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Electronic Servicing

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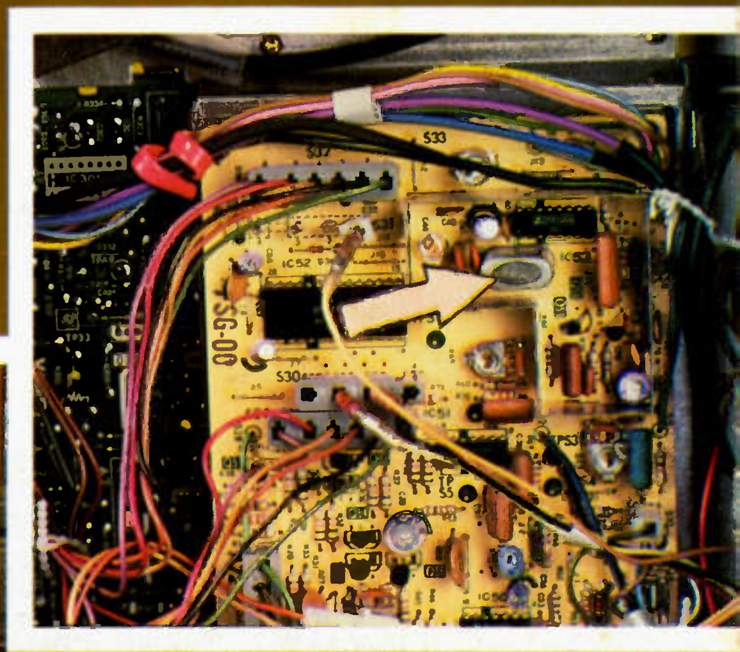

