

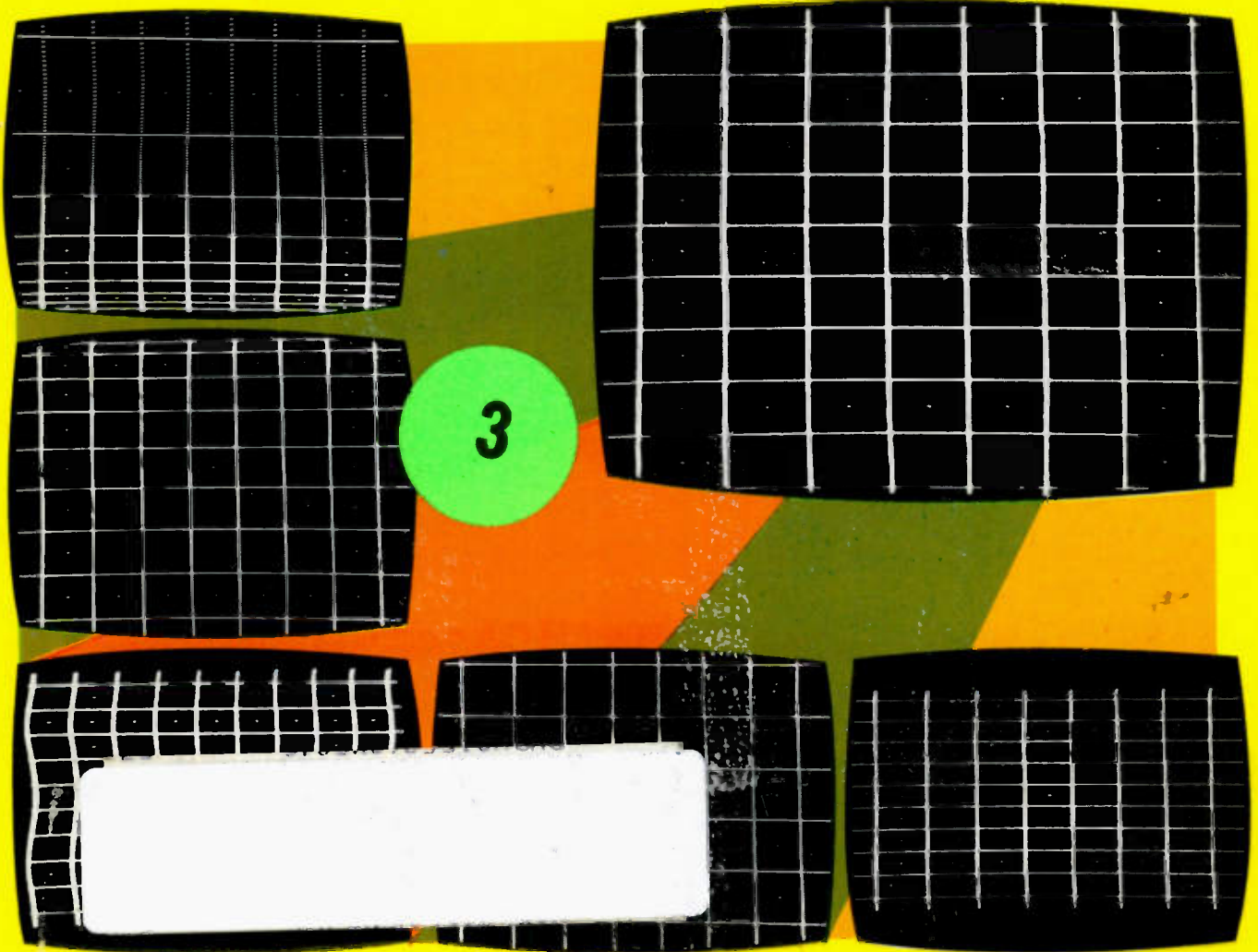
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Electronic Servicing



A HOWARD W. SAMS PUBLICATION

GE Vertical



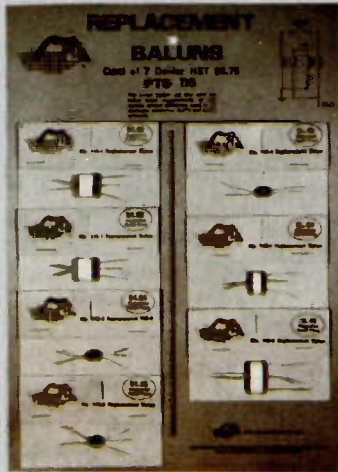
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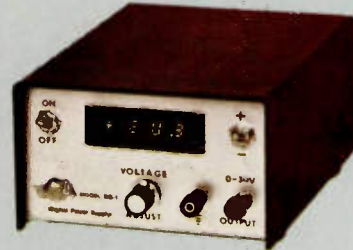
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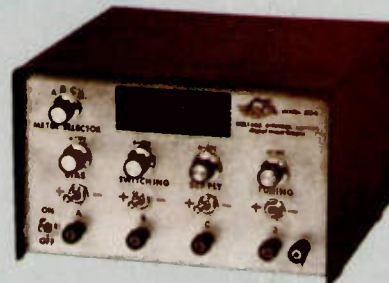
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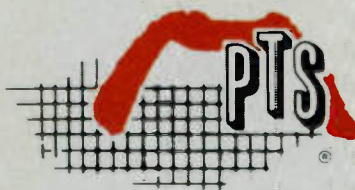
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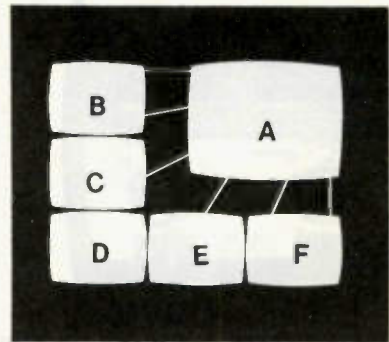
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Electronic Servicing

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- 13 Service management seminar, part 11**—In order to receive a fair profit on the sales of parts, perhaps you should establish your own selling prices. Several methods are suggested—*Dick Glass.*
- 18 Servicing GE 13" color TV, part 3**—Schematics, voltages, waveforms and a part-by-part analysis are provided for the GE AA-D vertical-sweep circuit. More troubleshooting tips will be given next month—*Gill Grieshaber.*
- 32 The basics of industrial electronics, part 17**—In this last article of the series, Sam gives some practical and commercial examples of counters and digital displays—*J.A. "Sam" Wilson.*
- 36 Servicing Betamax videotape recorders, part 7**—The Betamax mechanical systems are interlocked with the electronic circuits that control them. This is important during servicing, since defects in either can produce the same symptoms—*Harry Kybett.*
- 42 Sam Wilson's technical notebook**—The limitations of electronic "models" and the characteristics of dielectrics in charged capacitors are the subjects—*J.A. "Sam" Wilson.*

About the cover—Photographs were taken from the screen of an AA-chassis General Electric color-TV receiver during a simulation of component failures. These conditions are shown: (A) normal height (there is no linearity control); (B) leakage of about 6K ohms in diode Y610; (C) the resistance of R643 is too low; (D) the first filter capacitor is open, causing hum and a small picture; (E) height control is turned to maximum, but the linearity is good; (F) at minimum height adjustment, the linearity remains good.



DEPARTMENTS

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ELECTRONIC SERVICING

electronicscanner

news of the industry

A single-beam color picture tube without a shadow mask is scheduled for introduction in some Panasonic models by next spring, according to *Retailing Home Furnishings*. Electronic circuits control the beam landing on the proper color phosphor. A special phosphor on the screen detects the electron beam, and the signal is processed and used to control the beam so that it strikes the color dots in the designated sequence. No degaussing is required because no shadow mask is used. The new picture tube requires only 60% of the power needed by shadow-mask types. Panasonic also has demonstrated a prototype monochrome portable TV that includes a flat-screen picture tube.

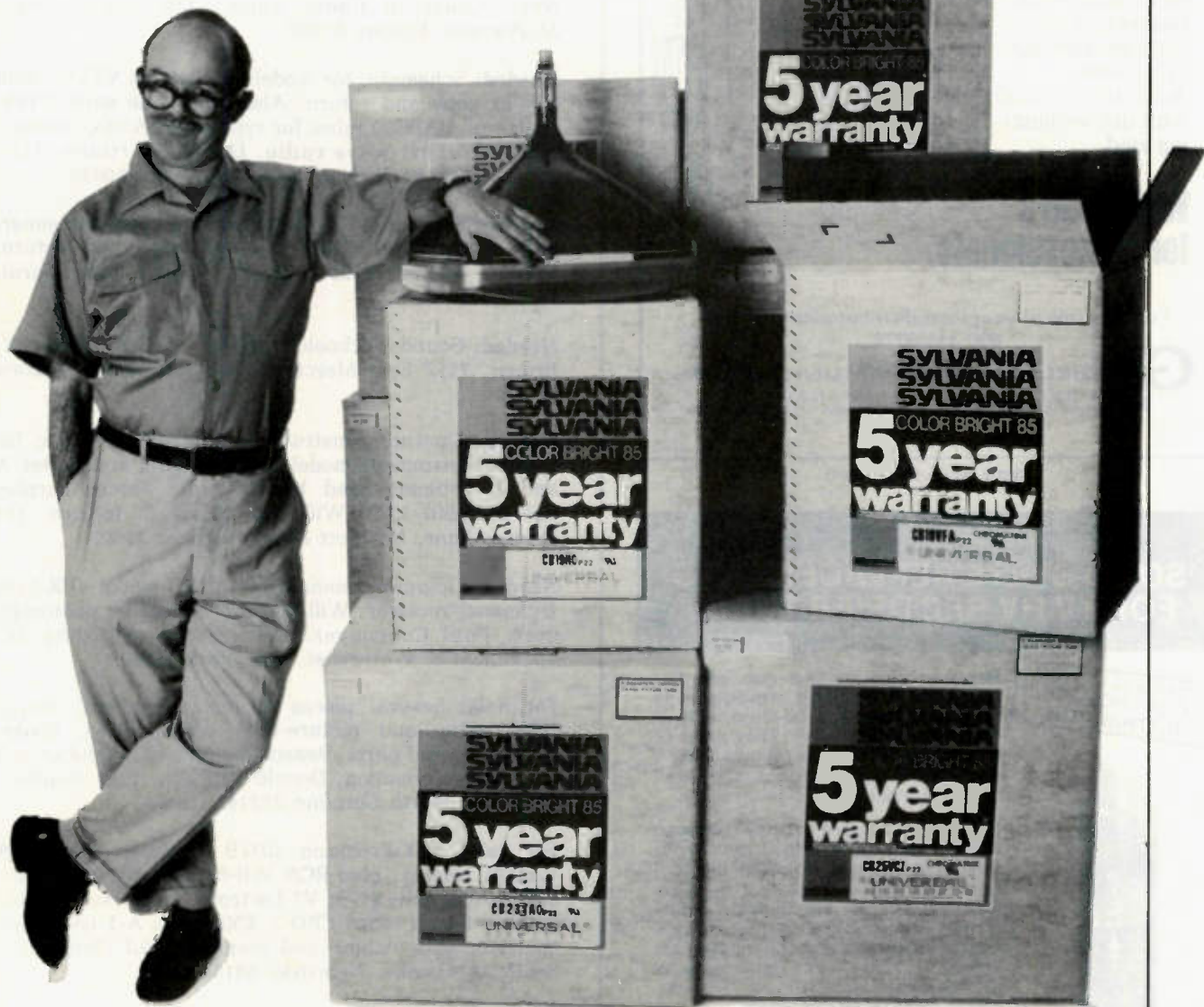
No evidence of extraterrestrial intelligence was found in the latest search by a new radio-telescope. The National Astronomy And Ionosphere Center (NAIC) observed 185 stars that are within 82 light-years of our earth without finding any artificial signals. An antenna giving a gain of 22,000 and a receiving system maintained near absolute-zero temperature was followed by parametric amplifiers and a dual-conversion radio receiver with several bandpass filters. Computer control of the oscillator frequency was necessary to correct for the Doppler shift from the earth's spin.

Electro-chromic display (ECD) might replace liquid-crystal displays, according to Sharp. Several advantages are claimed for ECD, including better contrast, lower-power consumption, and the ability to be seen from any angle. Color of the display is blue against a white background. After a certain pattern is activated, the display remains for about 24 hours without any refreshing voltage. Commercial production for large display boards, watches, and clocks is scheduled for next spring.



Videodiscs are approaching the marketplace. Many companies have made prototypes and have conducted test marketing of videodisc players. So, what's the problem? None of the systems are compatible. Since videodiscs can't be used for home video recording, the discs must be produced by the usual record companies. For this kind of world-wide backup, one system is mandatory. Several of the Japanese manufacturers are delaying their introductions of videodiscs, while attempting to have all agree on one type. Many of the videodisc players (with the addition of an adapter) are capable of playing the pulse-code modulation (PCM) ultra-low-noise music records. In general, the capacitive principle has problems with dirt or dust on the surfaces, and the optical (laser) types are more expensive. JVC believes it has solved both problems with a grooveless disc and capacitive pickup. A stylus with a large, flat-tipped point rides on the record's surface, and a small electrode attached to one side of the stylus picks up the video and sound signal. These signals are recorded as tiny "pits," and other "tracking pits" are located along both sides of the signal pits. The stylus arm is moved by a servo system that keeps the stylus over the imaginary groove. Any time-base errors are corrected electronically.

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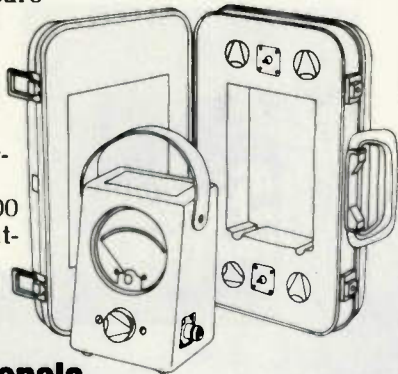
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Needed: Present address of the Masterwork Company for components. My letter to 607 Middlesack Road, Great Neck, Long Island, New York was returned. *J.B. Neff, Coast to Coast Store, 220 North Main, McPherson, Kansas 67460.*

Needed: Schematic for model 909 Precise VTVM. Will buy or copy and return. Also, need one each UY85, UL84 and UABC80 tubes for type B2X68A/00G Norelco AM/FM/short-wave radio. *Daniel Martinez, 310E 115th Sreet, #11D, New York, New York 10029.*

Needed: Schematic for B&K-Precision color-bar generator model 1240. Will buy, or copy and return. *William Mayer, 5722 S.W. 1st Court, Cape Coral, Florida 33904.*

Needed: Sound Technology 1700B or H-P 339A. *J.V. Brown, 7117 East Mercer Lane, Scottsdale, Arizona 85254.*

Needed: Operating instructions and/or schematic for Electro Instruments model T-121A digital multimeter A and B cabinets used by U.S. Air Force, surplus FSN-6625-902-3329. Will buy. *Willie E. Jeffries, 111 Jenness Lane, Newport News, Virginia 23602.*

Needed: Operators manual for a JVC model 4VR-5446 4-channel receiver. Will pay for manual or photocopy cost. *Paul Cournoyer, Leisureville, Building 26, Apartment 3, Watervliet, New York 12189.*

For Sale: Several pieces of test equipment: scope, tube tester and picture-tube tester. Also, books, magazines and parts. Reasonably priced. Write or call for more information. *Donald R. Sides, 1201 Regeher, Charlotte, North Carolina 28214.*

For Sale: B&K-Precision 1077B Analyst, \$195; RCA WR99A marker, plus RCA WR-69A sweep generator, sold as one unit, \$175; V7 Lectrotec Vectorscope, \$65; Jackson 5-inch scope CRO-2, \$50; all in A-1 condition, complete with cables and manuals. *Val Obal, 3201 South 73, Omaha, Nebraska 68124.*

Needed: Any new or old stock of old car radio parts, such as vibrators, vibrator transformers, volume controls, on/off switches, signal-seeking coils, relays, motors and local electron tubes. *Frank's Radio Repair, 416 Quackenbush Place, Ridgewood, New Jersey 07450.*

Needed: Service manual for model 3800 Cavalier radio. *Joseph LaSchiavo, 212 Oak, Medford, New York 11763.*

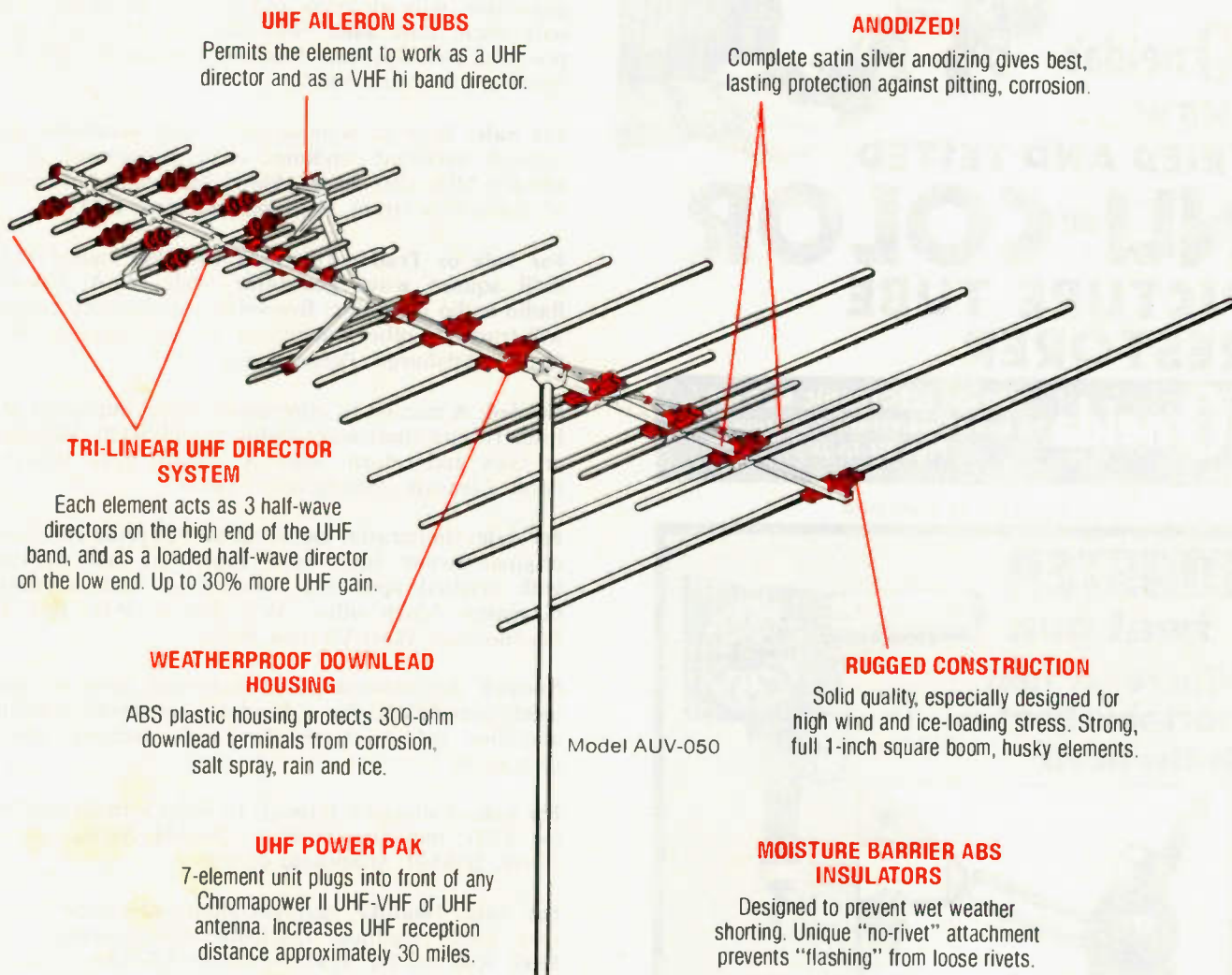
Needed: Schematic for a Midwest Audio mobile page model 520D, an AM radio with paging input. *Bob*

continued on page 8

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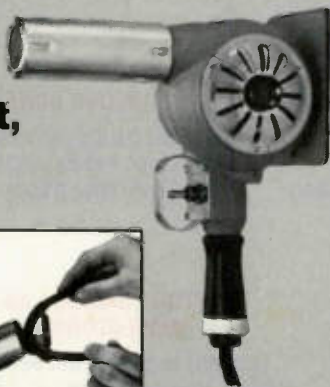
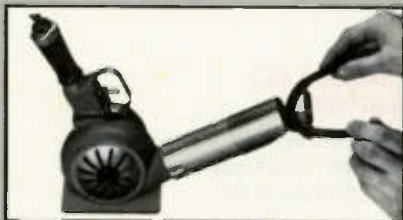
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reader's exchange

continued from page 6

Pierce, 1822 Sun Valley, Jefferson City, Missouri 65101.

Needed: Instruction manual for Paco RF signal generator model G-30. Send copy, or I'll copy and return. Grady O. Wilson, 3610 Davis, Texarkana, Texas 75501.

For Sale: B&K-Precision model 415 sweep/marker generator, with all leads and manual, in carton, used only once, cost \$485, will sell for \$375 and ship pre-paid. J.A. Nesheim, Nesheim Electronics, Box 293, Roundup, Montana 59072.

