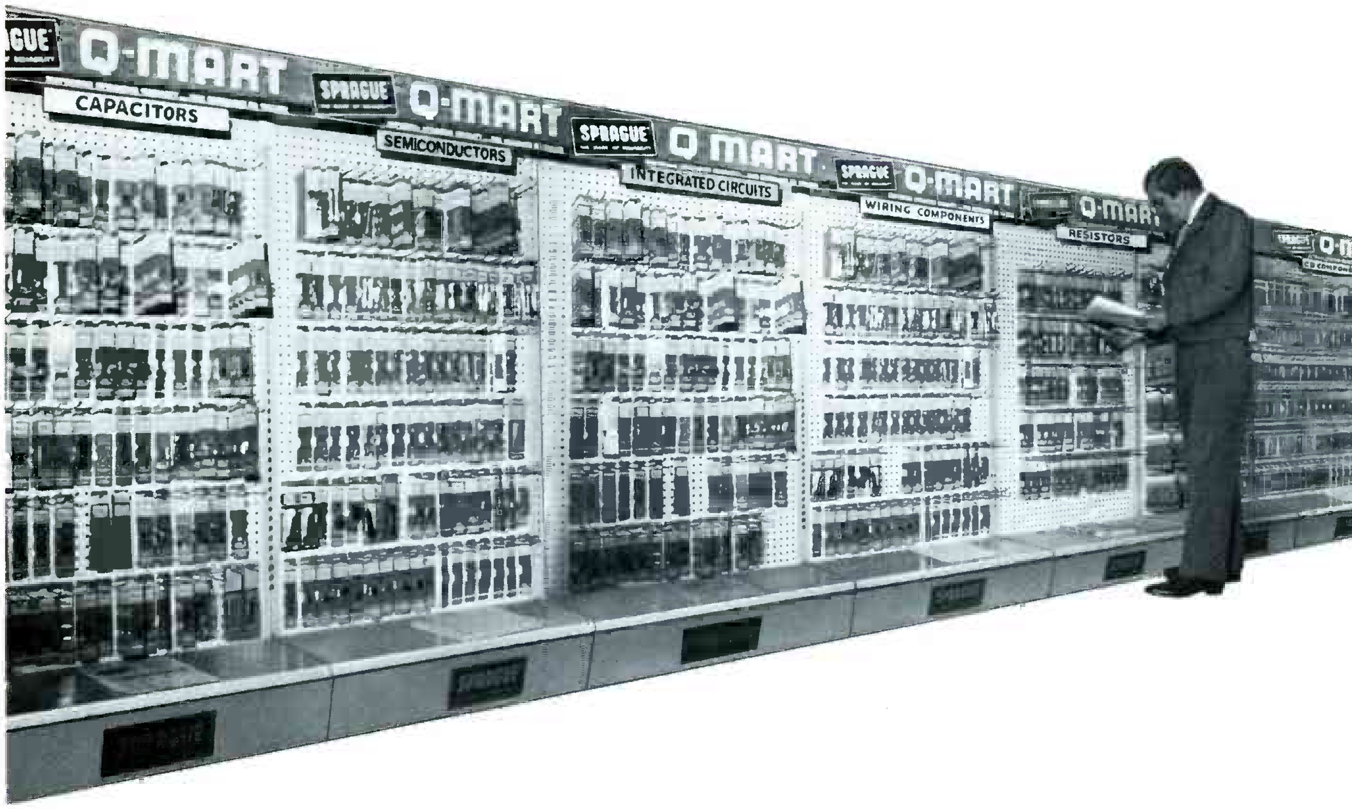

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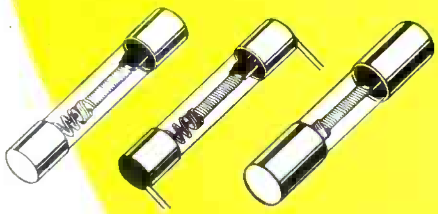

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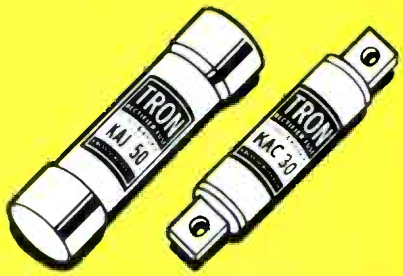

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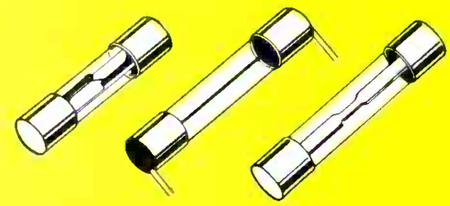

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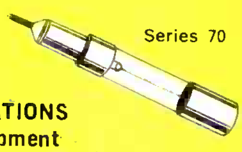

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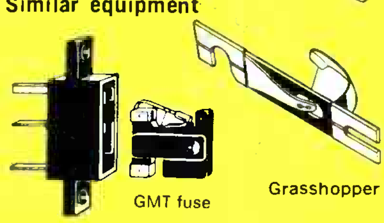

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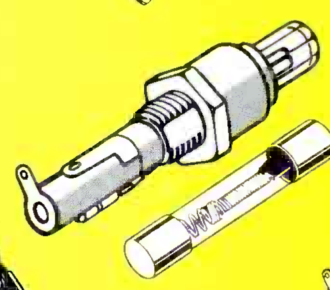

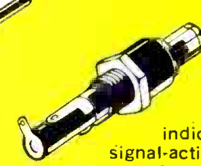

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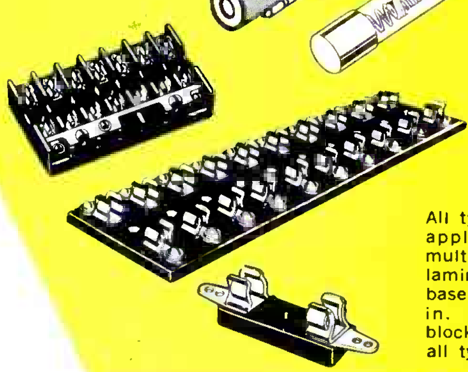

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