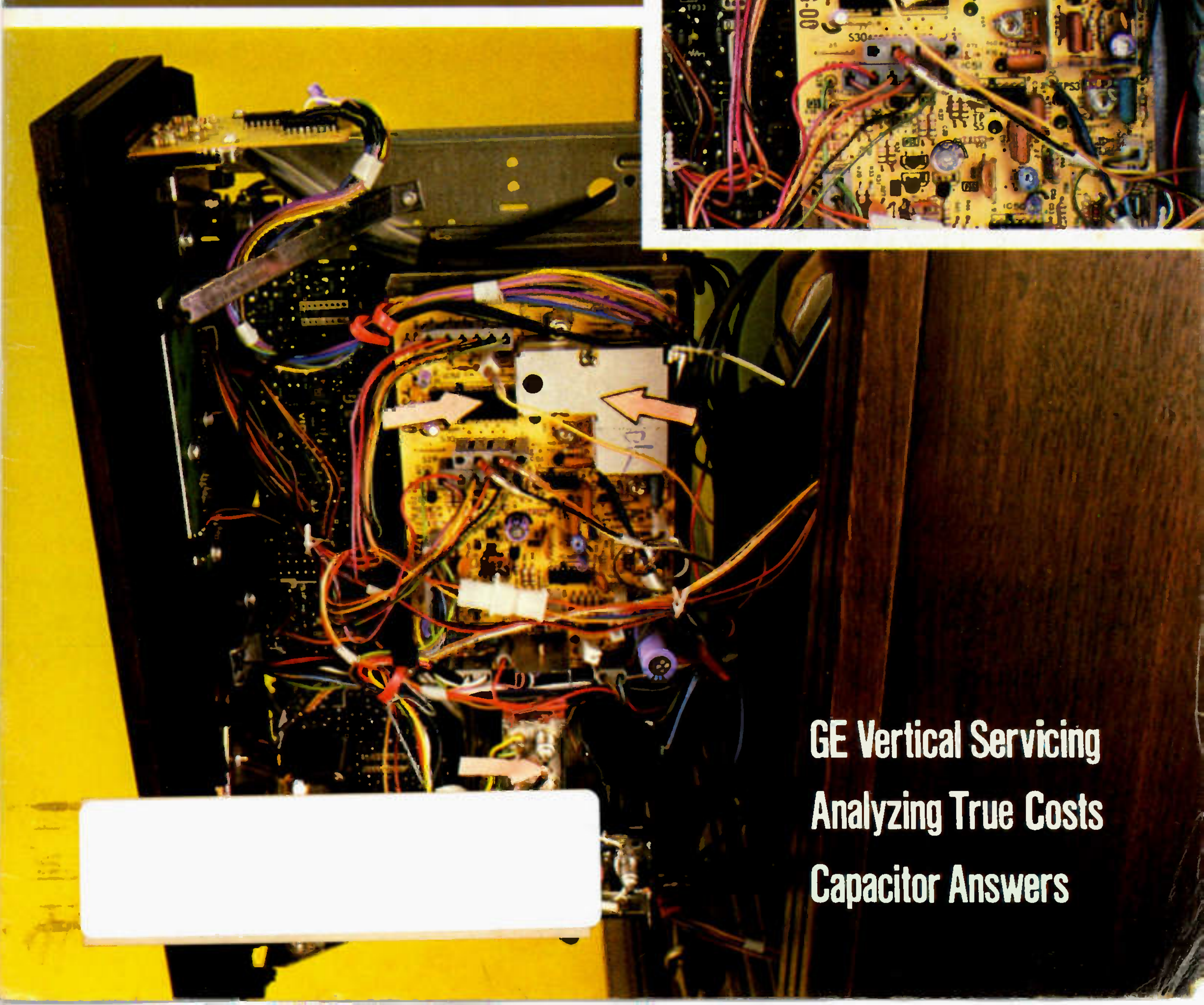

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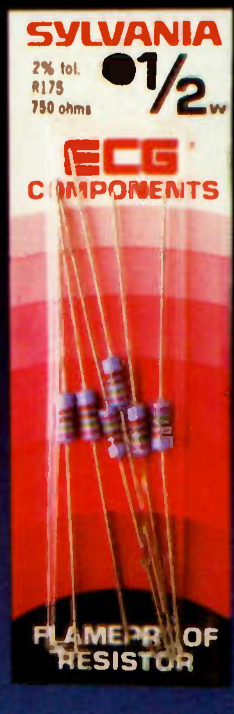