For Sale: Bearcat Scanner BC-2 with schematic and manual, excellent condition, scans 8 channels in the 450-470 MHz UHF band, \$55 delivered. R.J. Horsley, 67 Theodore Street, Buffalo, New York 14211.

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Needed: A manual or information about alignment of a Hallicrafters short-wave radio, model S-120. Will buy, or copy and return. Sean A. Devitt, 2237 Wharton Road, Glenside, Pennsylvania 19038.

For Sale: Hallicrafter model SX-62/620 radio receivers, original owner, little used, intact but not working, with original operating instructions and schematic diagrams. Make offer. W.J. Kerns, P.O. Box 59, Buckhannon, West Virginia 26201.

Needed: An audio-output transformer (new or good-used) part 022889 for a Fender twin-verb 100-watt amplifier. D.J. Aijala, 50 Fir Circle, Babbitt, Minnesota 55706.

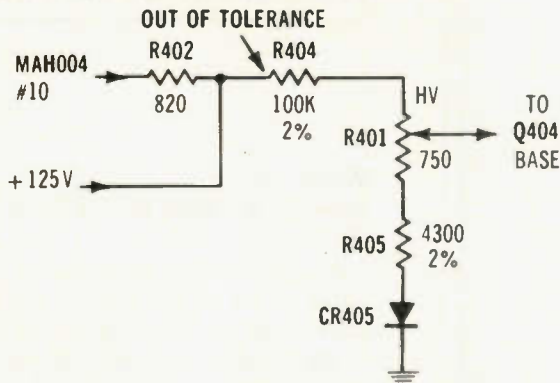
For Sale: Volumes 1 through 12 Rider's radio manuals for \$200, including postage. Donald Aijala, 50 Fir Circle, Babbitt, Minnesota 55706.

For Sale: Heathkit mutual-conductance tube tester, very good condition, complete with manuals, cost \$300, will sell for \$150. Alphonse Kieltyka, 1 Tobey, SJ, Augusta, Maine 04330.

For Sale: Demonstrator DuMont/DeForest model MM-200, list price \$134, will sell for \$72. Domino Unlimited, Inc., P.O. Box 9309, Fort Wayne, Indiana 46899.

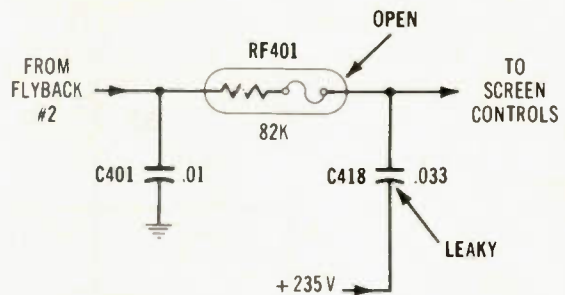
For Sale: RCA 10J103 color test jig, with CRT, HV meter, Telematic Transverter TA-3000, and 22 adapters, \$165; RCA WR-514A TV sweep Chanalyst, \$145; RCA WR-99A signal generator, \$85; RCA WT-524A transistor tester, \$55; EICO model 147A signal tracer, \$25; Conar communication receiver model 500, \$15; Conar model 400 communication transmitter, \$15. All are in good working condition with probes and manuals supplied. William D. Shevtchuk, 1 Lois Avenue, Clifton, New Jersey 07014.

Chassis—RCA CTC71
PHOTOFACT—1435-3



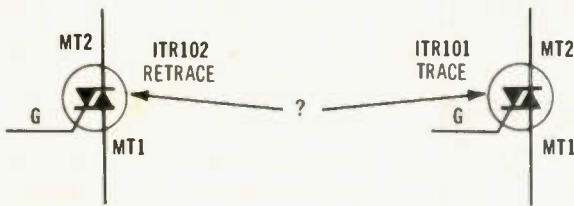
Symptom—Horizontal won't lock, and regulated DC is too high
Cure—Check R404 carefully, and if out of tolerance, replace it with one of 1% or 2% tolerance

Chassis—RCA CTC81
PHOTOFACT—1572-2



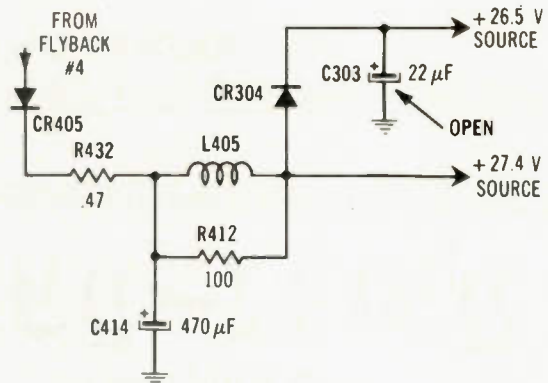
Symptom—RF401 is open, and the picture is dim
Cure—Check C418, and replace it if leaky or shorted.

Chassis—RCA CTC72
PHOTOFACT—1439-2



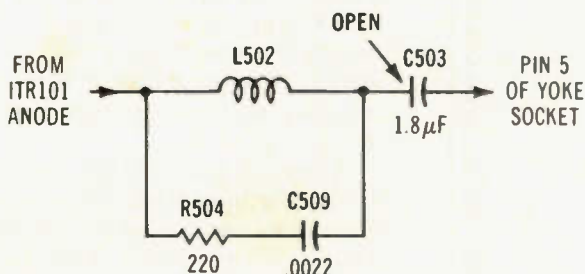
Symptom—Intermittent picture and sound, then none
Cure—By substitution, check ITR101 or ITR102

Chassis—RCA CTC90
PHOTOFACT—1710-2



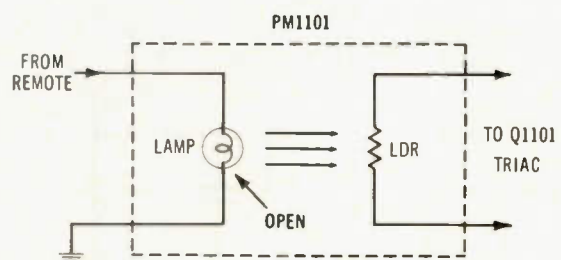
Symptom—Severe horizontal pulling that moves through picture
Cure—Check filter C303, and replace it if open

Chassis—RCA CTC74
PHOTOFACT—1599-2



Symptom—R510 and R508 overheat, and RF401 is open
Cure—Check C503, and replace it if open (check for other opens)

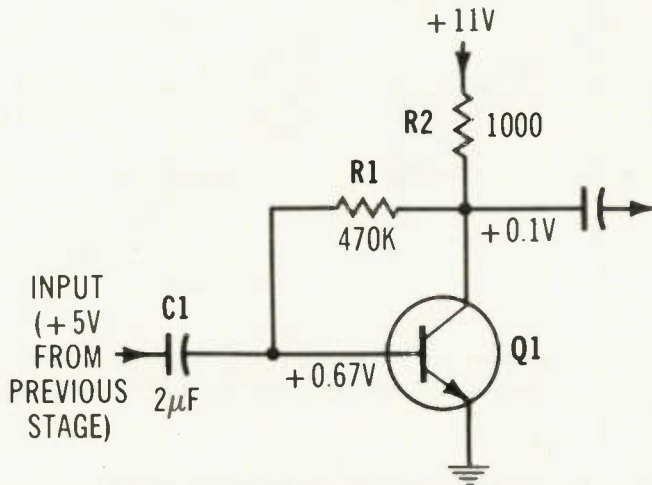
Chassis—RCA CTC90
PHOTOFACT—1710-2



Symptom—No power to the TV; remote has power
Cure—Check the lamp in PM1101, and replace the assembly if the bulb is open

QUICK-QUIZ #1

By Wayne Lemons



WHICH PART IS BAD?

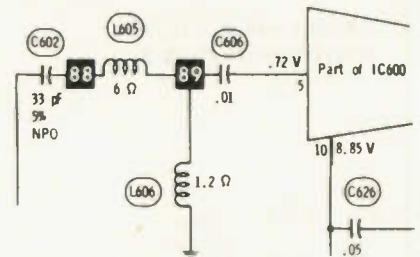
ANSWER ON PAGE 50

troubleshootingtips

Weak Color

Sylvania & Philco E20, E21, + E22 (Photofact 1595-1)

Maximum adjustment of the color control gave only enough color to prove the program was not in black-and-white. All DC voltages in the chroma system checked within tolerance. After all of the ICs were replaced, the color remained very weak.



Scope waveforms of the chroma circuits showed some signal, but little amplitude. These symptoms should have alerted me to the type of problem, When *all* chroma IF signals are weak, the defect must be *ahead* of that point. However, I didn't think of this until later.

Then another E20 came in for minor problems. We repaired this chassis rapidly, and used it as a standard for comparison tests, since it had normal, strong color.

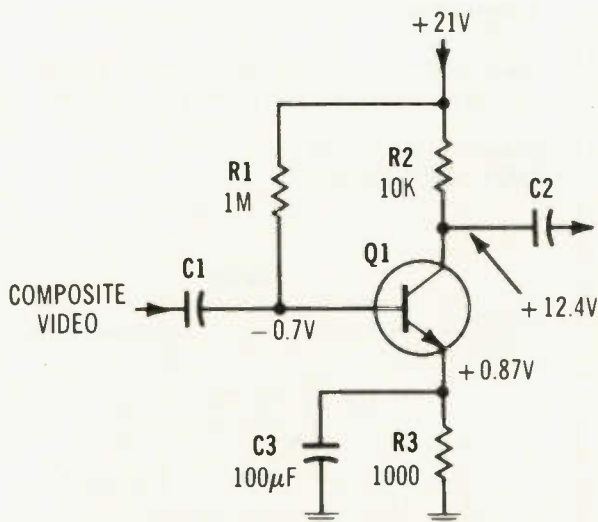
The good E20 had a strong chroma and burst signal at pin 5 of IC600, but the "dog" didn't. Some waveform was there, but it was wrong. (The good chassis helped by showing the correct waveform we should expect.)

At the emitter of Q202, the video buffer for the video detector, the waveforms were normal in both chassis. The defect had to be between those two points. A few ohmmeter tests found an open in L605A, and a new one restored strong color.

Curtis Routley
Columbus, Mississippi

QUICK-QUIZ #2

By Wayne Lemons



RIGHT OR WRONG VOLTAGES?

ANSWER ON PAGE 50

Increasing profits from parts

Service management seminar, Part II

When your component parts profits are insufficient, probably you should determine your own retail prices, rather than using "suggested list" prices from the manufacturers.

By Dick Glass, CET

Parts pricing problems

"How can I price parts properly and profitably?" This question has been asked of me many times in my work as financial advisor and business consultant to independent sales and service stores.

In addition, most shops are having increasing difficulties in maintaining an adequate variety of the parts. Sometimes the excessive time required to locate and deliver a certain part can cancel all of the profit on the sale and even reduce the labor profit. Although the problems of parts availability are not a direct factor in the pricing of parts, the two problems do affect each other. Therefore, we will deal with both together.

Here are some of the current parts problems:

- Sales of high-mark-up vacuum tubes are diminishing.
- Electronic products are becoming more reliable, requiring fewer repairs.
- Fewer parts are used per repair, than in previous years.
- Repairs of each brand require many more **specialized** parts, and fewer universal parts. Thus, the stocking problem is made worse.
- Although the "suggested" mark-up of some parts remains profitable, more and more large components—such as modules, picture tubes and special items—have list prices that allow as little as 20% gross profit.
- Parts gross-profit percentages are

steadily diminishing, according to profit-and-loss statements.

- Stock parts become obsolete at a faster rate, yet a wider variety of parts are needed to minimize extra trips to the local distributor.
- Many dealers believe they *must* follow all "suggested" list prices.
- Few know that it's legal to establish their own selling prices.

Parts versus labor profits

In the "good old days," profit from parts sales provided most of the income in a high-percentage of electronic-repair shops. Labor was billed at less than cost.

This was possible because picture tubes failed more often, and small tubes carried enormous mark-ups (in addition to having a very high rate of replacement).

By contrast, the failure rate of modern solid-state color TVs has plummeted to about one repair in two or three years—and the rate continues to drop. Also, the volume of parts sales is diminishing even more rapidly.

Under today's conditions, then, it's *not* possible for an electronic-repair shop to operate solely from parts sales. And, if you are trying to subsidize inadequate labor rates by using parts profits, your business is (or shortly will be) in deep trouble!

Operate without parts profit

What should you do, if you are depending too much on parts

profits? Well, the answer is in two halves.

First, imagine that you have **zero parts sales**. Figure your labor expense versus needed income, and calculate a labor rate that will bring in sufficient money to pay your employees properly and to reimburse yourself for your time, investment and risk. Begin using the new labor rates.

Second, after new labor rates (which need no subsidy) are established, you should calculate the mark-up required for you to make a normal profit from the sales of component parts.

Remember to include all of the legitimate expenses that often are ignored and left in the miscellaneous category.

After you have instituted separate rates and profits for labor and components, your business will be secure, even if parts sales drop to zero.

Remember, this major decline of parts sales and profits probably is not due to any mistakes on your part, but it's a general change in the entire industry. This conclusion is verified by careful studies of the following "typical" profit-and-loss statements.

Analyzing P&Ls

Figure 1 and Figure 2 are slightly-exaggerated examples of profit-and-loss statements for the years of 1970 and 1978.

Notice that both labor sales and

continued on page 14

Service Management

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Dick's TV Service 1970 Profit-and-Loss Statement

Parts Sales	\$40,000	
Parts Costs	\$20,000 (50%)	
Parts Gross Profit		\$20,000
Labor Sales	\$30,000	
Labor Costs	\$20,000 (67%)	
Labor Gross Profit		\$10,000
TOTAL GROSS PROFIT		\$30,000

Overhead Expenses _____

Net Profit _____

Figure 1

Dick's TV Service 1978 Profit-and-Loss Statement

Parts Sales	\$20,000	
Parts Costs	\$15,000 (75%)	
Parts Gross Profit		\$ 5,000
Labor Sales	\$40,000	
Labor Costs	\$30,000 (75%)	
Labor Gross Profit		\$10,000
TOTAL GROSS PROFIT		\$15,000

Overhead Expenses _____

Net Profit _____

Figure 2

labor costs increased (probably from inflation), although the percentage of profit declined.

Parts figures, however, changed the most. Not only did the parts sales decline from \$40,000 to \$20,000, but the costs rose to 75% from the former 50%. Parts profits in 1970 probably were helped by sales of receiving tubes. But inflation should have increased the 1978 parts sales almost to the 1970 level. Therefore, the drop of parts sales in 1978 is highly significant.

These trends are impossible to spot on a monthly basis, because of seasonal variations. Yearly P&Ls *might* show bad conditions, but a comparison of many yearly P&Ls certainly will pinpoint the problem area.

The problem

According to the P&Ls of Figures 1 and 2, the basic problem is a loss of \$15,000 in parts gross profit. \$10,000 of this loss could have been avoided if the parts had been priced for a flat 50% profit.

Also, don't overlook the additional indirect expenses for time spent locating the exact-replacement components demanded by solid-state designs.

Some owner/managers believe that the general change from universal parts to specialized parts was one of the major causes of increased overhead and reduced profits.

Solve the problem

Before you attempt to solve the parts-profit problem, analyze your labor rates. Attempt to increase productivity, and then raise the labor rates so the labor income is two to three times the cost of labor and fringe benefits (including taxes on wages) plus the owner's wages (when he functions as a technician).

After the question of labor profits is settled, you can face the parts problem squarely, knowing that the realistic labor rates offers protection even if parts sales dwindle to zero. Don't depend on parts-sales profit to supply any insufficient labor income. **Both must show a profit after expenses.**

Simply stated, **the missing parts profit can be restored by increasing**

the selling prices. Of course, we have been brain-washed for many years to accept manufacturers list prices, without any questions. The inference is that, if you operate your business right, these list prices will bring in a normal profit.

Therefore, you probably will need



Figure 3 This view of a Sperry Tech parts-pricing book shows the format for the universal-parts listings and the locating tabs at the right.

to re-orient your thinking by studying these truths:

- You are free—both legally and morally—to set your own parts selling prices, according to the profit you need.

- From your monthly P&Ls, figure the parts-cost percentages. If they average 80%, but you need 50%, then your selling prices are too low.

- Losses from obsolete parts should be counted as overall parts expenses.

Remember, you didn't stock the components for yourself, but for the customers' benefits.

- Added space required for the wider variety of specialized parts is expensive to you. Therefore, parts prices should be raised to include such expenses.

- Those extra trips to the distributor for special parts should not be absorbed as general expenses, but must be added to the parts prices.

- Include parts shipping charges in the selling prices. They are legitimate expenses.

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TABLE NO. 4

Dealer Price	X = (Times)	Gross Margin
.00 - .15	12.50	92.0%
.16 - .18	10.00	90.0%
.19 - .22	8.33	88.0%
.23 - .27	7.14	86.0%
.28 - .33	6.25	84.0%
.34 - .40	5.60	82.0%
.41 - .48	5.00	80.0%
.49 - .57	4.44	77.5%
.58 - .67	4.00	75.0%
.68 - .78	3.60	72.5%
.79 - 1.25	3.33	70.0%
1.26 - 2.00	3.08	67.5%
2.01 - 3.50	2.86	65.0%
3.51 - 5.00	2.67	62.5%
5.01 - 7.50	2.50	60.0%
7.51 - 10.50	2.35	57.5%
10.51 - 14.00	2.22	55.0%
14.01 - 18.00	2.11	52.5%
18.01 - 22.50	2.00	50.0%
22.51 - 27.50	1.90	47.5%
27.51 - 33.00	1.82	45.0%
33.01 - 40.00	1.74	42.5%
Over 40.00	1.67	40.0%

Figure 4 Six tables of mark-ups and discounts are available. You choose the mark-up you want (thus, making the pricing plan legal).

Anyone can be replaced.



Raytheon did it.

We just replaced every single one of our more than 100,000 replacement numbers—replacing the old RE numbers system with easier-to-use, universal REN numbers.

Now all 362 different types (including 67 new types) of our semiconductors for home entertainment service are at your fingertips faster. Without the fuss and bother of crossreferencing numbers. Our new system exactly corresponds to the one most often used by the service industry.

But that's all we changed. Using this new red book still opens the way to all of Raytheon's famous advantages. Highest quality. Highest availability. Immediate delivery.

Your new replacement guide is available at your Raytheon distributor. Ask for it today.

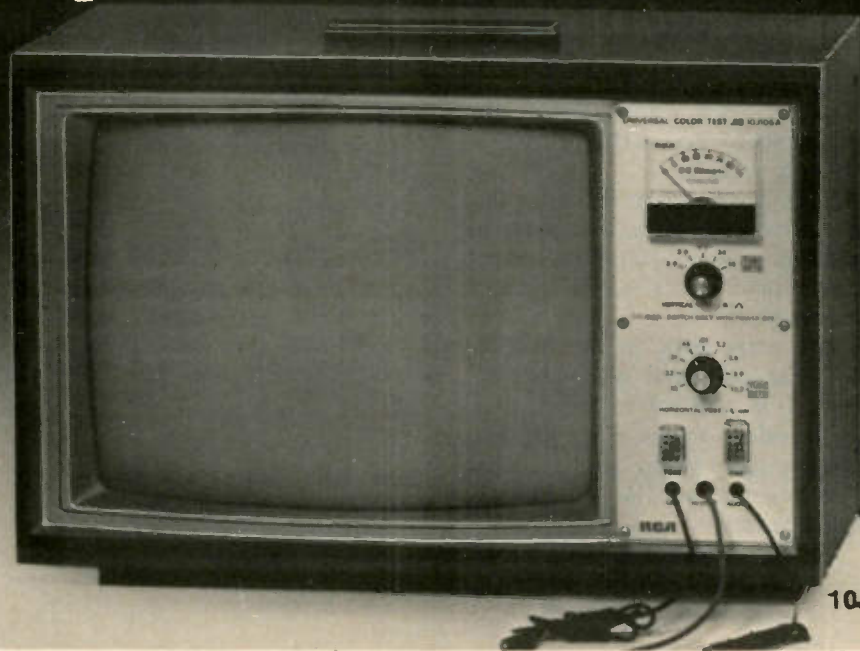
Raytheon Company, Fourth Avenue, Burlington, MA 01803 Tel. 617-272-6400.



ASK YOUR DISTRIBUTOR ABOUT OUR CURRENT PROMOTION.

Circle (23) on Reply Card

Now! RCA offers you three time and money-saving options in Color TV Test Jigs.



10J106A

10J107

Facts about Sperry Tech parts pricing

With the Sperry Tech Parts Pricing System, a computer stores the net prices of parts from 17 major TV and stereo manufacturers, plus universal parts, semiconductors, tubes, and a tax table. After a service dealer selects the mark-up he wants (there's a choice of 6, from 45% to 65% discount), the selling prices are calculated and printed by the computer, and the pages are inserted into a durable loose-leaf book, which has tabs at the edge to make the sections easy to find (Figure 3).

All prices are on a sliding mark-up, with low-priced parts having the largest mark-up and expensive ones showing less.

Figure 4 shows the Table Number 4 of mark-ups.

As shown in Figure 5, the specialized parts are listed by manufacturer's number, and the letters "A" through "F" tell the approximate turn-over. "A" parts

are fast movers, while "F" parts usually should not be stocked.

Any number of books can be ordered. For example, two 6-inch X 9-inch books, plus a subscription to the Automatic Updating service, cost between \$16 and \$24.50 per book, depending on how many books are ordered.