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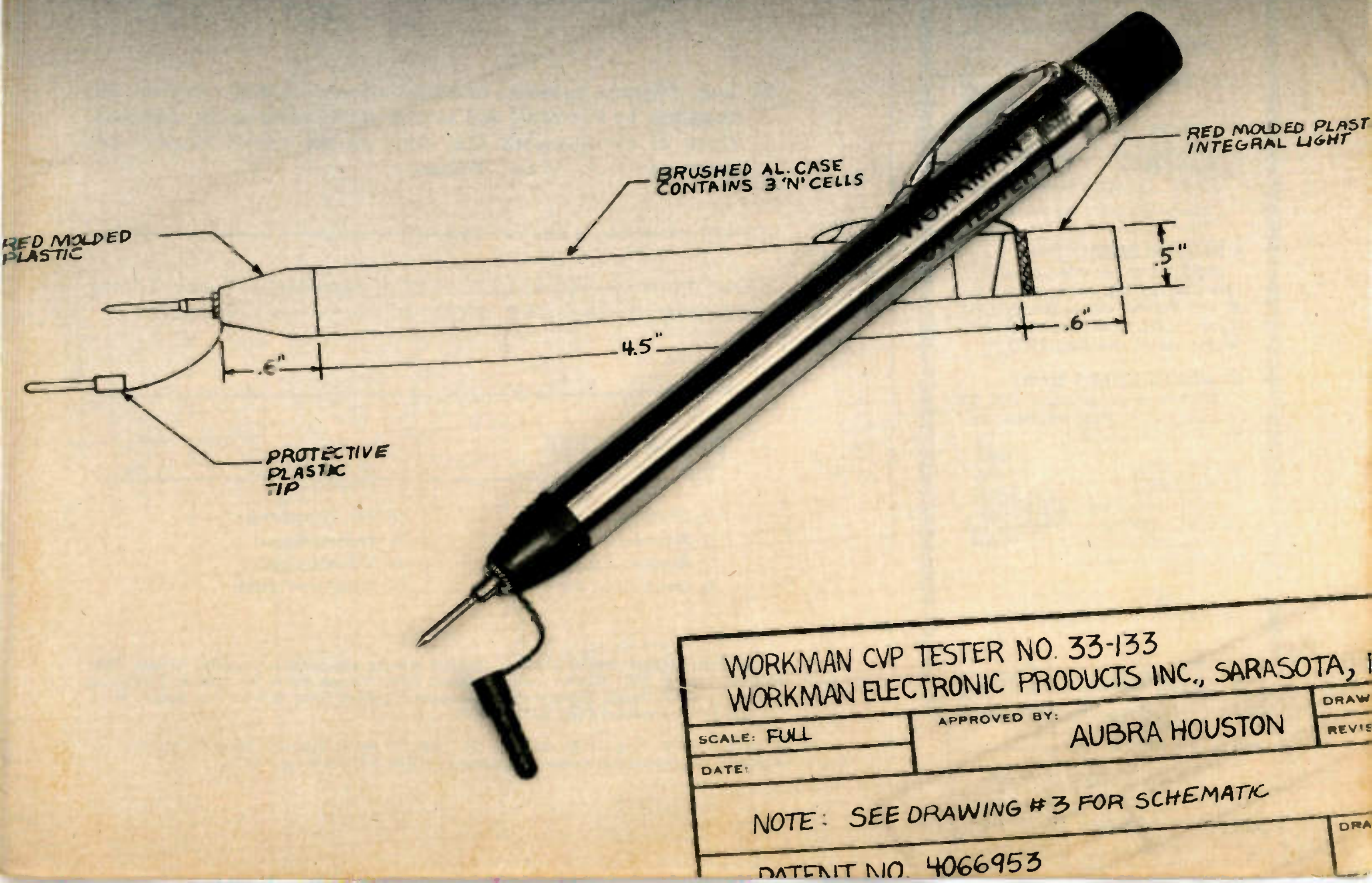

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December, 1978 □ Volume 28, No. 12

Electronic Servicing®

Contents

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TYPE	25-UP	10-24	1-9
2SA 102	.20	.27	.30
2SA 234	.45	.53	.59
2SA 473	.45	.53	.59
2SA 484	1.50	1.75	1.95
2SA 495	.30	.35	.40
2SA 497	1.00	1.20	1.30
2SA 509	.30	.35	.40
2SA 561	.30	.35	.40
2SA 562	.30	.35	.40
2SA 564A	.20	.27	.30
2SA 634	.40	.45	.50
2SA 643	.30	.40	.45
2SA 673	.35	.40	.45
2SA 678	.35	.40	.45
2SA 682	.80	.90	1.00
2SA 683	.30	.35	.40
2SA 684	.35	.40	.45
2SA 695	.40	.53	.59
2SA 699A	.50	.64	.70
2SA 706	.85	1.00	1.10
2SA 719	.30	.35	.40
2SA 720	.30	.35	.40
2SA 733	.20	.27	.30
2SA 747	4.20	4.40	4.90
2SA 818	.70	.80	.90
2SA 841	.20	.27	.30

2SB

TYPE	25-UP	10-24	1-9
2SB 22	.30	.35	.40
2SB 54	.20	.27	.30
2SB 75	.35	.40	.45
2SB 175	.20	.27	.30
2SB 186	.20	.27	.30
2SB 324	.30	.35	.40
2SB 337	.70	.80	.90
2SB 405	.30	.35	.40
2SB 407	.80	.90	1.00
2SB 434	.80	.90	1.00
2SB 435	.90	1.10	1.20
2SB 463	.90	1.10	1.20
2SB 473	.80	.90	1.00
2SB 474	.70	.80	.90
2SB 492	.60	.70	.80
2SB 507	.80	.90	1.00
2SB 528D	.70	.80	.90
2SB 595	1.10	1.40	1.50
2SB 596	1.10	1.40	1.50

2SC

TYPE	25-UP	10-24	1-9
2SC 281	.30	.35	.40
2SC 372	.20	.27	.30
2SC 373	.20	.27	.30
2SC 380	.20	.27	.30
2SC 394	.20	.27	.30
2SC 458	.20	.27	.30
2SC 495	.45	.55	.60
2SC 509	.35	.40	.45
2SC 515A	.80	.90	1.00
2SC 517	2.50	2.70	3.00
2SC 535	.30	.35	.40
2SC 634A	.35	.40	.45
2SC 696	1.00	1.20	1.30
2SC 710	.20	.27	.30
2SC 711	.20	.27	.30
2SC 730	3.00	3.20	3.40
2SC 732	.20	.27	.30
2SC 735	.20	.27	.30
2SC 756	1.50	1.80	2.00
2SC 756A	1.50	1.80	2.00
2SC 781	1.90	2.10	2.40
2SC 784	.30	.35	.40
2SC 799	2.00	2.20	2.50
2SC 828	.20	.27	.30
2SC 839	.30	.35	.40
2SC 867	3.20	3.40	3.70
2SC 867A	3.20	3.40	3.70
2SC 897	2.00	2.20	2.50
2SC 930	.20	.27	.30
2SC 945	.20	.27	.30
2SC 983	.50	.64	.70
2SC 959	1.10	1.20	1.30
2SC 1000BL	.35	.40	.45
2SC 1014	.50	.64	.70
2SC 1018	.60	.70	.80
2SC 1030C	1.80	2.10	2.40
2SC 1061	.70	.80	.90
2SC 1079	3.40	3.55	3.90
2SC 1096	.45	.55	.60
2SC 1098	.50	.64	.70
2SC 1111	2.10	2.50	2.80
2SC 1124	.80	.90	1.00
2SC 1172B	3.20	3.60	3.95
2SC 1173	.50	.55	.60
2SC 1226	.50	.55	.60
2SC 1226A	.50	.55	.60
2SC 1239	2.20	2.70	2.90
2SC 1306	1.30	1.45	1.60
2SC 1307	1.90	2.10	2.40
2SC 1318	.35	.40	.45
2SC 1383	.30	.35	.40
2SC 1384	.35	.40	.45
2SC 1419	.60	.70	.80
2SC 1675	.20	.27	.30
2SC 1678	1.10	1.25	1.40
2SC 1728	.70	.80	.90
2SC 1730	.45	.53	.59
2SC 1760	.70	.80	.90
2SC 1816	1.50	1.75	1.95
2SC 1856	.50	.64	.70
2SC 1908	.30	.35	.40
2SC 1909	1.80	2.00	2.25
2SC 1945	4.50	5.00	5.60
2SC 1957	.60	.70	.80
2SC 1970	2.10	2.50	2.80
2SC 1978	5.40	6.00	6.60
2SC 2028	.50	.64	.70
2SC 2029	1.50	1.80	2.00
2SC 2076	.50	.64	.70
2SC 2091	.90	1.10	1.20
2SC 2092	1.80	2.00	2.25
2SC 2166	1.40	1.60	1.80

2SD

TYPE	25-UP	10-24	1-9
2SD 72	.50	.64	.70
2SD 234	.60	.70	.80
2SD 235	.60	.70	.80
2SD 261	.35	.40	.45
2SD 287	2.50	2.70	2.90
2SD 313	.60	.70	.80
2SD 315	.60	.70	.80
2SD 325	.60	.70	.80
2SD 427	1.80	2.00	2.25
2SD 525	.90	1.10	1.20
2SD 526	.60	.70	.80

FET

TYPE	25-UP	10-24	1-9
2SK 19BL	.45	.55	.60
2SK 23	.70	.80	.90
2SK 30	.40	.45	.50
2SK 33	.60	.70	.80
2SK 55	.60	.70	.80
3SK 22Y	1.40	1.60	1.80
3SK 39	.90	1.10	1.20
3SK 40	.90	1.10	1.20
3SK 41	1.30	1.45	1.60
3SK 45	1.30	1.45	1.60
3SK 48	3.40	3.55	3.90
3SK 49	1.30	1.45	1.60