The monthly subscription fee is paid through the Electronic Funds Transfer System (EFTS), and automatically deducted from the bank account of your company. For more information about prices or the books write direct to Sperry Tech. Although the prices seem high, the increased profits from parts sales should make it a bargain.

Write to Sperry Tech at P.O. Box 5234, Lincoln, Nebraska, 68503, or call 402/464-9181. This information is not a paid ad, but is presented as a service to our readers.

Service Management

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- Realize that parts prices are changing constantly. Although it is a nightmare to keep up with continual price changes, it must be done. (We will suggest an easier way, shortly.)

- A printed book or list containing all of the parts prices should be available to each employee. This is especially important, after you have decided to set your own prices.

After you study these reasons for establishing your own parts prices, you should be convinced the benefits will outweigh the work required to set up the system.

Designing a parts-pricing system

Keeping up with parts price changes is not easy. You must acquire the latest price lists, including those for tubes and special parts. Then, you must figure new retail selling prices, based on the mark-up you need. Finally, these new prices must be typed or

10J106AX



With the new RCA 10J106A Color TV Test Jig you can troubleshoot a TV chassis without bringing the cabinet and picture tube into the shop. The 10J106A helps you isolate picture tube or chassis malfunctions quickly, and without disturbing your customer's picture-tube alignment.

The 10J106A features a 19-inch shielded picture tube; built-in high voltage meter calibrated to 35 kV; two unique front-panel switches for easy changing of yoke impedances; and a built-in speaker. Yoke, picture tube socket, and high-voltage extension cables are supplied, plus a Set-Up Index and instruction book. With the 10J106A you can service thousands of sets whether tube, hybrid or solid-state — including Precision-in-Line types.

The new RCA 10J106AX Color TV Test Jig is exactly the same as the 10J106A except that it comes without a picture tube for those who prefer the economy of installing their own tube.

The RCA 10J107 Color TV Test Jig Adapter modernizes most older test jigs to perform like the 10J106A. And, if you're a do-it-yourselfer, you can build your own jig from a salvaged TV receiver.

See your RCA Distributor for all the details about which option suits you best. Or contact RCA Distributor and Special Products Division, Deptford, NJ 08096.

RCA Color TV Test Jig

printed, and copies made for all your employees.

Sliding mark-ups

Audio shops were the first to be affected by the all-solid-state equipment, which requires low-margin, slow-turn, and fast-obsolescence replacement parts.

Managers of these audio shops learned rapidly to disregard the traditional manufacturer's suggested list prices.

Many of them adopted a sliding scale of price mark-ups. For example, parts that cost under 50 cents would retail for \$2.50. Parts costing between \$1 and \$2 would sell for \$5 to \$7. Higher net cost items progressively received less mark-up, until those above \$50 were sold for the manufacturer's list price.

The disadvantage of this method is that you must look up your cost of every individual part and then calculate the selling price. It's time consuming.

The Sperry approach

Another practical method of pricing parts combines a sliding mark-

up with the detailed and complete printed listings of parts, but has someone else with a computer make up the lists (for a moderate fee) and install the pages in an attractive book.

This company with a computer is Sperry Tech (the same one offering the pricing guide).

John Sperry had the same pricing problems as all other shop owners and managers have. His solution now is offered to other shops.

Details are given somewhere in this article. Briefly, it is a complete system that supplies parts prices of 17 manufacturers.

It's legal for you to use such a system, because you choose the percentage of mark-up you want. Obviously the system is handy to use. But there is another important benefit: a printed book of prices is an "outside authority" in the eyes of the customers.

Establish a parts-pricing system

Some shop managers estimate that following these parts prices (which are determined by the methods I have outlined) could increase the profits of a small repair shop by at least \$50 per week.

Obviously, such a sizeable boost of income is worth investing considerable time and money to obtain.

Therefore, I urge you to establish your own parts-pricing system—one that will bring you the mark-up necessary to stay in business and provide good service to your customers. □

RCA

Part	Rank	Description	Price
74882	F	CONNECTOR	1.80
78324	C	SPRING	1.35
105330	B	CRYSTAL	7.05
106364	D	CAPACITOR	8.25
107191	A	RESISTOR	3.10
108602	E	WHEEL	5.75
109227	C	CAPACITOR	4.85
109229	D	CAPACITOR	2.10
109257	C	COIL	2.90
109806	C	CAPACITOR	1.80
109816	F	SOCKET	12.80

Figure 5 Here are a few listings from a page of specialized components, showing the type of information and the layout.

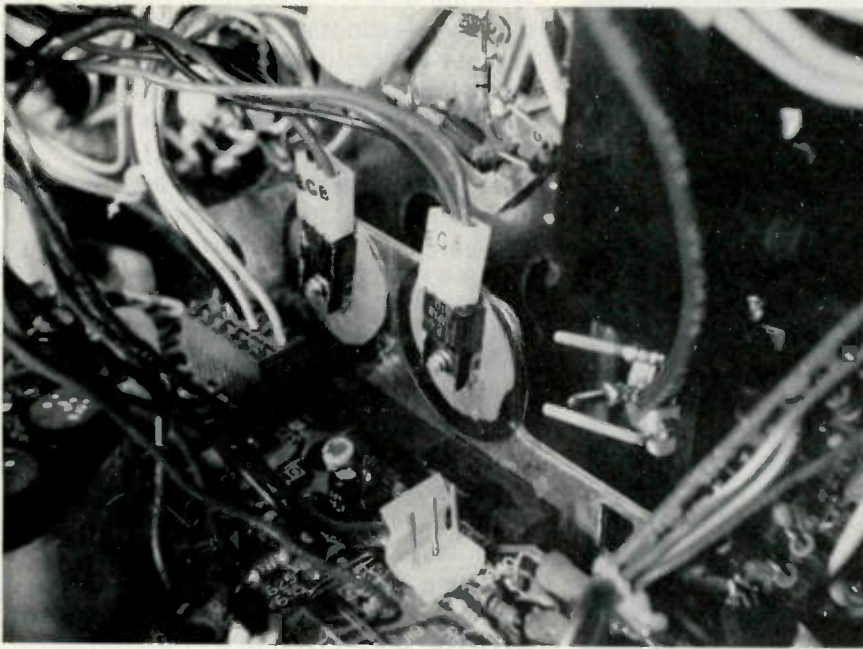


Figure A Two PNP output transistors (Q640 and Q645) are mounted on the metal panel that's beside the large module in the GE AA-D chassis. Sockets with long wires allow the module to be removed without dismounting the transistors. Or, a replacement transistor can be tried as a test, before it's mounted, by inserting it into one of the sockets.

General Electric

Servicing GE 13" Color TV, Part 3

By Gill Grieshaber, CET

How can a B+ supply that's powered from horizontal sweep have 60-Hz hum ripple? The answer involves vertical sweep in the GE AA-D chassis. This circuit has some similarities to others analyzed previously, but the differences affect troubleshooting. A detailed description of circuit operation is given, complete with voltages and waveforms. A follow-up next month will present scope waveforms and raster pictures that illustrate the effects of specific defects.

General features of the vertical

One distinction between types of vertical-sweep systems is the origin of the positive-feedback signal that makes the circuit oscillate. Some systems (not this GE) bring back samples of the output signals to the oscillator (or switch) transistor. Thus, the entire sweep circuit is the oscillator. These are large closed loops, and all stages must be working correctly before the right frequency and height can be obtained.

However, the General Electric AA-D chassis has a two-transistor

oscillator, followed by several stages of amplification.

Troubleshooting often is easier with systems of this kind, since the oscillator can be checked with a scope, even when the output transistors both are bad or removed from the circuit. Also, most cases of poor linearity can be located faster, because the oscillator seldom is the source, and the waveforms can be scoped stage by stage.

Two basic types of power-output stages have a positive-voltage and a negative voltage supply, which allows the usual output coupling capacitor to be eliminated. One is the "complementary" type with two identical output transistors, except of opposite polarity (one PNP and one NPN).

Although the AA-D circuit resembles this type, it really is a "totem-pole" variety, using one NPN driven direct (Q640), and an identical NPN (Q645) plus a Q635 to invert the base signal. Perhaps one advantage of having two identical outputs (rather than comple-

ments of different polarities) is that no serious change of height or linearity occurs if the output sockets are removed and then returned to the wrong transistor.

A waveform from the yoke current is fed back to the Q620 amplifier transistor, making any linearity control unnecessary.

All vertical components (except the large module, near your right yoke) are located in one corner of the large module, near your right hand as you face the rear of the TV. These are in front of the vertical hold, vertical size, and the vertical centering controls, as shown by the arrows in Figure 1.

Watch for these features, as we analyze the circuits in detail.

Power supply voltages

Figure 2 shows the four DC voltages produced by the main power supply that operates from the power line. (Some of the decimals could not be read in the September article.) The same +147 volts that supplies the horizontal-

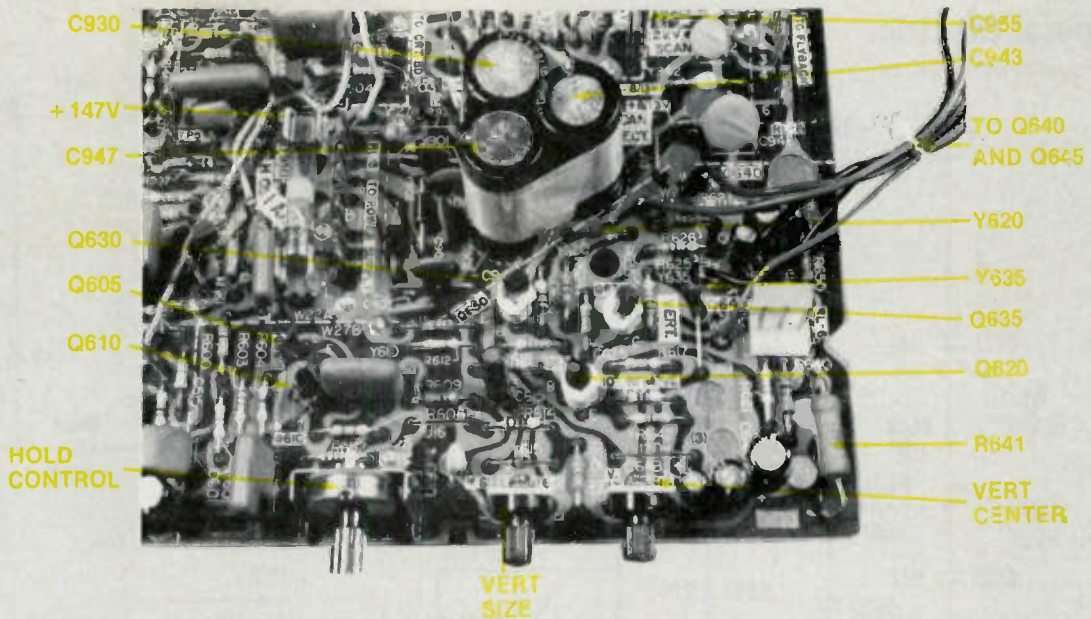


Figure 1 Arrows point out the transistors and other important components of the AA-D vertical circuit, which is located near one corner of the large module.

Vertical Sweep

sweep circuit also goes to the vertical-size control. Other DC voltages for the vertical come from rectified horizontal power. So, any variations of the horizontal output can't change the voltage at the vertical-size control. This gives added height stability.

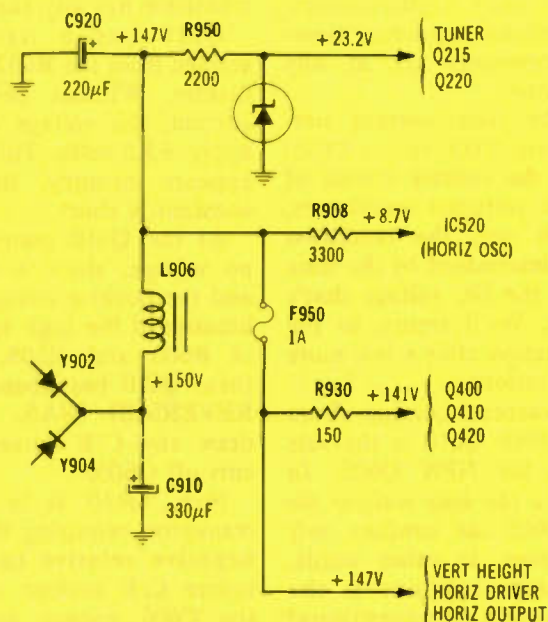
Vertical-oscillator operation

Figure 3A is a schematic of the entire vertical-sweep system, including the two-transistor vertical oscillator. Waveforms are in Figure 3B.

Both PNP Q610 and NPN Q605 are oscillators, operating in a type of time-constant multivibrator. Operation of a similar circuit used in the GE YC-2 chassis was described carefully in the November, 1976 issue of *Electronic Servicing*. However, a brief description will be given for those who might have missed the other analysis.

In Figure 3A, the collector of Q610 is direct coupled to the Q605 base, and the Q605 collector is coupled through a low-value resistor to the Q610 base.

continued on page 20

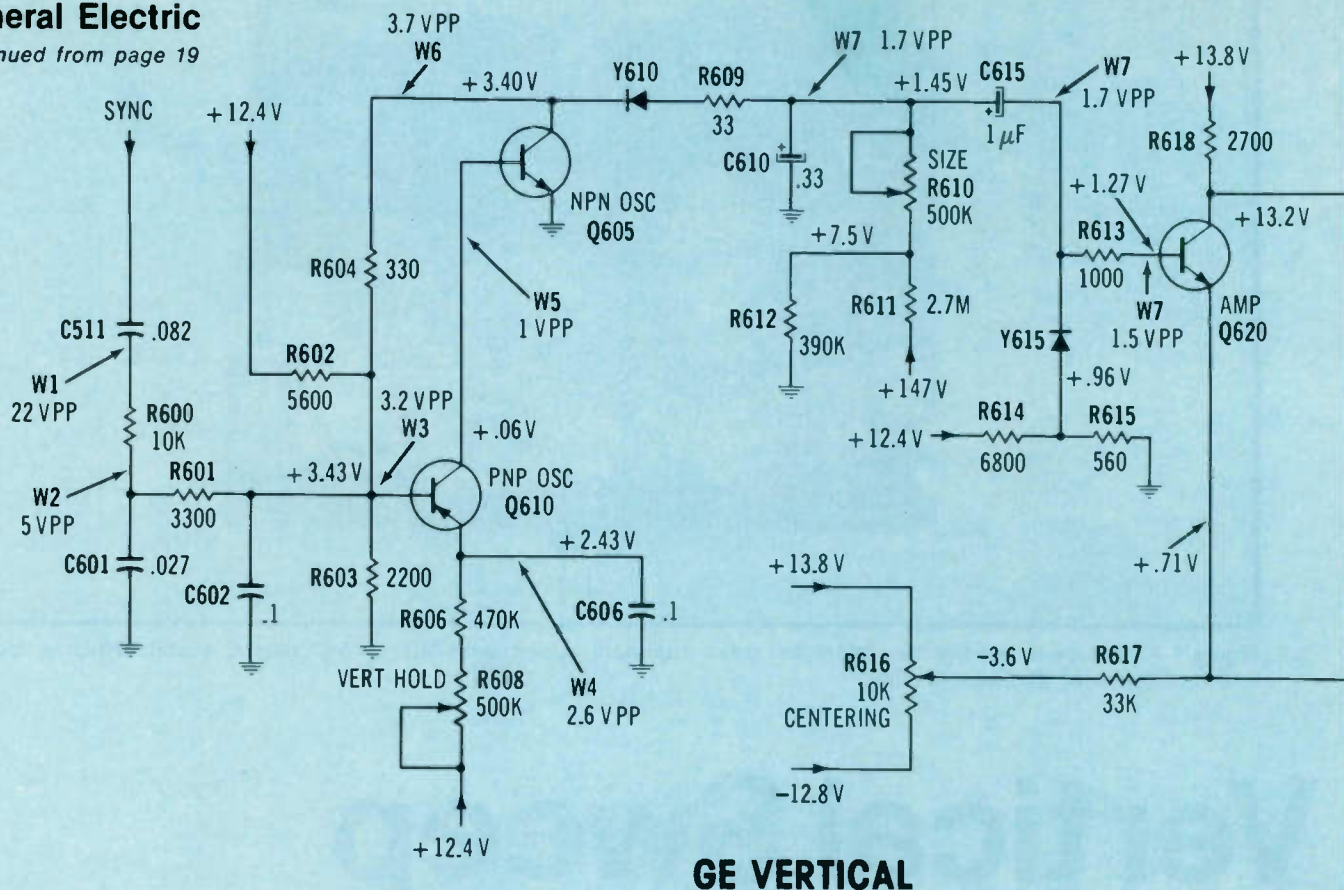


GE AA-D CHASSIS MAIN POWER SUPPLY

Figure 2 The 60-Hz power supply produces these four important B+ voltages. Other supplies are powered from the horizontal-sweep circuit, as shown later.

General Electric

continued from page 19



GE VERTICAL

tor to the base of Q610. So far, this is similar to many multivibrators, except no resistor/capacitor time-constant components are at any base or collector.

Instead, the time-constant network (R606 plus R608 versus C606) is located in the emitter circuit of Q610. In all untuned oscillators, including this one, the repetition frequency is determined by the time constant and the DC voltage that's applied to it. We'll return to the circuit explanation after a few more general observations.

Collector current coming from B+ through PNP Q610 is the sole forward bias for NPN Q605. In effect, Q610 is the bias resistor for Q605, and Q605 can conduct only when Q610 does. In other words, both transistors conduct at the same time—unlike conventional multivibrators—and loss of current in either one stops the other transistor from conducting.

Next, we'll describe the oscillator operation in sequence.

Vertical oscillation

When DC voltage first is applied

to the oscillator stage, neither transistor has any current.

Q610 has a fixed DC base voltage from the R602/R603 voltage divider. Without any Q610 base current, the voltage divider would apply +3.5 volts. This base voltage appears instantly, since the time constant is short.

At the Q610 emitter, C606 has no voltage, since it is uncharged, and the positive voltage rises slowly because of the high total resistance of R606 and R608. At turn-on, then, Q610 has about 3.5 volts of REVERSED BIAS, and it can't draw any C/E current. This also cuts off Q605.

Now, Q610 is a PNP-polarity transistor, requiring the base to be negative relative to the emitter before C/E current can flow. So, the C606 voltage at the emitter must rise to about +3 volts before much C/E current will flow.

When the Q610 emitter voltage finally rises about +0.5 volt above the positive base voltage, Q610 has some forward bias, and a small C/E current flows. This tiny current comes from C606 (where it was

stored) through Q610 and finally reaches the base of Q605, causing it to conduct slightly. Then, because the Q605 collector is connected to the Q610 base by only 330 ohms (R604), the Q605 slightly reduces the base voltage of Q610.

But, notice that reduction of the Q610 positive base voltage actually is increased forward bias, so Q610 conducts more, increasing the forward bias of Q605. This forces Q605 to conduct more, which reduces the Q610 base voltage, causing Q610 to conduct more, and so on in a self-feeding regenerative action that progresses very rapidly.

Two operations are going on simultaneously. The regeneration is decreasing the Q610 base voltage (increasing the forward bias) at a very rapid rate. On the other hand, the stronger Q610 emitter current is discharging C606 and reducing the positive voltage at the emitter. However, the reduction of emitter voltage is slower than the decrease of base voltage, otherwise there would be no bias change.

End of the regenerative action

continued on page 22

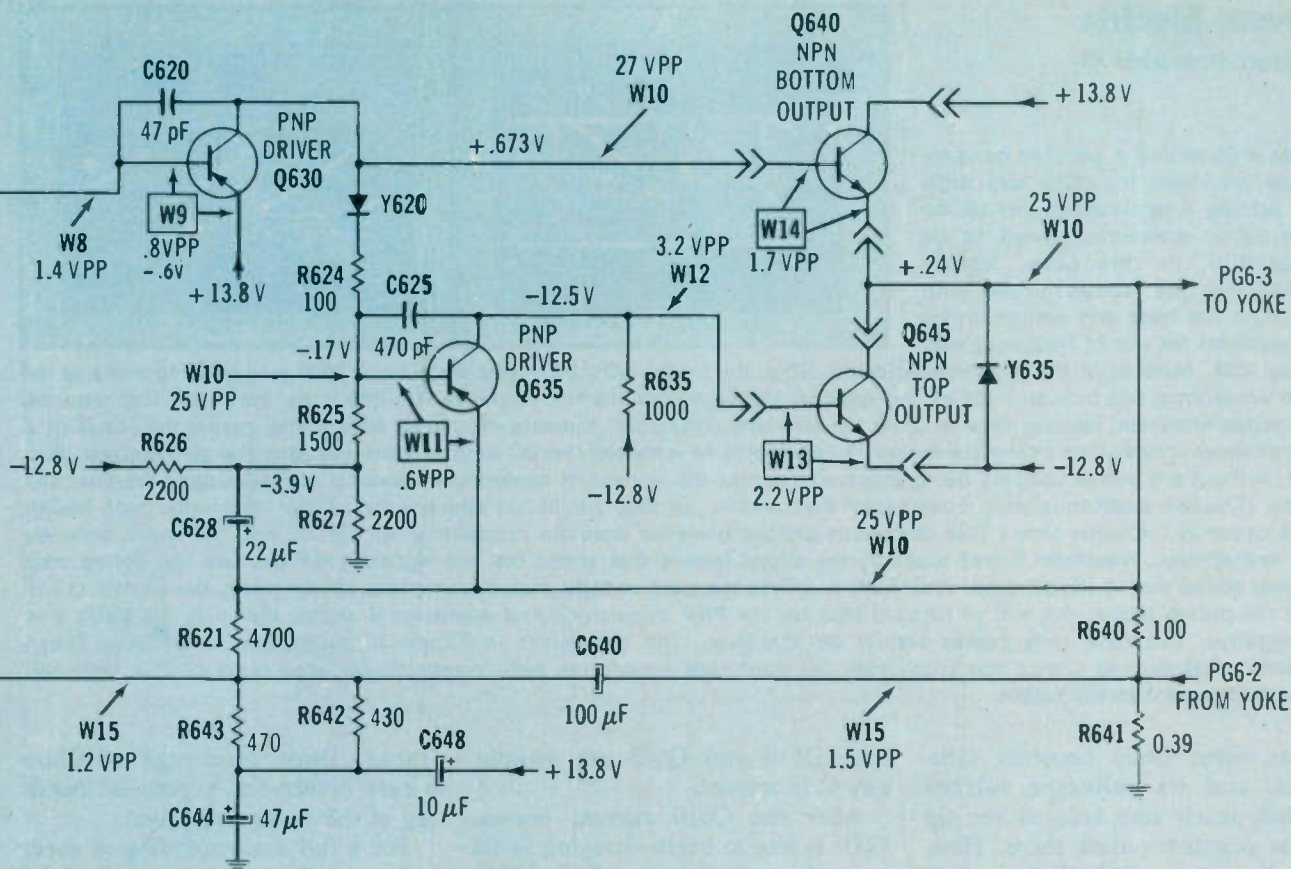
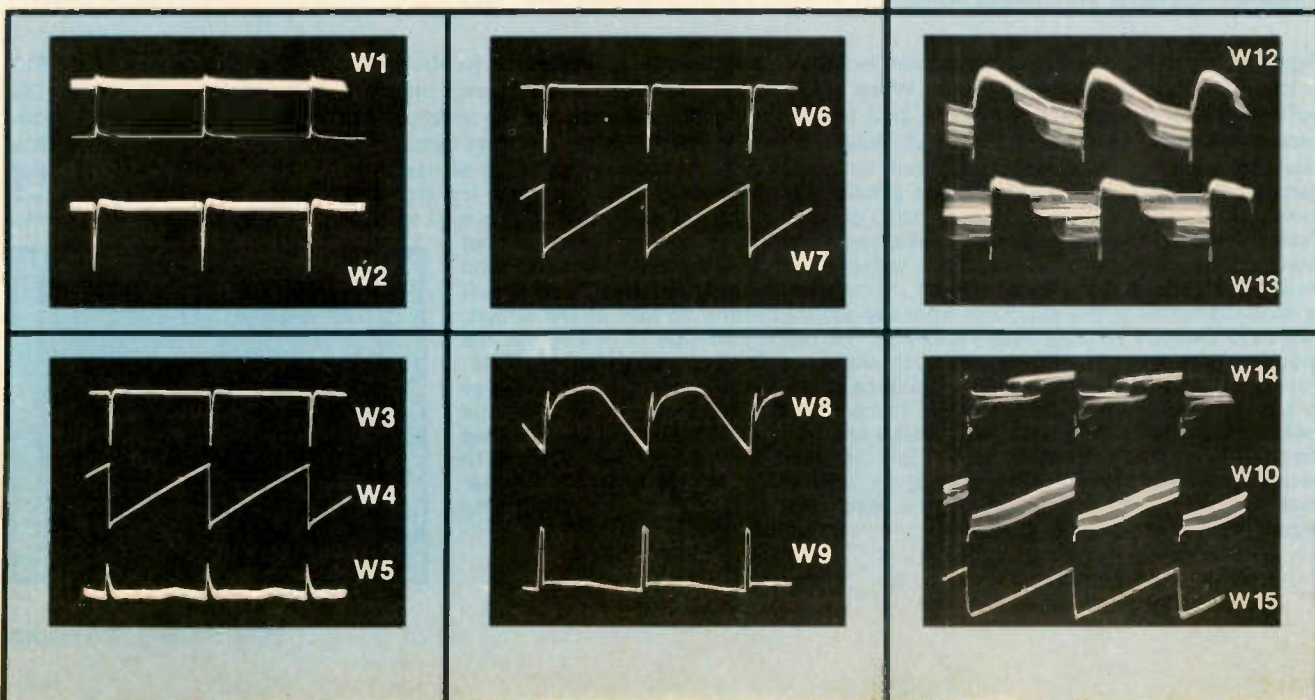


Figure 3A (above) This is a schematic of the entire vertical-sweep system in the GE AA-D chassis, except for the yoke and convergence coils. Waveform numbers in boxes were scoped between the points shown, and not to chassis ground as the others were.

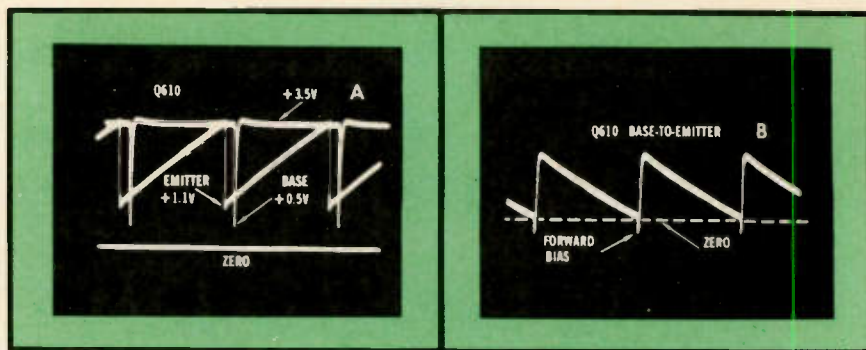
Figure 3B These waveforms match the "W" numbers in Figure 3A. Some of the vertical lines have been touched up because they were too faint to print well.



General Electric

continued from page 20

Figure 4 Obtaining a genuine base-to-emitter waveform for Q610 was difficult. Adding a zero-voltage line to the same scope waveform proved to be impossible, in this case. Merely connecting the scope probe and ground to the base and emitter threw the oscillator far out of frequency and vertical lock, because of the added capacitance. Now, the model 1470 B&K-Precision scope (that was used to make all of these waveforms) has provision for adding together the signals of the two channels into one trace. However, that requires both scope channels, leaving none to show the zero line. Therefore, separate exposures were made, giving the result of a three-channel scope. One dual-trace exposure (waveform A) recorded the DC emitter sawteeth plus the zero-voltage line. Then, without any scope controls being adjusted—except the horizontal centering—a second exposure gave the base DC pulses. (The two waveforms were moved apart horizontally, so they would not obscure each other. Normally, both falling edges occur at the same time.) This composite picture gives an accurate comparison of the AC and DC levels between base and emitter. Waveform B was made by the scope feature that added the two signals together, and the dotted zero line was added during the printing. Waveform A proves the base voltage does become less positive than the emitter at the tip of the pulses (about -0.6 volt of forward bias for the PNP transistor). And waveform B shows that only the pulse tips are negative; therefore, only pulses should be amplified. The waveforms in Figure 3B prove this to be true. These methods of explaining circuit operation from DC dual-trace waveforms were presented because tests of this kind will become important in the future.



occurs when Q605 becomes saturated, and its collector voltage reaches nearly zero volts at the tip of the negative pulses there. However, the base of Q610 has additional voltage entering through R602, and the 330-ohm R604 between Q610 base and Q605 collector prevents the base voltage of Q610 from dropping below +0.4 volt relative to ground. At that point, the regenerative build-up begins to reverse, with the positive voltages at base and emitter of Q610 increasing (but the base voltage rising faster than the emitter voltage, because of C606). This is decreased Q610 forward bias, and each round of decreasing current in the loop reduces the transistor currents still more, until

both Q610 and Q605 are without any C/E current.

After the Q610 current ceases, C606 is free to begin charging in its natural sawtooth wave shape. **This is slightly more than one cycle of operation.**

Incidentally, at turn-on, the emitter voltage at C606 was zero volts. However, at the lowest-voltage point of each following cycle, the voltage does not drop below about +1 volt.

These various currents have produced narrow negative-going pulses in the positive voltages at the base of Q610 and the collector of Q605. However, the voltage pulses at the emitter of Q610 have been integrated into linear sawteeth because of C606. These sawteeth are very

linear, since discharge of C606 occurs before the hyperbolic bending of the curve is reached.

For a full understanding of these pulse circuits, you need to look at the waveforms with a DC scope, and notice where the zero-voltage line crosses each waveform.

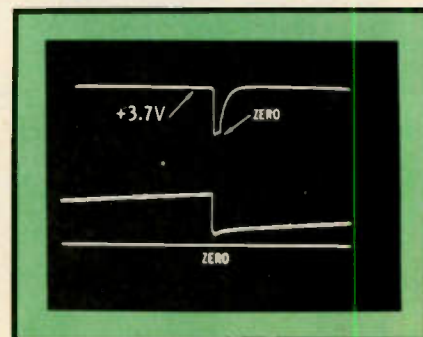
Some important DC waveforms are included in those of Figure 4. Study them carefully.

Locking the oscillator

The vertical-hold control is adjusted so the vertical-oscillator stage goes through about 59 complete cycles (of the kind just described) per second. This is slightly slower than the 59.94-Hz repetition frequency needed for correct locking.

continued on page 24

Figure 5 These DC waveforms have been expanded horizontally by the scope to show the voltages that force diode Y610 to conduct only at the proper time. When Q605 is not conducting (top trace), the Y610 cathode has +3.7 volts DC (voltage divider R602/R603 and R604). Just before the oscillator conducts, the anode DC voltage is +2 volts (see bottom trace). Therefore, Y610 has 1.7 volts of reverse bias, causing it to be an open circuit. (This allows C610 to charge in a sawtooth waveform, whose DC maximum voltage is determined by the setting of the height control.) When the oscillator transistors conduct, the Y610 cathode suddenly falls to about zero volts (see top trace). Since the anode has about +2 volts, this is a huge forward bias, so Y610 conducts, pulling down the C610 stored voltage to +0.6 volt (drop across the diode). As Q605 begins to conduct less, the Y610 anode voltage rises too, but more slowly because of C610. This reduces the forward bias at Y610, and shortly the bias is near zero causing Y610 to stop conducting. This open circuit in Y610 disconnects the oscillator from the sawtooth-forming part of the circuit. The Y610 cathode voltage rises rapidly to the resting voltage of +3.7, but the anode voltage rises in a linear sawtooth shape as C610 charges through R610. During height adjustments, lower resistance in R610 allows the C610 DC voltage to rise higher before Y610 switches to reduce it. Therefore, more drive and greater height is obtained. As the positive charge in C610 rises, the reverse bias changes from about 3.4 volts to 1.7 just before the oscillator fires. This Y610 switching action simplifies the circuit by eliminating any need for the buffer (that usually is placed between the oscillator and the sawtooth-forming capacitor).



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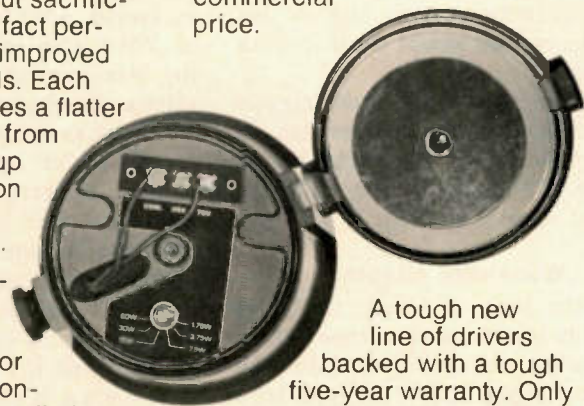
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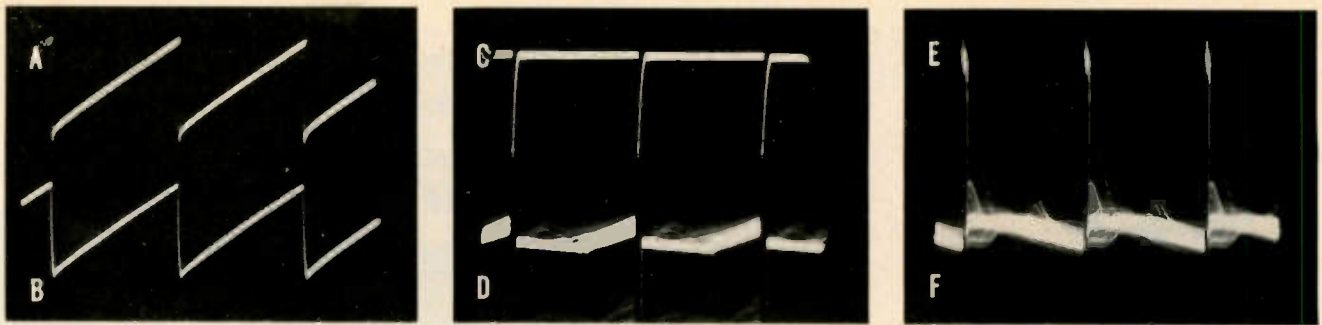


Figure 6 Q620 appears to have sawteeth coming into it—and pulses at the output. This is misleading, as these waveforms prove. Traces A and B are the base and emitter waveforms, respectively. Of course, the emitter signal subtracts from the base signal (in effect) and trace C shows the B/E waveform, which apparently consists ONLY of negative-going pulses, plus some hash. But, if this waveform is made very tall, and then is measured for DC levels, we find in trace D that the **only** positive forward bias is a plateau and a small sawtooth for each cycle. (In trace D, zero is about at the bottom of the picture.) Almost all of the pulse amplitude is below the positive conduction bias of the transistor, or it is negative (reversed bias). Therefore, Q620 ignores most of the pulse amplitude. The plateau has a DC level of about +0.50, and the peak of each sawtooth is about +0.03 volt higher. Since the pulse amplitude is 1.5 volts, you can see why the usual waveforms don't show the tiny sawteeth. But, this +0.03 volt increase of bias is enough to operate the transistor. Trace E proves this analysis, by showing at the Q620 collector a sawtooth/pulse ratio that's similar to many in tube-powered vertical circuits. Tips of the pulses represent transistor cut-off, so the DC level at the tips is +13.8 volts (supply voltage). The power-supply ripple was eliminated from trace E by connecting the scope from collector to +13.8 volts. The important part of the output signal (trace E) that drives the next stage, Q630, is the negative-sloped sawtooth of each cycle.

General Electric

continued from page 22

Therefore, just *before* the two oscillator transistors begin to draw current, the negative-going vertical-sync pulse (integrated from the composite sync) reaches the base of Q610. The Q610 base shortly is due to be driven less positive by the Q605 current, and the negative sync pulse forces Q610 (and Q605) to begin drawing current slightly before the circuit would do it without any sync.

In other words, the sync triggers the oscillator so it operates in perfect step with the vertical scan at the TV station. We call this normal vertical locking.

Waveform shaping

At the base of Q605, the drive signal is made up of narrow pulses of positive voltage. Therefore, the collector signal should be (and is) a series of negative-going narrow pulses (see the Figure 3A waveforms).

Most vertical circuits place a large capacitor at the collector to produce linear sawteeth. This one is slightly different. The capacitor (C610) is there, but it's at the other end of diode Y610. Therefore, **negative-going pulses (W6) are**

found at the Q605 end of Y610, and sawteeth (W7) are produced at the anode of Y610.

Incidentally, neither the W6 pulses nor the DC at the cathode of Y610 vary as the vertical-size control is adjusted. However, the W7 sawteeth amplitude does change. DC voltages of this sample measured +1.3 volts at the anode of Y610 with minimum setting of the size control, and about +1.7 volts at maximum rotation.

When sawtooth-forming capacitor C610 is open, there is no vertical deflection except a thick horizontal line about three inches from the bottom of the raster.

Diode Y610 separates the pulses from the sawteeth because it is forward biased only when the base of Q610 and the Q605 collector are at minimum positive voltage (tips of the negative-going pulses). At that time, the collector pulses come through Y610 and cause the falling edge of the sawteeth. At all other times, Y610 is reversed biased and non-conducting. In other words, it is a closed switch during vertical-retrace time, and an open switch at all other times.

Figure 5 shows the DC wave-

forms at both ends of Y610, along with an explanation of the switching as it's told by the waveforms.

Amplifier and driver

Q620 is labelled as an amplifier—which is a bit misleading—since there is a slight loss between input and output. Its input doesn't load-down or distort the linear sawtooth waveform coming from C610, and that's some advantage.

But, Q620 is included mainly so negative feedback from the yoke current can be connected to the emitter. Also, vertical-centering is accomplished by variations of the Q620 emitter voltage (through R616 and R617).

Figure 6 shows the Q620 waveforms, including some expanded ones with DC voltages marked, to make the explanation more clear.

Both the base and emitter of Q620 have sawteeth that are almost identical, differing most in the speed of the retrace (falling side). Of course, **a transistor amplifies ONLY the difference between the base and the emitter waveforms.** So

continued on page 26

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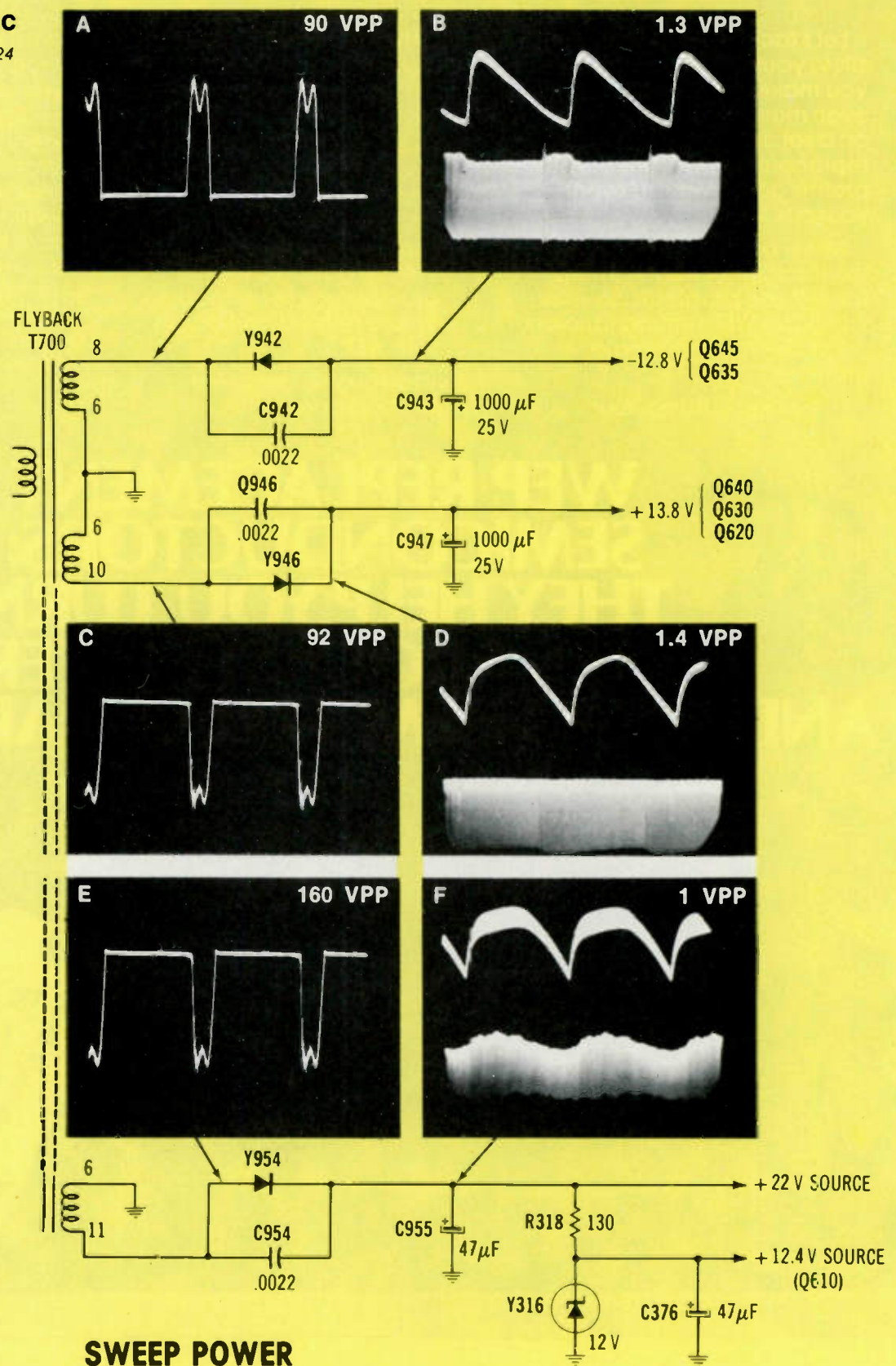


Figure 7 Waveforms and peak-to-peak AC voltages are included in this schematic of the scan-rectified power supplies. Although the pulses have the usual horizontal repetition frequency of 15,734 Hz, the ripple is mostly 59.94 Hz from the load of the vertical-output transistors. The vertical-frequency waveform is the top trace, and the horizontal ripple is the bottom trace of the ripple waveforms.