IC

TYPE	25-UP	10-24	1-9
AN 214Q	1.30	1.70	1.90
AN 239	4.20	4.40	4.90
AN 247	2.50	2.70	3.00
AN 274	1.50	1.75	1.95
AN 313	3.00	3.20	3.40
AN 315	1.80	2.00	2.25
BA 511A	1.80	2.00	2.25
BA 521	1.90	2.10	2.40
HA 1151	1.50	1.75	1.95
HA 1156	1.60	1.80	2.00
HA 1306W	2.00	2.20	2.50
HA 1322	2.50	2.70	3.00
HA 1339	2.50	2.70	3.00
HA 1339A	2.50	2.70	3.00
HA 1366	2.50	2.70	2.90
HA 1366W	2.50	2.70	2.90
HA 1366WR	2.50	2.70	2.90
LA 4031P	1.80	2.00	2.25
LA 4032P	1.80	2.00	2.25
LA 4400	1.90	2.10	2.40
LA 4400Y	2.00	2.20	2.50
LA 4420	2.00	2.20	2.50
M51513L	2.00	2.20	2.50
STK 011	3.80	4.00	4.40
STK 013	7.60	8.00	8.80
STK 015	4.20	4.40	4.90
STK 435	4.50	5.00	5.60
TA 7045M	2.00	2.20	2.50
TA 7060P	.70	.80	.90
TA 7061P	.90	1.10	1.20
TA 7062P	1.10	1.25	1.40
TA 7089P	2.00	2.20	2.50
TA 7202P	2.50	2.70	2.90
TA 7203P	2.50	2.70	2.90
TA 7204P	2.00	2.20	2.50
TA 7205P	1.60	1.80	2.00
TA 7310P	1.30	1.45	1.60
TBA 810SH	1.90	2.10	2.40
TC 5080P	5.00	5.20	5.80
TC 5081P	3.00	3.20	3.40
TC 5082P	3.40	3.55	3.90
UHIC 002	4.20	4.40	4.90
UHIC 004	4.20	4.40	4.90
UHIC 005	4.20	4.40	4.90
UPC 20C	2.10	2.50	2.80
UPC 563	1.90	2.10	2.40
UPC 575C2	1.30	1.45	1.60
UPC 576	1.90	2.10	2.40
UPC 592HZ	.70	.80	.90
UPC 1001	1.90	2.10	2.40
UPC 1008C	4.20	4.40	4.90
UPC 1020H	1.90	2.10	2.40
UPC 1025H	1.90	2.10	2.40
UPC 1154	2.00	2.20	2.50
UPC 1155	2.00	2.20	2.50
UPC 1156	1.90	2.10	2.40
UPC 14305	3.00	3.20	3.40
UPD 861	8.00	8.40	9.50
UPD 857	8.00	8.40	9.50
UPD 858	6.00	6.30	7.00
PLL 01A	3.00	4.20	4.60
PLL 02A	5.00	5.30	5.90
PLL 03A	7.60	8.00	8.80

DIODES

TYPE	25-UP	10-24	1-9
1S 84	.45	.55	.60
1S 332	.35	.40	.45
1S 953	.16	.18	.20
1S 1007	.35	.40	.45
1S 1209	.35	.40	.45
1S 1211	.35	.40	.45
1S 1555	.20	.22	.25
1S 1588	.20	.22	.25
1S 1885	.16	.18	.20
1S 2076	.20	.22	.25
1S 2093	.35	.40	.45
1S 2473	.16	.18	.20
1N 34	.12	.13	.15
1N 60	.12	.13	.15
10D 1	.30	.35	.40
10D 10	.45	.55	.60
V06B	.30	.35	.40

ZENERS

TYPE	25-UP	10-24	1-9
WZ 071	20	22	25
WZ 075	20	22	25
WZ 090	20	22	25
WZ 120	20	22	25
WZ 192	20	22	25

MISC.