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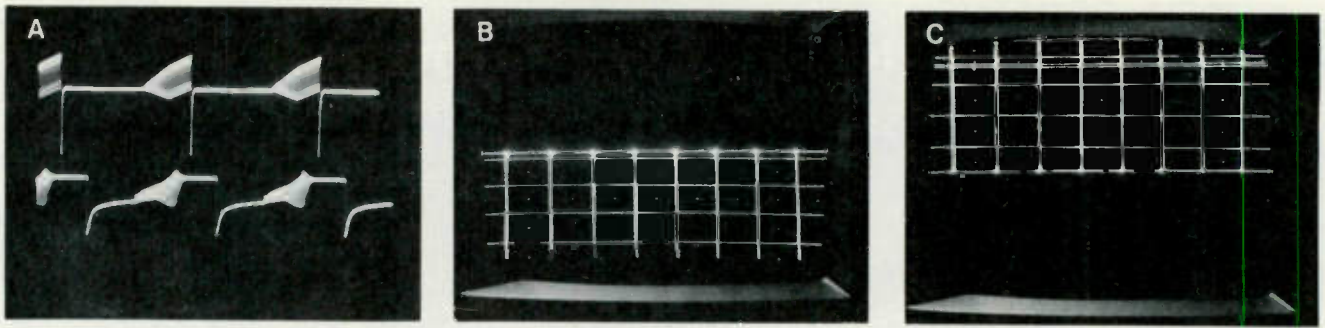


Figure 8 An open vertical-output transistor in the AA-D chassis can be identified by scoping the vertical-sweep output, or by analyzing a crosshatch pattern on the TV screen. (A) Because Q645 is open, this top scope trace shows deflection only during the second half of each cycle. An open Q640 gives sweep only for the first half of each cycle (top of picture). (B) Some deflection at the raster bottom is possible when Q645 is open. (C) Only deflection for the top half of the raster is produced when Q640 is open.

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the true B/E input can't resemble the base-to-ground waveform very closely.

When the scope is connected *between* base and emitter, and normal scope gain is used, the signal appears to be only large-amplitude negative-going pulses (waveform C in Figure 6). But when the amplitude is increased to drive the pulse tips below the screen, a sawtooth shape covering half of each cycle is revealed (Figure 6, waveform D). These sawteeth are the only part of the waveform that's positive enough to cause C/E current. DC scope tests show the flat part of the line to be at +0.50 volt above the emitter, with the sawtooth rising to about +0.52 volt. Since the conduction point of this transistor is about +0.50 volt, the remainder of the waveform—including the negative pulses—is ignored, and does not appear (inverted) at the collector.

The collector-to-B+ signal (waveform E in Figure 6) confirms this action, for it is an inverted replica of the B/E waveform, except the pulse amplitude is far less. DC waveform analysis shows the pulse tips are at the supply voltage of +13.8 volts. In other words, at the pulse tips the transistor has no C/E current.

Notice that a superficial analysis of the Q620 waveforms seems to show a sawtooth waveform at the input, and pulses at the output. Of course, that doesn't make any sense. After we identify the important areas of these waveforms, we

find both first impressions were wrong.

Driver operation

Transistor Q630 is a PNP type which functions as a simple amplifier to drive the base of output transistor Q640 and also the base of Q635, the inverter and driver of Q645. However, the waveforms can present a real mystery.

When scoped from the base of Q630 (and also the collector of Q620) to ground, the waveform (W8 in Figure 3B) appears to be a distorted and inverted version of the output waveform at the collector (W10 in Figure 3B). Again, the obvious is deceptive.

Power-supply ripple

One cause of the peculiar waveforms is that the power-supply ripple has amplitude *equal* to some of the signal voltages.

Perhaps you wonder how a power supply that rectifies 15,734-Hz sweep, and has a 1,000-microfarad filter capacitor can have any ripple. Well, it's *not* 15,734-Hz horizontal ripple! Instead, it is 59.94-Hz ripple produced by current of the vertical-output transistors. The large increase of current as each output transistor conducts for half of the vertical-sweep cycle changes the instantaneous DC voltage. Even the 1,000-microfarad filter only can smooth the vertical ripple waveform, but without eliminating it.

Both the minus and the positive supplies have ripple, and the waveforms are almost reversed (since the outputs draw current during oppo-

site halves of each cycle).

A ripple amplitude of 1.4 volt PP doesn't seem excessive until it is mixed with a signal pulse of 1.4 volts PP. The difference between the Q630 base-to-ground waveform (W8 in Figure 3B) and the base-to-emitter waveform (W9 in Figure 3B) is the power-supply ripple.

Refer to Figure 7 for the schematic and waveforms of the three scan-rectified power supplies. Compare the ripple waveforms with the vertical waveforms in Figure 3B.

PNP driver and its output transistor

When scoped between Q630 base and emitter (to eliminate the ripple), the input signal *appears* to be nothing but positive-going pulses (see W9 in Figure 3B). Again, as in the case of Q620, the pulses are misleading, since the tips have the same DC voltage as the emitter. So, the transistor ignores the pulses and amplifies the small sawtooth that's at the bottom of the pulses. The sawtooth represents a forward bias of -0.6 volt for the PNP transistor, and Q630 produces an inverted 27 VPP sawtooth that drives the base of Q640 output transistor.

Q640 is connected as an emitter follower, so the output from the emitter to the deflection yoke has the same sawtooth waveform (at least it does when Q645 is working too).

Base and emitter waveforms both have considerable amplitude of horizontal pulses (from the pincush-

continued on page 30

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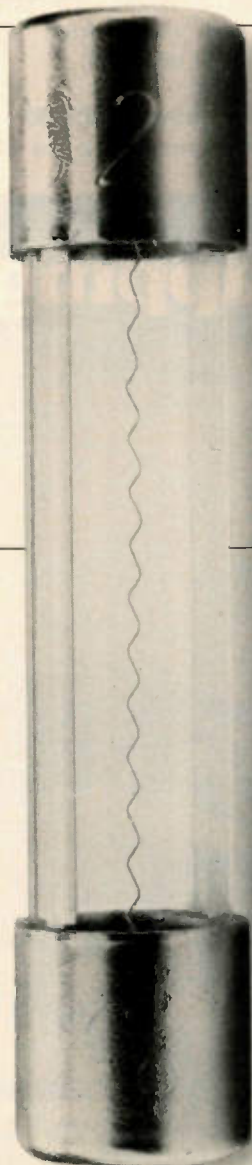
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continued from page 28

ion circuit) mixed with the vertical sawteeth, and these pulses make the sawteeth lines very thick.

Other waveforms in the output and driver stages have varying amounts of horizontal pulses. These include W11, W12, W13, and W14 in Figure 3B.

For the other half of the output power, PNP Q635 inverts the same sawtooth that's applied to the base of Q640, and drives the base of the other power output, Q645. Q640 and Q645 each conduct for half of the vertical-scan time.

At first glance, it seems the gain of Q635 driver would unbalance the output by applying too much drive to the base of Q645. However, there is hidden negative feedback to reduce the gain to unity. Do you remember in audio work the phase conditions of two stages in cascade, when both inverted the phase? Well, a signal from the second collector that's applied to the first emitter becomes negative feedback.

This is the case here. The collector of Q645 is connected *directly* to the emitter of Q635, the driver. Check the schematic in Figure 3A.

Output transistors

Q640 and Q645 are NPN-type transistors that are operated in Class "B." Each one conducts only for half of the sawtooth output. This can be verified by the W13 and W14 waveforms of Figure 3B, which show the B/E waveform of each transistor.

Therefore, it follows that about half of the TV picture will have deflection when one or the other of these transistors is open. Q640 deflects the bottom part of the raster, while Q645 supplies height for the top half.

Figure 8 shows the effects on scope and raster from opens in either Q640 or Q645.

Yoke feedback

Yoke current from the cold end

of the circuit flows through R641, causing a sawtooth voltage drop across R641. This waveform reveals the quality of the deflection linearity. (Refer to W15 in Figure 3B.)

A sample of the sawtooth is sent through C640 to the emitter of Q620. This is negative feedback, and it controls the linearity so well that a linearity control isn't necessary. Three of the cover pictures show the excellent linearity obtained at all height adjustments. Incidentally, the vertical didn't roll when the height was adjusted!

Troubleshooting methods

Next month we'll finish the vertical operation by discussing specific troubleshooting methods for the AA-D vertical system, including tips and comments, plus waveforms and raster pictures of simulated typical defects.

After the vertical servicing suggestions, our analysis of the picture-IF and sync sections begins. □

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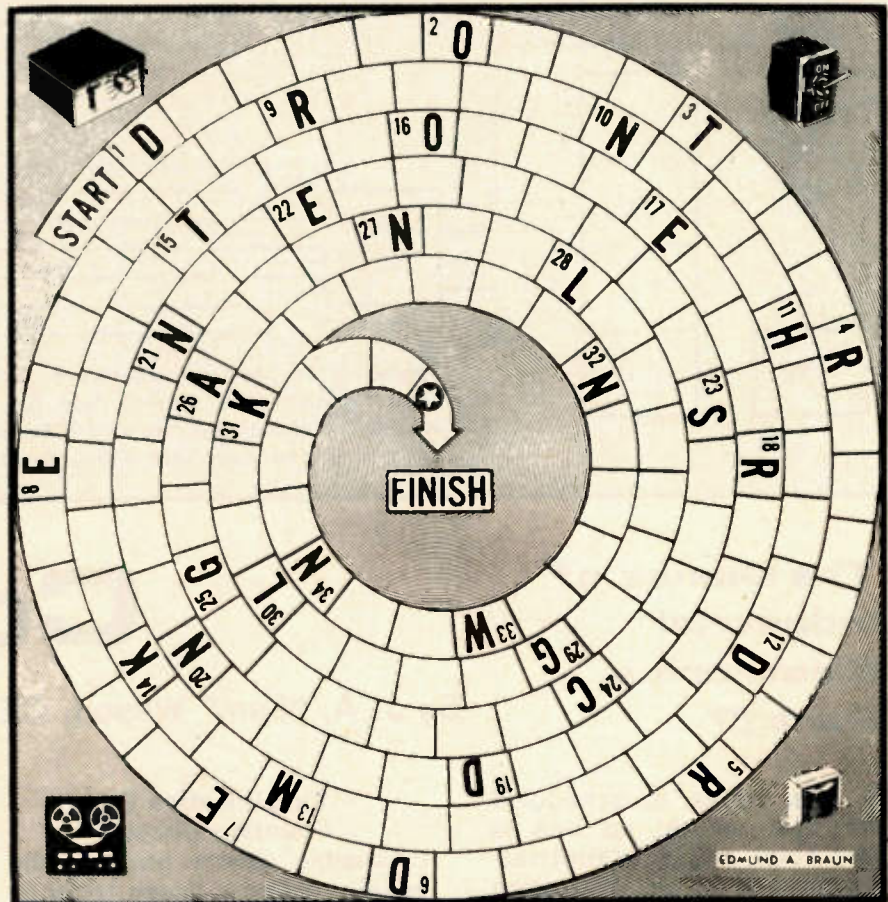
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AROUND THE WHIRLED!

By Edmund A. Braun

'Round and 'round this puzzle goes; where you'll stop, nobody knows! But give it a whirl. The last letter of each word is the first letter of the next word. Each correct answer is worth 3 points; a perfect score is 102. It should prove fairly easy except perhaps for someone who's sure "loading noise" is made by a slurpy drinker; and that "master stamper" works for the Postal Service! Now, start whirling!

- 1 Machine that converts mechanical energy into electrical energy, esp. into d.c.
- 2 The path of a body or particle influenced by gravitational or other force.
- 3 Special clock mechanism to perform switching operations at predetermined intervals.
- 4 Any device which emits energy from molecules and atoms owing to internal changes.
- 5 To transcribe for reproduction by phonograph, etc.
- 6 The force that produces acceleration of 1 centimeter per second on a 1 gram mass.
- 7 Process by which a signal recorded on tape is removed and may be used again.
- 8 Transducer which produces a large range of output voltage for a given amplitude range of input voltages.
- 9 A type of microphone.
- 10 A rectangularly shaped depression that extends below the sweep line of the radar indicator in some equipment.
- 11 An electronic circuit that contains both vacuum tubes and transistors.
- 12 Flexible membrane for producing audio frequency vibrations when actuated by electric impulses.
- 13 A frame mounted in front of a TV picture tube to limit viewing area of screen.
- 14 A removable portion in the side of a box or cabinet.
- 15 Prefix meaning due to or pertaining to friction.
- 16 Blue, gaseous, powerfully oxidizing form of oxygen.
- 17 An unintentional deviation from what is correct; a mistake.
- 18 Returned to working condition; fixed.
- 19 To diminish progressively in amplitude, usually said of waves or oscillation.
- 20 In mksa, unit of force that will impart an acceleration of 1 mps to a mass of 1 kilogram.



- 21 Junction point, branch point, or vertex.
- 22 Small telephone receivers attached over the head.
- 23 Noise in radio reception due to natural weather phenomena.
- 24 The association of two or more circuits or systems so that power may be transferred from one to another.
- 25 Prefix meaning one billion, or 10⁹.
- 26 Pertaining to a screw having a hexagonal hole or socket in its head.
- 27 Balanced condition which results in zero output from a device or system.
- 28 Restricting of the amplitude of a signal so that interference can be minimized.
- 29 Mechanical frame having two perpendicularly intersecting axes of rotation.
- 30 Condition that causes current to be shunted away from its destination through a low resistance.
- 31 A thermionic electronic tube, normally used as a high-voltage rectifier.
- 32 Not wide.
- 33 An alternating-current bridge used to measure inductance or capacitance.
- 34 The pointer on a meter, gauge, etc.

102 GENIUS!	60 - 66 Fair	30 Leak	25 Giga	20 Newton	15 Tribo	10 Notch	5 Record	1 dynamo	1 Orbital	2 Orbit	7 Erasure	12 Diaphragm	17 Error	16 Ozone	21 Node	26 Alien	31 Kenotron	69 - 75 Good	84 Gifted	87 - 99 Grand	102 GENIUS!
4 Radiator	3 TimeR	8 Expander	9 Ribbon	14 Knockout	19 Dampen	18 Repaired	23 Static	24 Coupling	29 Gimbal	34 Needle	27 Null	22 Earphones	21 Node	26 Alien	31 Kenotron	69 - 75 Good	84 Gifted	87 - 99 Grand	102 GENIUS!		

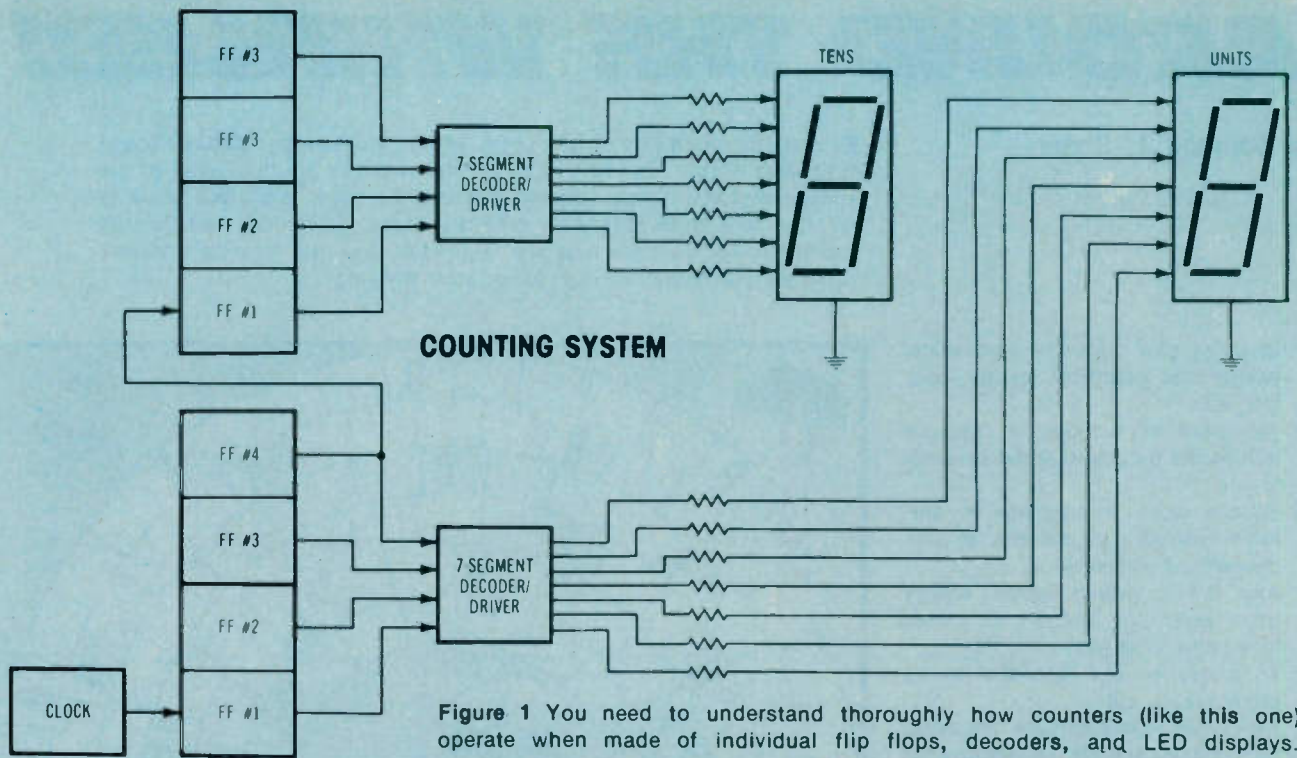


Figure 1 You need to understand thoroughly how counters (like this one) operate when made of individual flip flops, decoders, and LED displays. However, practical counters should be constructed around just a few ICs, with each containing many sets of the essential digital gates.

The Basics of Industrial Electronics, Part 17

Counting

By J. A. "Sam" Wilson, CET

A new series is scheduled for next month, so this is the final basic industrial-electronics article. Sam gives examples and block diagrams of many practical counter applications.

Simplification Of Counting Circuits

Counting circuits (such as the two-digit design of Figure 1) can be constructed easily, if you use ICs that have multiple gates. This saves much duplication of wiring, and minimizes mistakes. Four flip flops are needed for the units count, plus four more for the tens count. It would be time consuming to use individual flip flops. Worse yet is the thought of wiring individual flip flops from discrete transistors!

A number of ICs have two flip flops in each DIP. For example, IC 4027 in Figure 2 has two CMOS J-K flip flops, which can be connected to toggle, as needed for the counter.

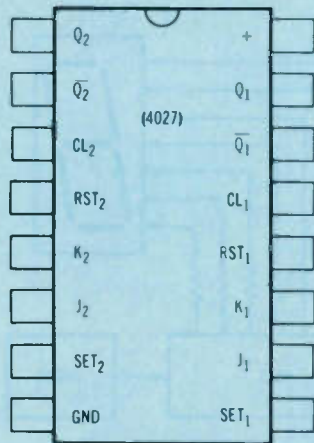
Decoder/Driver Circuitry

Separate decoders are used in Figure 1 for the units and tens counters. They are necessary for conversion of the binary-coded decimal (BCD) outputs of the flip flops into signals for lighting the

appropriate sections of the 7-segment displays. Power for operating the LED segments comes through each decoder/driver. Therefore, each output either is high (near the supply voltage) or low (near zero). Of course, all LEDs require current-limiting resistors, which usually are external to the ICs (as shown in Figure 1). These resistors are connected between the decoder/driver IC terminals and the individual anodes of the LED display. All LED cathodes are connected together, and then grounded.

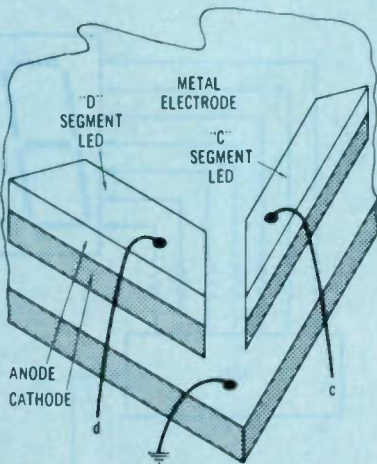
There are several basic ways of connecting the LED segments inside these displays. In Figure 3, each segment is made from long strips of anode and cathode material, with the cathode material in direct electrical contact with the metal that's bonded to the epoxy substrate. This automatically grounds all LEDs through the common ground plate, and only a "hot" wire connects to each anode.

Another type has three LEDs



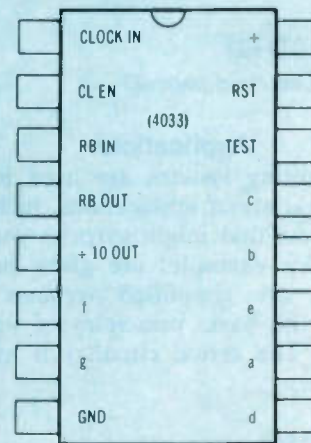
4027 HAS TWO CMOS J-K FLIP FLOPS

Figure 2 The 4027 CMOS IC contains two J-K flip flops. Two such ICs are used for each digit of a counter.



COMMON-CATHODE 7-SEGMENT LED DISPLAY

Figure 3 Here is one way "common cathode" 7-segment LED displays are manufactured.



COUNTER, DECODER, AND DRIVER IN ONE IC

NOTE: RB IS 'RIPPLE BLANK'

Figure 4 For more simplification, a 4033 CMOS IC includes the counter, decoder, and display drivers for one 7-segment digit. These can be cascaded for as many digits as desired.

Circuit Examples

formed on each segment strip. These three LEDs are paralleled, and therefore they light together. Each segment appears to be made up of three lighted dots during operation. Of course, different decoder/driver packages and different values of limiting resistors are required for these various types of displays. (Not all displays are of the "common cathode" type just described. Others have all anodes connected to the positive side of the power supply at a "common anode" terminal. Each segment is lighted by grounding its cathode lead through a decoder/driver unit.)

One-IC counter

After you have wired simple counters from individual gates, and know how they operate, you should assemble practical counters from ICs that have all essentials (except the display) in one package.

The CMOS 4033 of Figure 4 has all of the counting, decoding and

driver circuitry needed for one digit of a counter.

With IC 4033, the clocking signal for the count is delivered to the "CLOCK IN" pin-1 terminal, while the "÷10" terminal provides an output signal for clocking the next higher digit, if there is one. A proper signal at the clock-enable ("CL-EN") terminal can stop the count without interfering with the clock signal itself.

The count can be reset to zero by an input to the "RST" (reset) terminal, and the "RB" (ripple blank) terminal is used for blanking any undesired zeros at the display. Lower-case letters ("a" through "g") mark the terminals intended for connection to a standard 7-segment display.

As shown in Figure 5, only two 4033s are required to construct a two-digit counter.

Interfaces

Instead of LED displays, a designer may choose a liquid-crystal

display (LCD), incandescent lamps, or a gas discharge (neon lamp) type.

A decoder/driver intended for LED use probably can be used with these other systems if an appropriate interface device is added. This interface might be a single IC that's designed for the job. Another approach is the use of optical couplers.

Remember that an interface of some kind is necessary for operation of a component having a voltage, current, or power requirement of different rating than the logic-system output.

Figure 6 shows how an interface could be inserted between a counter and a gas-discharge display. TTL counters have outputs of about +5 volts, and CMOS usually have slightly more. This interface must accept an input of low voltage, and supply an output of 65 volts for the gas-discharge digits.

continued on page 34

Industrial

continued from page 33

Applications

Counting systems are used in a wide variety of applications, including some that might surprise you.

A few examples are given here. These are simplified versions to show the basic principles of operation. The actual circuitry is more complex.

Stopwatch

A counter can be connected as a stopwatch, as shown in Figure 7. The clock signal must be exactly 60 Hertz and have a square waveform. It can be obtained by squaring 60-Hz sine waves from the power line, or it can be counted-down from a crystal oscillator of a higher frequency.

Counting of the stopwatch is started when the clock enable (CLK EN) terminal is pulled high. It's stopped by application of a low to the same terminal, and the display shows the number of seconds that have elapsed while the enable terminal was high.

A high applied to the reset (RST) terminal returns the display back to zero seconds.

Frequency counter

A modification of the previous schematic can change it into a frequency counter, as shown in Figure 8. The unknown frequency replaces the clock signal.

Some waveforms require a change to pulses or square waves to insure accuracy of count. Conditioning by the Schmitt trigger eliminates the problem.

The clock-enable terminal is held high for one precise second while individual cycles of the input signal are counted. Therefore, the readout shows the cycles-per-second (Hertz) of the input signal. Actual counters read and display the frequency continuously, and many have provision for a choice of several sampling times.

Digital voltmeter

Many different basic methods are used to measure DC voltages digitally. All require some kind of analog-to-digital converter. Figure 9 shows one method. (If the unknown

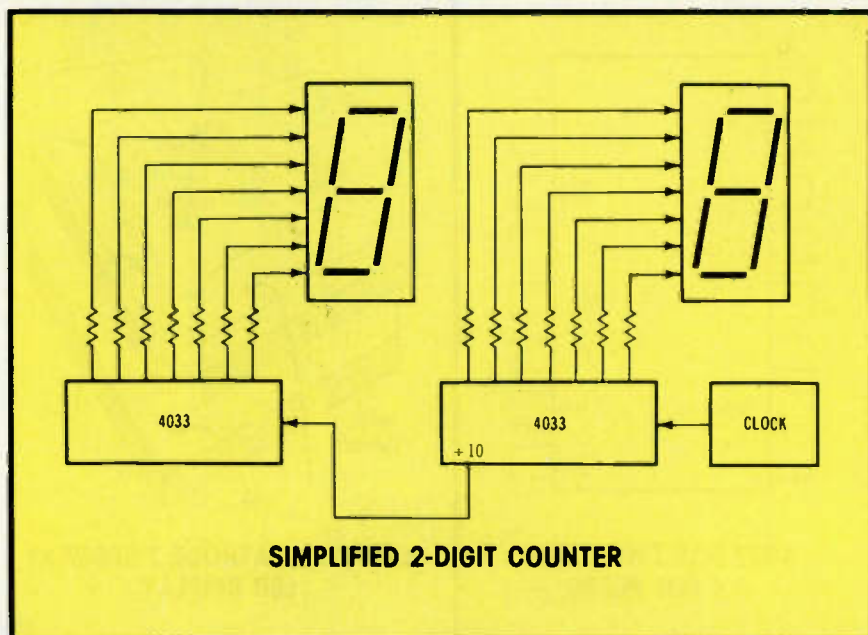


Figure 5 Two 4033 ICs can be wired as shown to provide a two-digit counter.

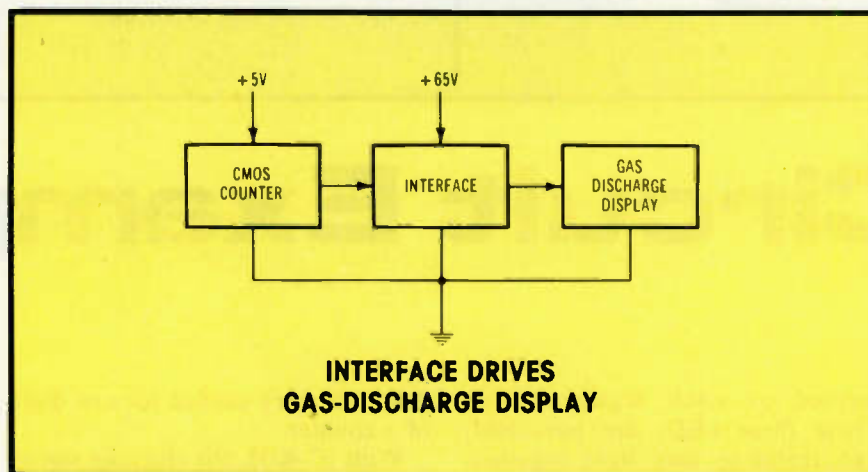


Figure 6 Other types of display can be used, if an appropriate interface is added. Its input matches the counter, and the output must drive the display with the voltages and currents that are needed.

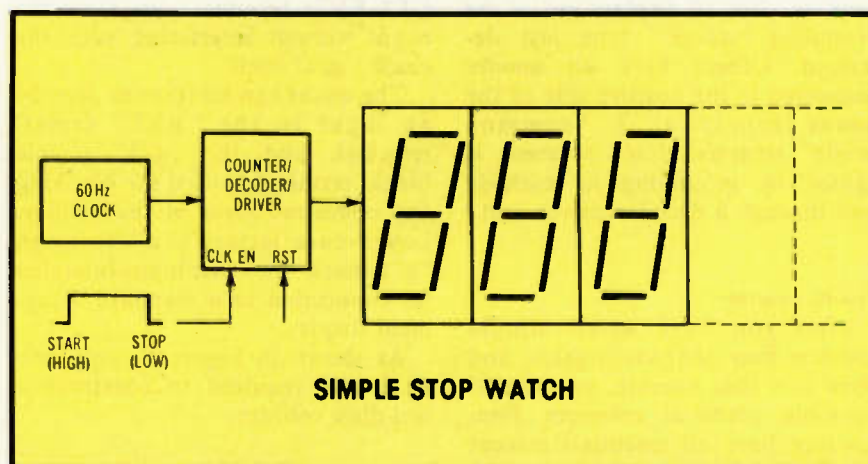


Figure 7 The least-significant digit (at the right) of this stopwatch reads in tenths of a second up to 0.9. Three digits could read to 99.9 seconds.

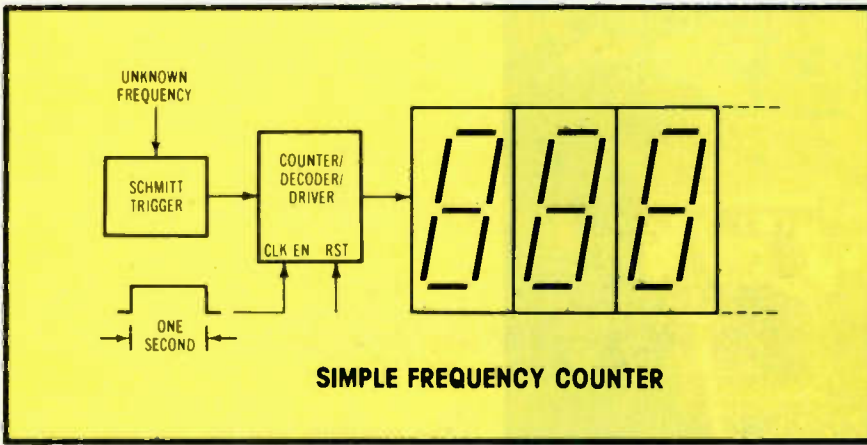


Figure 8 A counter that's sampled for one precise second will read directly in cycles-per-second (Hertz).

voltage is AC, it first must be changed to DC.)

Frequency of the voltage-controlled oscillator (VCO) is determined by the amount of the unknown voltage. When the unknown is zero volts, the frequency divider counts the VCO output as 0 Hertz, and the display shows 0 volts.

A higher DC unknown voltage increases the VCO frequency, and the counter circuit is calibrated to read the DC voltage correctly.

Last Of The Series

This article is the 17th and last of the series about *basic* industrial electronics.

The series began with studies

about open-loop and closed-loop circuits, and the many types of transducers that sense conditions or locations. Later the emphasis was shifted to basic logic gates and circuits, since many of the new industrial systems have digital controls. During the past few months, the fundamentals of counting circuits were explored.

Next

The next digital subject will be microprocessors, including the makeup of the systems, typical circuit operations, and some uses for them. Watch for our microprocessor series. □

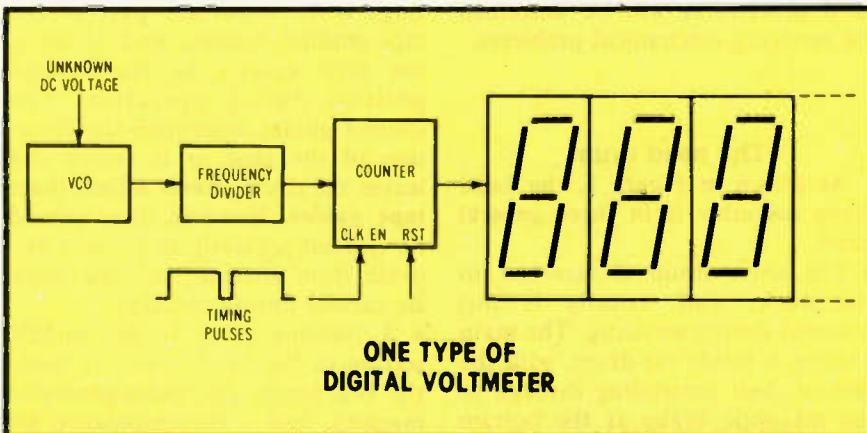


Figure 9 Frequency of a voltage-controlled oscillator is changed by the unknown DC voltage, and a counter displays the frequency, but calibrated in DC volts.

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103	1.05	172A	.72	224	5.06	293	1.08
103A	1.11	175	1.62	225	4.34	294	1.14
104	1.08	178	2.98	226	1.87	295	2.02
105	2.27	177	.49	228	1.38	297	1.13
106	80	179	5.69	229	3.66	298	1.13
107	79	180	5.96	230	3.60	299	2.02
108	89	181	4.95	231	3.96	300	2.02
121	2.15	162	3.35	232	.70	302	2.80
123	99	183	3.63	233	.74	308	2.80
123A	79	184	1.37	234	.72	307	2.57
124	1.53	185	1.70	235	2.45	308	1.65
126	1.16	186A	1.46	236	5.75	309	3.27
127	4.80	187A	9.46	237	5.07	310	7.65
128	1.37	188	1.59	238	7.95	311	2.13
129	1.56	189	1.59	239	3.02	312	1.13
130	1.95	190	1.85	241	1.71	313	1.00
131	1.98	191	2.07	242	1.90	314	7.85
132	1.01	192	.96	276	5.72	315	2.01
133	1.14	193	1.04	278	2.35	316	2.74
152	1.43	194	.82	279	5.85	317	24.20
153	1.85	195A	2.87	280	8.08	318	20.65
154	1.85	196	1.98	281	6.35	319	1.11
155	2.02	197	1.89	282	4.24	320	26.00
157	1.43	198	1.05	283	6.32	321	1.05
158	1.08	199	.59	284	7.35	322	1.80
159	.86	210	1.37	285	7.99	323	3.53
160	1.43	211	1.56	286	5.75	324	3.53
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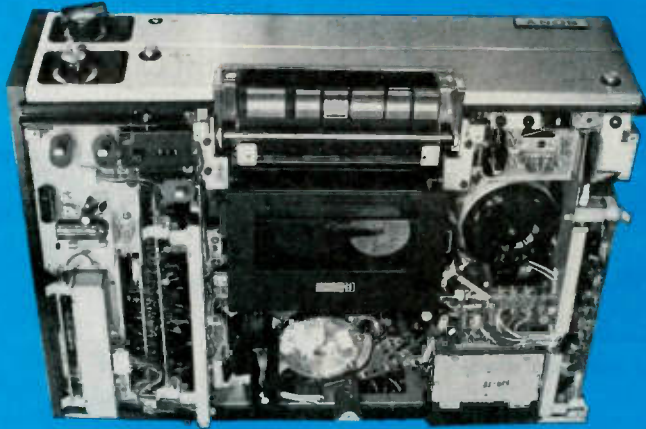
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The threading ring can be seen just beyond the tape-cassette compartment of this Betamax, with the head-drum assembly inside it.

Servicing Betamax Videotape Recorders

PART 7

Betamax Mechanical Features and Control System

By Harry Kybett

An overview is given of the mechanisms that thread the tape from the cassette and guide it around the head drum. Also described are the control circuits that have jurisdiction over the mechanical systems.

Introduction

The system-control circuit operates several important mechanical functions. And, the mechanical operations affect the status of the system-control circuits. That's why it's best to discuss these two general sections together.

Descriptions of the mechanical parts will be somewhat brief. Their functions are understood best as you watch an actual Betamax in operation during routine maintenance procedure. This discussion will cover the generalities of the head drum, threading ring, videocassette and tape reels and the function-button block.

Problems of the system-control

circuit will be discussed in detail. Finally, some new ideas and standard procedures will be described for servicing mechanical problems.

The head drum

As shown in Figure 1, the head drum assembly is in three general parts.

- The lower drum is attached to the deck, and usually is not removed during servicing. The main bearing is inside the drum, with the central shaft protruding through to the magnetic brake at the bottom just above the pulley (for the drive belt). A precision-machined ridge

goes around the surface of this lower section, at an angle. The ridge is an important part of the tape-guiding system, and it holds the tape exactly in the desired position during operation. The slanted guides determine the direction of the tape as it enters and leaves the drum. **Never adjust these tape guides.** However, they should be cleaned regularly to prevent any oxide from altering the tape path. Be careful during cleaning.

- A rotating plate is the middle section of the head drum. It holds the two heads, the pulse-generator magnets, and a counterbalance for the magnets (to minimize vibration during rotation).

- The top section of the head drum does not rotate, and it is there mainly to help guide the tape. Two light springs help hold the tape in its correct path.

Threading ring

Videocassette machines must have a threading ring, as shown in Figure 2. It is the distinctive difference between cassette and open-reel machines.

The threading ring is driven by the DC-powered threading motor, as it pulls the tape out of the cassette and around the threading path. Several guides and the pressure roller are mounted on the ring, and notches in the ring control the operation of several levers and moving parts of the mechanism. One of the notches actuates the end-of-thread switch when the tape is threaded fully.

Reels inside the cassette

Two reels inside the videocassette contain the tape. The space between the reels is protected by a flap or door which is opened automatically when the cassette is dropped into position as it is inserted into the Betamax. The bottom of each reel fits over a spool table, making them operate in similar fashion to those of a reel-to-reel machine.

Reel tables

These reel tables are driven by idlers (or pucks), which are moved by linkages so they contact the take-up or the feed spool, according to the mode of operation. They are driven by a belt that connects the central idler wheel to the main AC-operated motor.

Positions of the various linkages and idlers are shown in the service manual. If you are familiar with audio machines, you should have no difficulty in understanding the Betamax tape handling.

Function pushbuttons

Six buttons (or keys) are mounted in a block at the front of the machine, where they can be operated conveniently. All are interlocked, so when one is pressed, all others (except "stop") are locked out. Also, two microswitches called F1 and F2 are mounted on the

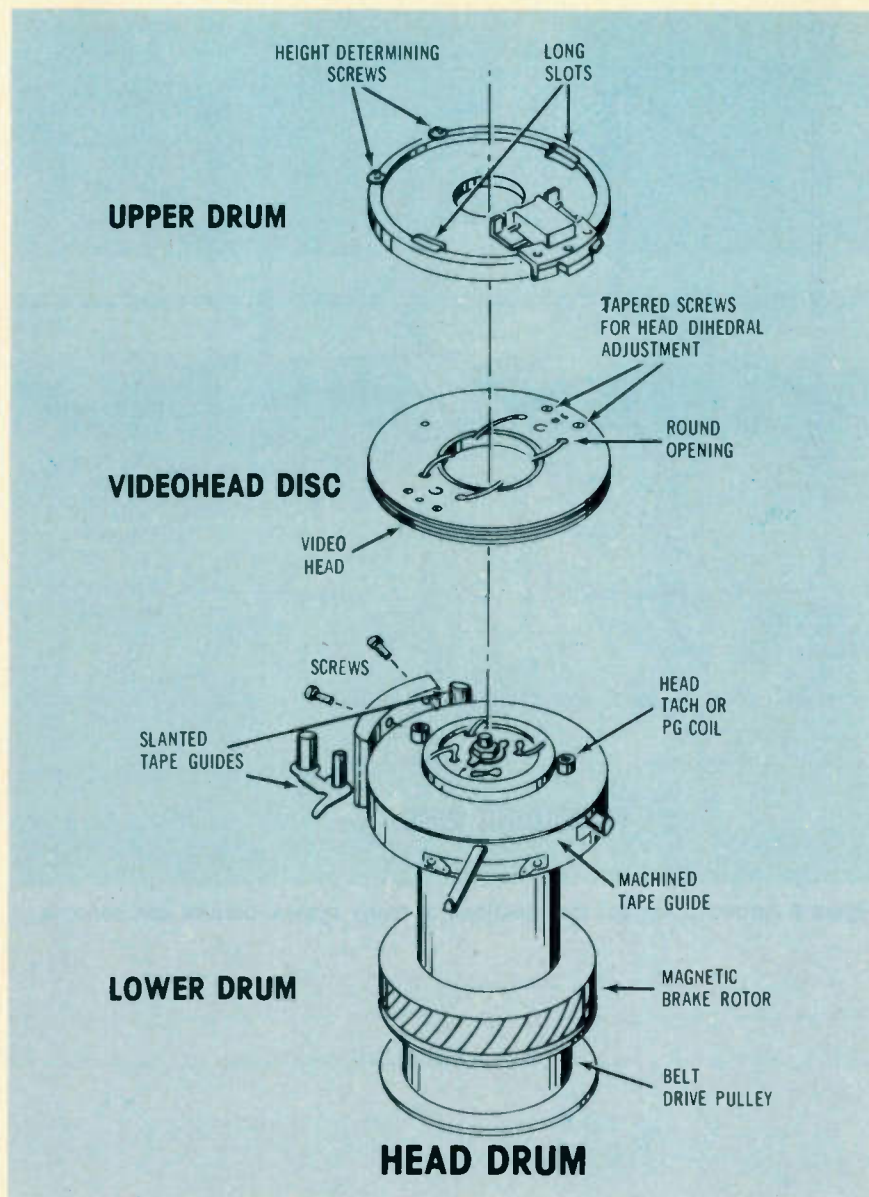


Figure 1 The Betamax head-drum system is in three assemblies. Only the center head-disc section rotates. The machined tape guide is a groove for the tape, and is not shown clearly here.

block (see Figure 3). F1 connects the pulse-generator pulses to the rotation-sensor circuit in the system control, and F2 provides AC to the main motor.

On the block also are the stop solenoid and the microswitch that's associated with it. This stop solenoid is powered from the AC line, through the system-control circuits.

The system-control circuit

This circuit is located on the SY board at the front of the machine directly under the function keys. Figure 4 is the block diagram. It is rather simple, since most of the important functions are produced

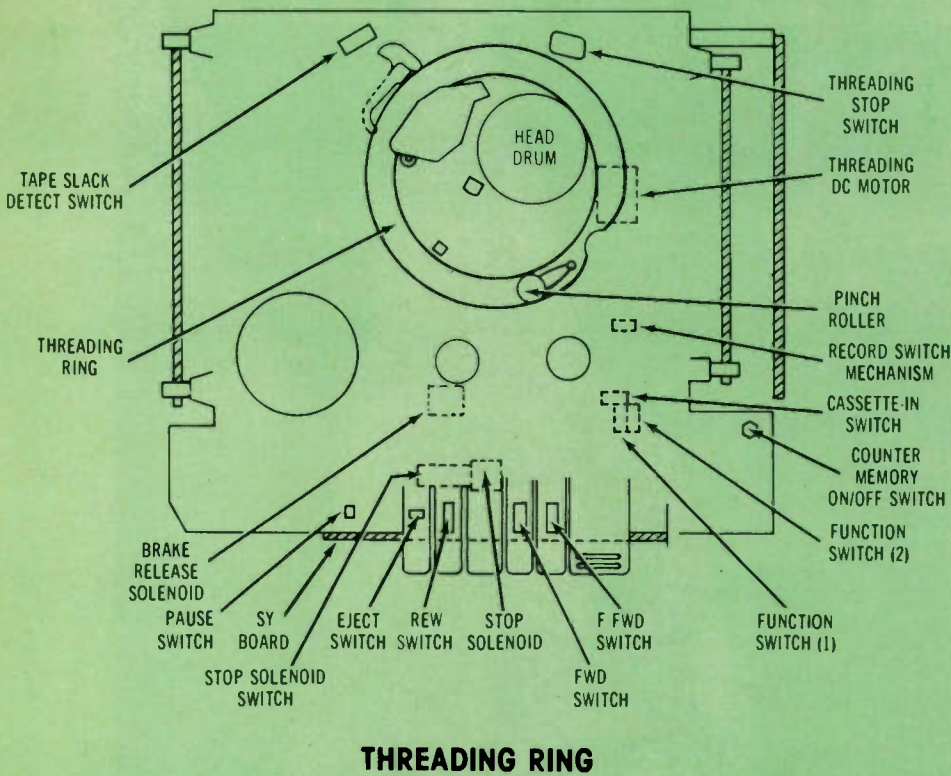
in one IC. Mechanical switches and power transistors are the other parts not inside the IC.

Inputs for the system control are from the function switches, end sensors, slack detector, condensation detector, and the head-program pulses.

Outputs of this circuit control the auto-stop relay, brake relay, and the threading motor. In some models, they also control the muting, pause release, and the still-frame vertical-drive pulse.

Problems of the system control

Several common and typical sys-
continued on page 38



THREADING RING

Figure 2 Arrows point out the locations of many system-control components.

tem-control problems are described next, along with the most-likely causes and solutions. In many cases, the problem and its solution will be obvious. For example, dirty contacts on the switches of the system board, faulty contacts in the microswitches on the deck, and loss of power together account for a majority of servicing.

Failure to thread or unthread

First, check the cassette "in" switch to determine if it is applying +12 volts to the system board. If power is reaching the board, then check to see if it is reaching the DC motor.

If a new threading ring has been installed, make sure it is not too tight. It would be very helpful for you to view the procedure on the Sony instruction tape.

Auto-stop not working

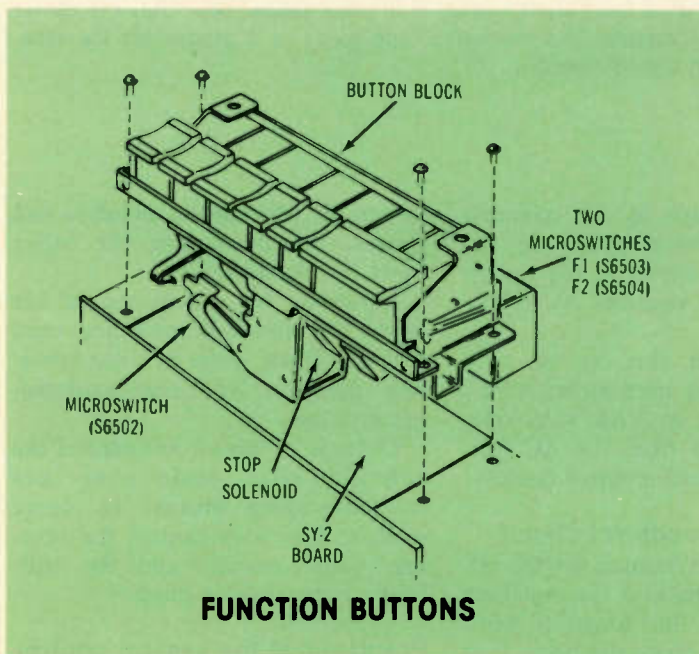
The auto-stop circuits should pull-in the stop solenoid. If this doesn't occur, the most likely cause is that the end-tape sensors are positioned too far from the tape. To test them, place a screwdriver near one while a tape is playing. Scope testpoints 1 and 2 on the system board to see if the oscillators are working. Often, the wires to the end sensors are broken.

Stop solenoid does not pull in

Several of the problems just discussed can cause this, too. Check the voltage across the solenoid, and check Q8 of the system board for opens. If the stop solenoid does not allow any function to be selected—but will allow threading to occur and an EE picture to be seen—it's possible the AC motor is open, or the S6503 function switch F1 is not sending power to the motor. This prevents rotation of the heads, which in turn stops the PG pulses. Thus, the solenoid appears not to release. Also, check that F2 (S6504) is closed, so the PG pulses can reach the system board.

Slack tape in the machine

This either is a tension problem, or the brake solenoid is not being



FUNCTION BUTTONS

Figure 3 Various control switches are mounted with the function pushbuttons.

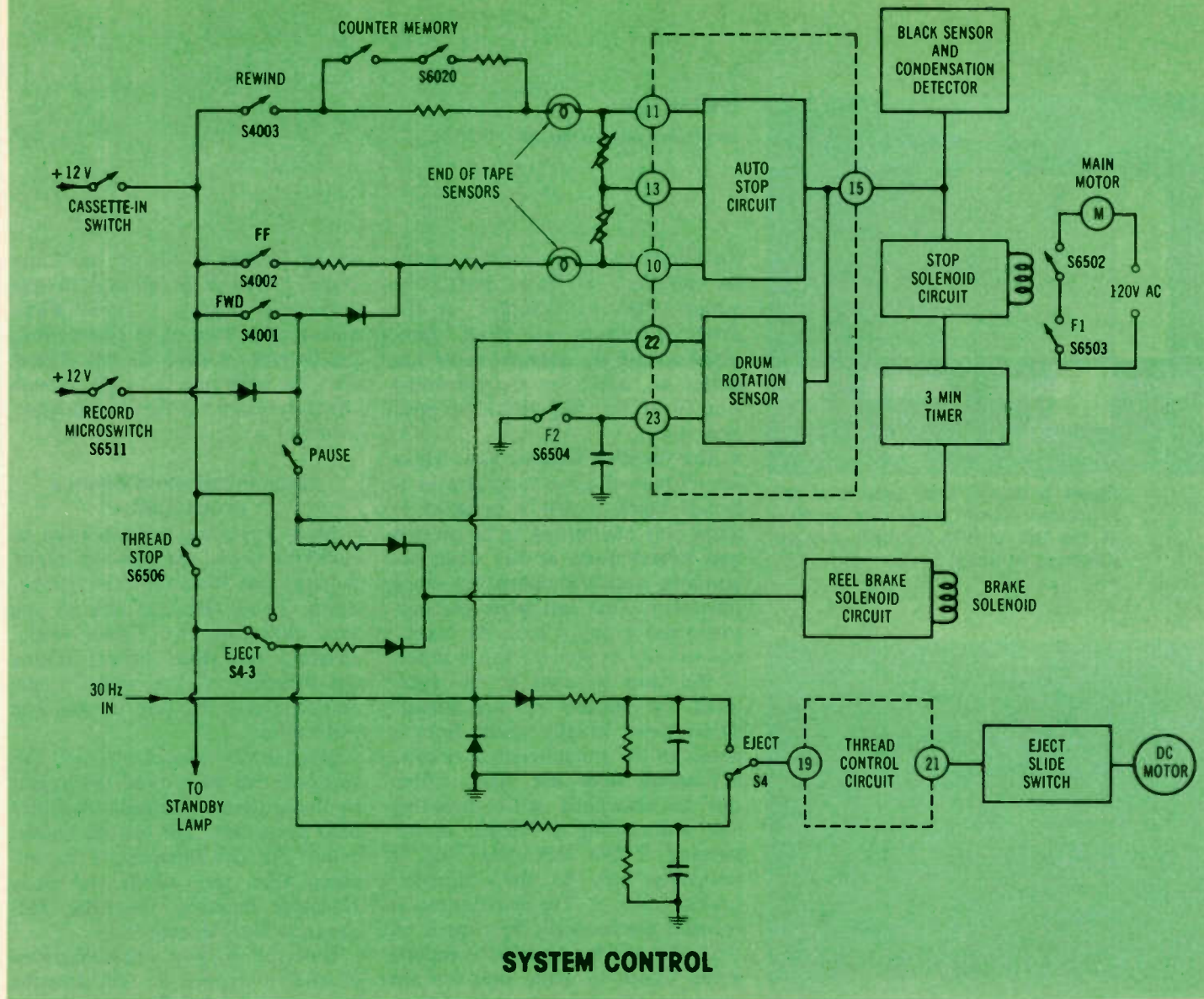


Figure 4 The system-control circuit is relatively uncomplicated, because most of the active components are in the IC.

pulled in by the system-control circuit. Check the voltage at the brake solenoid.

No tape motion

In normal operation, the buttons engage the mechanical linkages, close the two function switches (at the end of the block), and operate the switches that are on the ST board. Make sure these switches actually operate, and that their contacts pass the voltage.

Mechanical problems

Mechanical problems sometimes will affect the picture. For example, when the tape does not move, the symptom is a blank screen with no sound. Usually, however, mechanical problems show up as a failure

of some mechanical part or operation.

Some mechanical problems involve the system-control circuits. Others are purely mechanical.

Before you attempt any mechanical maintenance on the Betamax, we must give you two items of important advice:

- Do NOT adjust the tape guides.
- Do NOT touch the "X" bars that are located underneath the deck.

Most mechanical problems result from wear, or because of damage from careless operation. Repairs often are affected by installation of new mechanical parts, followed by a simple alignment procedure (refer to the manual).

The first step is to determine what has gone wrong. Sometimes it

is obvious, such as a visibly broken part or one not moving as it should. In other cases, a bit of detective work is called for.

Mechanical problems

These are the five most common mechanical problems:

- **The heads don't rotate.** Look for a broken belt, or one that has come off the pulleys. Belts are easily replaced, but make sure they have the correct side toward the metal, and the right side away from the metal. A bad AC motor can prevent head rotation. First, check micro-switch F1. This might be open, thus preventing power from reaching the motor. Check the fuses.

- **The tape does not move.** Check

continued on page 40

Betamax

continued from page 39

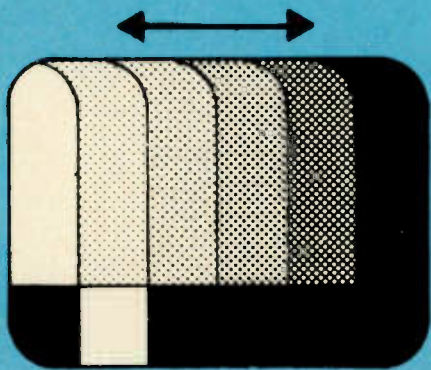


Figure 5 Wrong tape tension at the heads can cause "skew-error" bending at the top of the playback picture. (Courtesy of Sony)

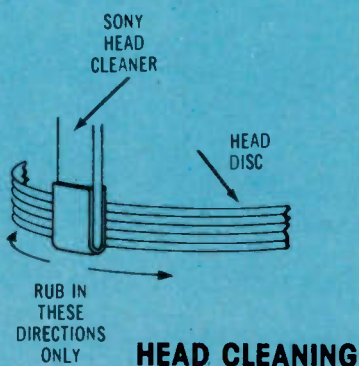


Figure 6 When using the Betamax head-cleaning tool, wet the tool in Isopropyl alcohol and rub it sideways across the rotary heads, as shown. NEVER move the tool vertically during cleaning.

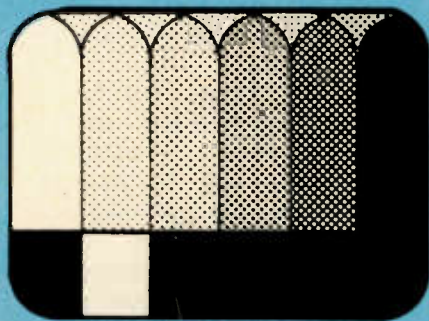


Figure 7 A picture that's split at the top proves the head dihedral is wrong. (Courtesy of Sony)

the capstan and the capstan motor for rotation. If they don't, the motor might be defective, or the driver transistors are dead. Also, make certain the pressure roller has pulled in, and that the threading ring is in the fully-threaded position.

- **The function buttons jam.** These are all part of a mechanically-interlocked block, which is designed to allow only one button to be pressed and locked down at any time. So, jamming usually is caused by wrong operation. Find out what the customer did wrong. Check the assembly visually as you try the buttons. If the stop solenoid is not energized, the buttons will not release. These cases usually result from a defect in the system-control circuit.

- **Cassette does not eject.** Often this is associated with threading and unthreading problems, so determine if the threading ring is returning fully to the "tape-in" position, or not. The eject button is released mechanically by a catch on the side of the cassette compartment. Check to make sure it's not jamming, which can be caused by a serious bending or misalignment of the cassette compartment (possibly from customer damage). Check the contacts of the eject slide switch and the system-control circuit.

- **Tape tension is wrong.** Tape tension is vitally important in any VTR, and especially in the Betamax, where a thin tape is used. If the tape is stretched too much, the servos can't correct enough, and the picture will be highly unsatisfactory. Excessive tension stretches the tape, wears out the heads too fast, causes oxide to shed from the tape, and promotes head clogging. Tension that's too loose produces noisy pictures, since the tape and the head don't make solid contact. In extreme cases, the tape can fall out of its path into the mechanism, and become ruined. Seldom will the machine be damaged if care is used during removal of the tape pieces. The worst visual fault caused by

wrong tension is known as "skew error," which is shown in the drawing of Figure 5. Some VTRs have a skew control to correct this, but Betamax models do not. Therefore, the only cure is to go through the sequence of tension adjustments.

Mechanical maintenance procedures

Many operating problems can be cured by going through the major mechanical maintenance procedures. Those that are new to you are: changing the video heads; cleaning the video heads; setting the dihedral of the video heads; and adjusting the tape tension and reel tables.

Mechanical procedures of this sort only can be learned thoroughly by doing them. Written procedures help somewhat, but are of limited value. For the Betamax, I recommend that you watch the Sony videotape entitled "SL-8200 Mechanical Maintenance."

However, to give you some idea of what to expect, we will describe the procedures briefly.

Head cleaning

All magnetic tapes shed oxide, and some oxide always remains on the tape path. Eventually, the tape guides and the heads will require cleaning. In VTRs, the problem is more severe, since the head tip penetrates the tape oxide slightly.

Cleaning the tape path is very easy. Use a cotton swab or a dry chamois that's wetted with isopropyl alcohol, and gently rub all of the areas where the tape touches. Dirty guides can alter the tape path enough to defeat any hope of interchanging tapes from one machine to another. Clean guides are vitally important.

Head cleaning also is easy, but it must be done properly. **Don't use cotton swabs, Q tips, or cloth when cleaning the video heads.** Fibers can snag on the head chip, and break it (ferrite is very brittle).

Instead use a chamois leather

that's wrapped around a finger; or use a Sony head-cleaning pad, which consists of a small piece of chamois on the end of a plastic stick.

Wet the chamois in alcohol and rub it across the head in the direction of the head rotation. Do not rub the head in an up or down movement. The correct motion is shown in Figure 6. You can hold the head motionless by covering a finger of the other hand with a small piece of chamois and placing it over the other head. Grease from fingers (or natural skin oils) will cause dust to stick, and dust particles can ruin the surface of videotape (which is polished to a mirror-like smoothness) or cause fast head wear.

It's strongly advised that you keep all food, drink, and cigarettes far away from any VTRs. Cigarette-smoke particles are larger than the particles of tape oxide, and can cause tape and heads to wear needlessly. Many large TV studios forbid smoking in the VTR area.

Head changing

The head-changing procedure is covered fully in the service manual, and a good demonstration is given in the tape mentioned before. Therefore, it will not be repeated here.

When changing heads, you must remember this principle: **work CAREFULLY!** It is one of the few procedures which require a special tool. The head disc must be perfectly concentric with the central shaft and the rest of the head drum. So, a small gauge is required when you install the head disc. Take painstaking care while doing this, for a badly-installed head drum will not play or record tapes properly, it can't be controlled by the servos, and it also will lead to head wear and possible breakage.

Head dihedral

The two heads are not mounted exactly 180 degrees apart on the

drum, and this precise position needs adjusting after installation of the heads. If this dihedral is not right, then the picture will appear split in two at the top, as shown in Figure 7. Make the adjustments slowly, a small step at a time, use much care, and you'll get it right.

Tension and skew adjustments

We will not describe the tension adjustments, but they are important and critical, and we'll give some advice about them.

Checking and adjusting the tension is about the same as with audio machines, but more precision is required. Tension troubles usually are caused by wear of brake bands and tape-reel tables.

When the reel tables and brake bands are old and worn, it's impossible to obtain perfect tension in any machine—audio or video. If the tension is wrong, install new parts, and then go through the adjustment procedure. These parts can't be repaired, and it's a waste of time to try.

Always be certain the rest of the machine is in working order and is clean before you change parts or adjust the tension, because faulty operation and the friction caused by dirty guides can affect the tension.

NEVER load an alignment tape into a machine with either suspected or known wrong tension. Operation with *wrong tension* ruins tape for all future uses. This is particularly true with thin videotape.

A customer might think that new bands and reel tables are an unnecessary expense, but they are cheaper over a period of time than the destruction of tapes and heads.

Next month

Although this is the end of the explanations about Betamax circuit operation, we will present next month some of the troubleshooting tips and procedures that were omitted from previous articles. □

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I certify that the statements made by me above are correct.

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Publisher

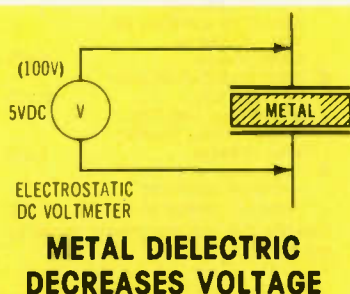
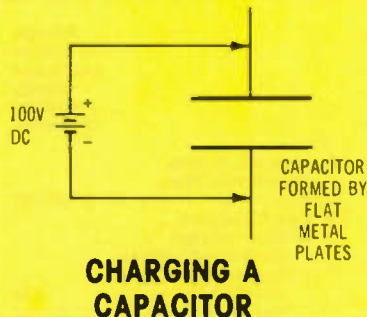
Sam Wilson's Technical Notebook

EFFECTS OF DIELECTRICS

By J.A. "Sam" Wilson, CET

Your comments or questions are welcome. Please give us permission to quote from your letters. Write to Sam at:

J.A. "Sam" Wilson
c/o Electronic Servicing
P.O. Box 12901
Overland Park, Kansas 66212



Technical models can deceive you

Several months ago, I ran a 10-question quiz about capacitors, and I received many questions and arguments about the answers I gave. I've purposely allowed some time to elapse so all of your ideas could reach me.

Now it's time to explain why the quiz is so difficult for technicians. And, of even more importance, it's time for the answers.

During a survey—made with the help of NESDA and ISCET—I learned that questions dealing with capacitors were the most difficult for experienced technicians. Later,

when I taught an Electronic Industries Association (EIA) course, I brought up the subject for discussion. All of the "students" in the course were experienced teachers. One of them suggested that students in electronic schools seldom are told actually how a capacitor works. Instead, they are given a "model" that fits *most* of the situations they will encounter in practical service work.

Here are a few of the characteristics given for the capacitor model:

- A capacitor will pass AC but not DC power. The term "blocking capacitor" is used often to reinforce that thought.
- A capacitor is charged by forcing electrons onto one plate, and taking them away from the other plate. Commonly, schematics show the charging and discharging paths of a capacitor.
- A larger capacitor holds a greater charge.
- A capacitor is a component that opposes any change of voltage across its terminals.

All of these statements are partially true. However, they can be misleading since they do not cover *all* situations. They are incomplete.

Now, I want to make clear that I don't oppose the teaching of circuit theory in this way. But, I believe strongly that it's very wrong to give technicians the impression that these are any more than useful examples. **They should not be presented as the final and all-inclusive authority on the subject!**

Several years ago, after I realized that the typical capacitor model

Figure 1 To test the effects of dielectrics on the charged voltage, construct a capacitor from two flat pieces of metal. Charge it, as shown, remove the charging battery, and then measure the capacitor voltage using an electrostatic voltmeter. The meter will show 100 volts, when the dielectric is dry air.

Figure 2 While the 100-volt charge remains in the capacitor of Figure 1, insert a like-sized piece of metal between the plates (being careful not to touch either plate). When the metal is fully inserted, the meter will measure almost zero volts.

doesn't explain some actions, I published four basic applications which are not explained by these convenient models, and challenged technicians to answer the questions. This aroused a storm of criticism.

My critics said I didn't play fair. After all, if I chose little-known examples, why should I *expect* technicians to know the answers? However, that's just the point. They could have answered correctly if their model for capacitors was complete, and didn't need modifications or additions.

One fact emerged from the controversy: most technicians *don't* understand capacitors.

Other models

Let me digress for a few moments and explain that capacitor theory is not the only subject taught by use of a simplified model.

Probably the most famous model is the one of electron flow for current. It's a convenient way to describe circuit action, but it should not be taken as an absolute and complete truth about electricity. In the future, I'll prove to you that the idea of electron flow is only a model, and it's one which will not work for certain applications!

An important experiment

The capacitor of Figure 1 consists of two flat plates made of metal which are separated by a dielectric of dry air. It is charged from a DC power source, then the charging source is disconnected, leaving the capacitor charged with a full 100 volts that can be

measured by an electrostatic voltmeter, which does not draw current from the voltage being measured.

In Figure 2, a metal plate has been inserted between the plates of the capacitor, but without allowing it to touch either of the plates.

As the metal is slowly inserted between the plates, the voltage decreases. Also, when the metal plate is withdrawn slowly, the capacitor voltage increases to the original value.

Usually, technicians are confused by the experiment. They have been

taught that a capacitor is charged by forcing electrons onto one plate and simultaneously removing electrons from the other plate.

In this experiment, the total number of charges on each plate has not changed. Obviously, **the model doesn't explain such behavior.**

Magnetic and electrostatic flux...A review

The previous experiment can be *continued on page 46*

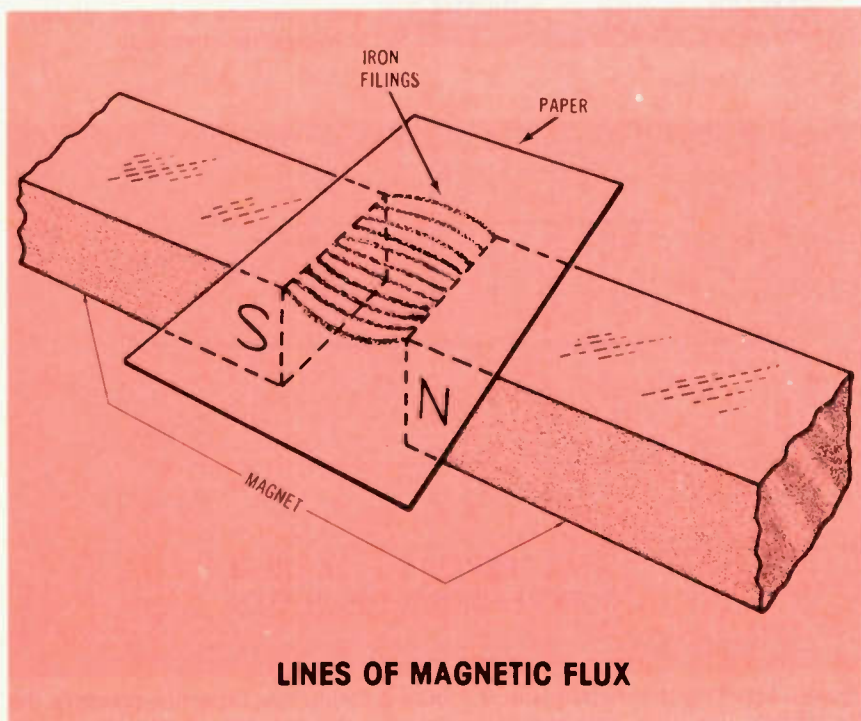
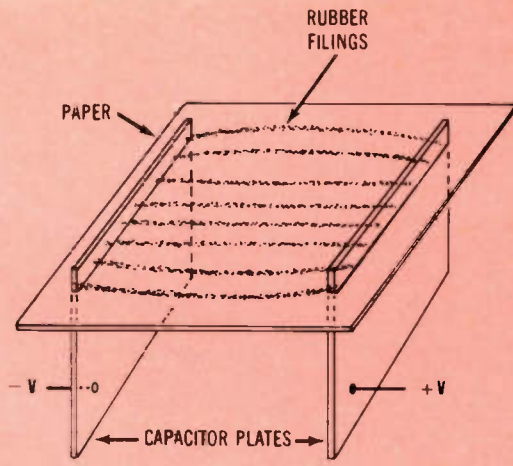
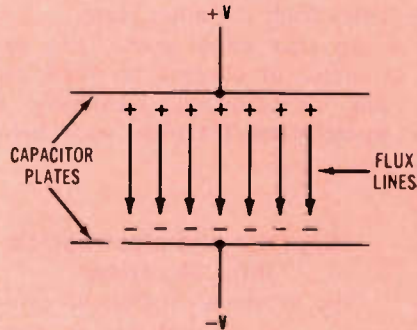


Figure 3 Lines of magnetic flux can be proved by this experiment using tiny iron filings.



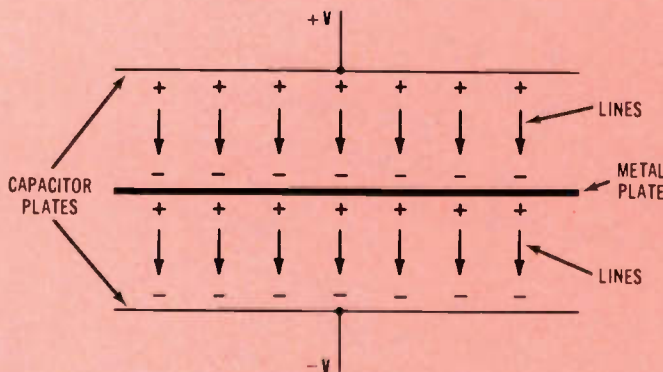
LINES OF ELECTROSTATIC FLUX

Figure 4 Lines of electrostatic flux can be verified in an experiment similar to that of Figure 3 by sprinkling tiny rubber filings in the electrostatic field of a capacitor.



ELECTROSTATIC FLUX LINES ARE BETWEEN + AND - CHARGES

Figure 5 Electrostatic flux lines are thought to extend from the positive charges across the dielectric to the negative charges of a capacitor. More lines produce a higher stored voltage after charging.



METAL PREVENTS FLUX LINES FROM REACHING THE PLATES

Figure 6 Inserting the metal plate of Figure 2 inside the capacitor prevents the electrostatic flux lines from extending between the capacitor plates. Therefore, the stored voltage is almost zero. Other dielectrics reduce the stored voltage, but not so much.

understood only by reviewing the idea of magnetic and electrostatic flux. If a paper is placed over a north and a south magnetic pole, and iron filings are sprinkled on the paper, the small particles of iron will arrange themselves into a pattern of lines, such as those of Figure 3. (Usually the paper must be tapped lightly to allow movement of the particles.) This tests magnetic flux.

A similar experiment can be performed for electrostatic flux by using a capacitor (which has been charged to a very high voltage), and sprinkling finely-ground rubber filings on the paper. When the paper is tapped gently, the rubber particles arrange themselves into lines, as shown in Figure 4.

These lines show the presence of high magnetic or electrostatic intensity.

Flux lines in capacitors

As proved by the preceding experiment, when a capacitor is charged, electrostatic flux lines are present in the dielectric between the capacitor plates.

The amount of voltage across a charged capacitor—and the amount of energy stored in a capacitor—depends upon the NUMBER of flux lines in the dielectric!

It is convenient to think of each flux line as originating with a positive charge on the positive plate, and ending at a negative charge on the negative plate, as shown in Figure 5. (These positive and negative charges actually are on the *inside* surfaces of the plates. They are shown here as though they are not touching the plates. Other drawings show the + and - signs on the outside surfaces, in an attempt to make it less confusing.)

When the piece of metal is inserted between plates of a charged capacitor, both positive and negative carriers in the metal move toward the capacitor plates. Of course, unlike charges attract, and like charges repel. Therefore, the negative charges (from electrons) move toward the positive plate of the charged capacitor, thus leaving the holes (positive charges) near the negative plate of the capacitor.

Figure 6 shows the metal in-

serted, and the positions of charges on the metal insert. (Although the drawing shows that *none* of the flux lines extend from one plate to another, in practice the flux lines are not completely eliminated, but are greatly reduced.)

The metal insert reduces the total number of flux lines between the capacitor plates. This reduces the capacitor voltage, since the number of flux lines determines the voltage. If the capacitance was determined by the charges rather than the flux, the metal plate would not affect the capacitance nor the voltage across it.

Effect of a dielectric

Imagine now that the capacitor is charged again as shown in Figure 1. But, this time (after the charging source is disconnected), a dielectric material is placed between the plates. Voltage across the capacitor again is reduced, but not as much as when metal was inserted.

From what has been presented already about the effects of flux, it

is obvious that the dielectric has reduced the number of flux lines between positive and negative plates of the capacitor.

However, the change of flux pattern from the dielectric is not so easy to explain as it was for the metal insert. With the metal insert, the charges were free to move around and align themselves with the flux lines. But, the charges are trapped in the dielectric.

A basic equation

Before I explain what happens inside the dielectric, I should explain how the metal and dielectric inserts have affected the capacitance (Capacitance is a measure of the amount of energy a capacitor can store.)

An important equation states: $Q = CV$, where Q is the charge in coulombs, C is the capacitance in farads, and V is the voltage across this capacitor.

Probably you remember from your school science class that a coulomb is the accumulated charge


of 6.25×10^{18} number of electrons. (Note, the number sometimes is incorrectly written as 6.28×10^{18} since 6.28 is 2π)

When metal is inserted between the capacitor plates in Figure 2, the voltage goes down. However, the charge (Q) can't change because there is no path for the current. Therefore, the capacitance *must* increase to keep the equation in balance. The total result is a decrease of voltage and an increase of capacitance.

When dielectric is inserted between the plates, the capacitance increases and the voltage decreases, but not so much as with the metal.

Next Month

According to the Faraday theory of capacitance, the dielectric has "dipoles" which align when the capacitor becomes charged. This concept will be used to answer the four unusual capacitance questions that don't fit the simplified model. □



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test equipment

Digital-readout power supply

The PTS Electronics DG-1 power supply provides adjustable and regulated DC voltage for testing televisions, stereos, radios, computers, microprocessors, appliances, CB equipment, electronic cash registers, security systems and other electronic devices.

The digital voltage meter is accurate to .05% and indicates to 0.1 V. The vinyl cabinet is available in walnut, black or blue and dealer net price is \$114.95.

Circle (35) on Reply Card

Dual-Trace Scope

A dual-trace, 25-MHz scope, the Telequipment D66A, features a TV trigger switch for television servicing. It allows the operator to obtain a stable display of TV line and field signals quickly. Calibrated sweep speeds range from two seconds to 20 nanoseconds per division; vertical sensitivity ranges from 10 millivolts to 50 volts-per-division. One millivolt-per-division sensitivity may be selected, but bandwidth then is 15 MHz.



The D66A is manufactured by Telequipment, a London-based division of Tektronix, and sells for \$1100.

Circle (36) on Reply Card

Digital multimeter

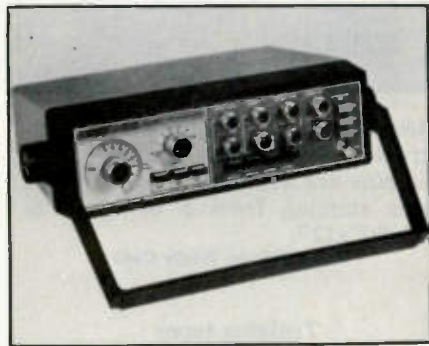
EICO has introduced a digital multimeter, model 272. The new multimeter reads out up to 1000 VDC, up to 600 VAC, up to 1000 milliamperes DC and AC, and up to 1 meg resistance on three 0.3-inch bright LED digits. Overrange is indicated by a flashing display. The zero setting is automatic and it is

not necessary to operate a switch or reverse the leads when the polarity is reversed as the polarity reading is also automatic.

The DMM sells for \$69.95.
Circle (37) on Reply Card

Sweep/function generator

Model 3020, a sweep/function generator from **B&K-Precision** replaces a function generator, sweep generator, pulse generator and tone-burst generator.



The instrument's frequency coverage spans 0.02 Hz to 2 MHz in seven ranges. Each range provides a linear 1000:1 frequency control. The operating frequency can be varied on each range by either the front-panel frequency control or by application of a control voltage to its voltage-controlled oscillator external input (sweep function).

Almost any wave shape can be generated by the 3020. The square-wave output can generate conventional square waves, or be shaped to produce rectangular waves or pulses. A triangle wave can be transformed into a sawtooth (or ramp) and sine-wave distortion can be simulated. All waveform types can be inverted.

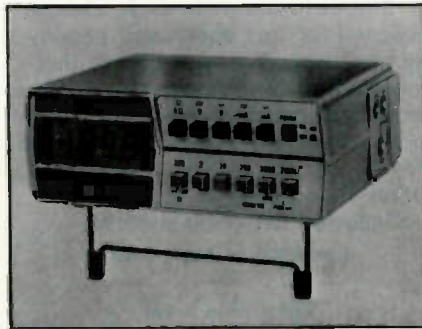
Circle (38) on Reply Card

Cordless LCD DMM

Simpson Electric Company has introduced a compact, portable digital multimeter. Model 463, priced at \$170, is a 3¼-digit liquid-crystal display (LCD) instrument with 26 AC/DC voltage, current and resistance ranges.

The LCD readout and all-LSI circuitry permit up to 200 hours of continuous operation from a 9V alkaline battery. No AC power or battery charger is needed. In addition, the 463 offers 0.2% accuracy for DC voltages plus a wide 20-KHz

AC voltage frequency response for audio measurements.



Transient suppression and overload protection is provided for all. It has five DC voltage ranges to 1KV, five AC ranges to 750V, six resistance ranges to 20 meg, five DC current ranges to 2000 mA and five AC current ranges to 2000 mA.

Circle (39) on Reply Card

Timing light

Heath Company has announced a new timing light kit for auto tune-ups. A single connection to the number 1 spark plug wire is made via a snap-on inductive pickup, so adaptors are not required for model CI-1098. The timing light has its own rechargeable power supply.



A built-in 120/240 VAC rechargeable high voltage power supply and xenon flash tube provide a bright flash for easy timing adjustments. A built-in tachometer has a choice of 2000 RPM and 6000 RPM scales.

Circle (40) on Reply Card

Portable VOM

BP Electronics has introduced a new VM-547B VOM with a DC accuracy of $\pm 3\%$. AC sensitivity is 10,000 ohms-per-volt. 250 mV ranges and 2.5 volts-full-scale are provided.

Suggested retail price is \$29.95.

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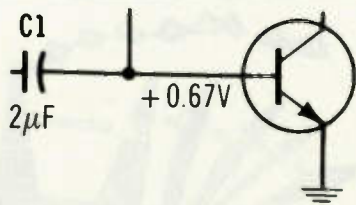
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QUICK-QUIZ

#1

ANSWER:

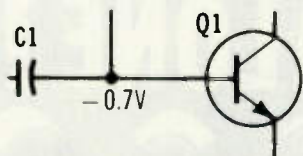
According to the DC voltages; Q1 is saturated from excessive forward bias. Where is the high base voltage coming from? The collector voltage is lower than the base voltage, so R1 and the collector voltage are not suspects. Internal leakage of Q1 also is not the cause, for the same reasons. Only C1 is not cleared.

C1 is leaky.

REFER TO PAGE 12

QUICK-QUIZ

#2

ANSWER:

According to the voltage drops across the R3 emitter and the R2 collector resistors, Q1 has 0.87 milliamperes of C/E current. This is about right for a resistance-coupled stage. However, the NPN Q1 must have the base more positive than the emitter to produce C/E current. Yet, a reverse bias of 1.57 is measured, so Q1 should be cut off. An open R1 plus C/E leakage might cause those voltages, but that's not likely. Sync pulses scoped at the output proves the circuit is operating. Therefore, the reversed bias is misleading, since it's produced by peak-reading B/E rectification of the input video.

The voltages and circuit operation are normal.

REFER TO PAGE 12

productreport

Cassette deck cleaner

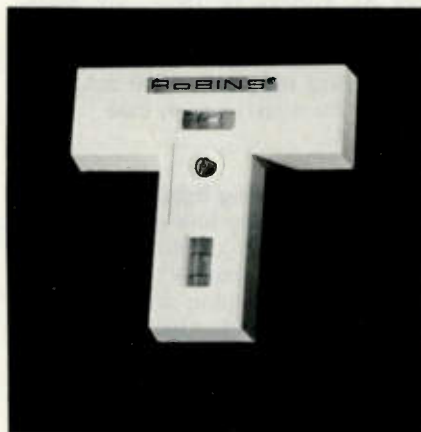
Allsop Automatic has introduced its 3-at-once cassette-deck cleaner designed for any equipment employing cassettes. The unit cleans three areas simultaneously: the deck's head; the capstan; and the pinch roller. The user inserts it into the player. It has virgin wool felts, rather than abrasive tapes.

Suggested list price is \$5.95.

Circle (42) on Reply Card

Turntable level

Robins Industries has introduced a dual-plane spirit-bubble level to allow azimuth and zenith leveling of turntables. The T-level consists of

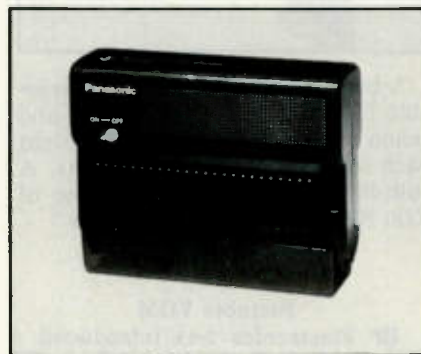


two over-sized precision levels with prominent positioning lines mounted at 90 degrees.

Circle (43) on Reply Card

Record cleaner

A battery-operated record cleaner, model BH-651E, offered by Panasonic, uses a rotary brush to

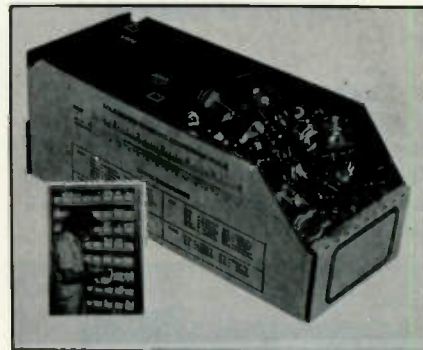


collect dust from the records surface and deposit the particles in a built-in dust box. It has a record guide and operates on two AA size batteries (not included).

Circle (44) on Reply Card

Parts bins

Kole corrugated bins have angled design, plus large front label and side data space permitting quick



identification of contents. Constructed of heavy-duty fiberboard, the bins are available in 88 different sizes ranging from 2"x9"x4½" to 24"x20"x12".

Circle (45) on Reply Card

Training tapes

Technicians can learn how to repair Betamax videocassette machines by playing training tapes. Sony dealers and authorized servicers can purchase Betamax Training Tapes which typically come in a series of eight, with each tape costing \$24. These tapes each play for 30 to 45 minutes. Included are block diagrams, waveforms, simplified schematics and circuit theory. All tapes show demonstrations of how to replace and adjust parts. Also, each series of tapes has a printed supplement, which has all of the major diagrams shown on the tapes, plus many that do not even appear in the service manual. An album case is included with each series of cassettes.

Circle (46) on Reply Card

Desoldering station

A controlled temperature desoldering station featuring the Magnastat closed loop system for protection temperature and voltage sensitive components, has been introduced by Weller for printed circuit board production repair.

The unit features lighted on/off power switch, quick connect/disconnect plug and receptacle with plug lock, in-line vacuum filter, safety iron holder, air pressure tubing with fittings, and air control foot switch.

Circle (47) on Reply Card

catalogs literature

70. GTE Sylvania—ECG212H-2, the 20-page supplement to the 1978 Sylvania ECG Semiconductor Master Replacement Guide, supersedes one published earlier this year and contains information on 31 new ECG devices. Approximately 3,500 industry part numbers also have been added to the cross-reference section, and separate listings give recommended changes in ECG replacements and deletions from the line. The Sylvania ECG line contains more than 2,000 solid-state devices, which are cross-referenced to more than 142,000 foreign and domestic part numbers.

77. Vaco—SD-268, a new merchandising-idea catalog is available from Vaco Products. It contains full-color illustrations and descriptions of Vaco's merchandising displays for screwdrivers, nutdrivers, pliers, wrenches, measuring tapes, fasteners and solderless terminals. In addition, the SD-268 catalog contains a full description of Vaco's

expanded line of super cases, the new super tool set, empty tool cases and several pouched tool kits.

101. Jensen Tools and Alloys—A 152-page catalog lists hard-to-find tools for electronic work. Major categories of 3,000 tools are: micro-tools, test equipment, soldering equipment, tweezers, screwdrivers, cutters, power tools and 36 pages featuring tool kits and tool cases.

102. Mura Corporation—A 4-color brochure describes CB accessories in 16 pages of photographs, illustrations and detailed specifications.

103. General Electric Company—1978 GE Replacement Semiconductor Guide includes a cross reference information for 36 types of Pro Line replacement semiconductors. Also in the guide is information on 32 Japanese original-equipment replacement transistors, two industrial rectifiers and two TTL-logic integrated circuits.

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