TYPE	25-UP	10-24	1-9
SG 613	5.20	5.40	5.95
78L05	.90	1.00	1.10
MPS U31	1.50	1.70	1.90

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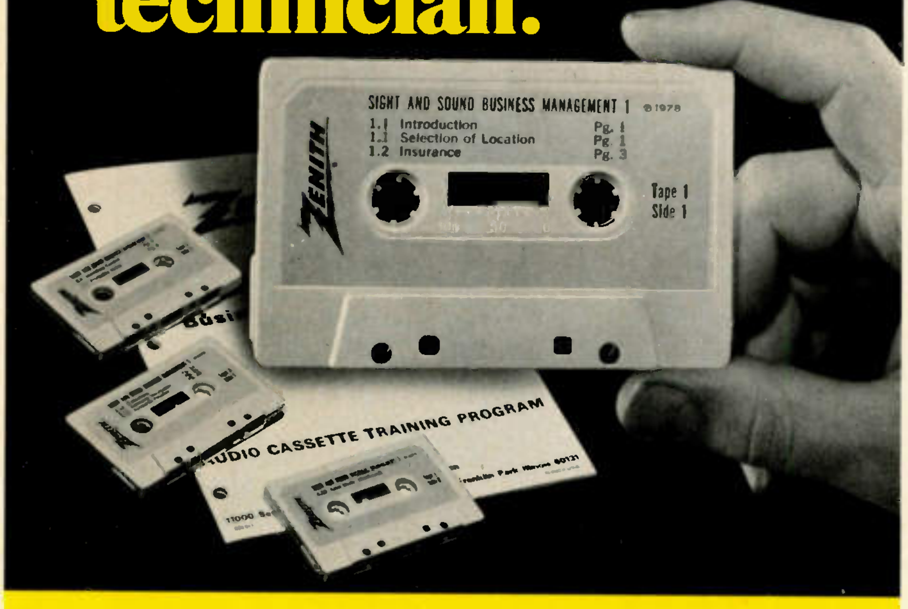

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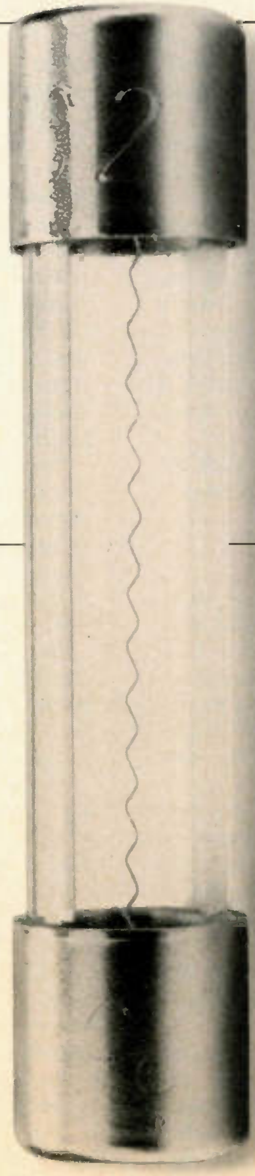

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Servicing Information...
What kind is best? What kind do you want?

By Carl Babcoke, editor

Theory versus practice

Some electronic technicians think of general service information as being "theory," while specific information is called "practical." After they graduate from tech school, many believe no more theory ever will be needed. That is wrong! A technician who uses correct theory *in practical ways* is certain to find defective components or wrong conditions much faster than if he only tapped, prodded, twisted and replaced parts instead of making accurate tests with proper equipment. I proved that in my own case. I was a competent tech although I had little formal training, but I diagnosed faster and more accurately after I learned correct theory.

In addition, one engineer in the Bureau of Standards is quoted as saying that nearly 50% of the "facts" in electronic books either are wrong or incomplete. I believe that statement is true. That's why most of our articles that describe circuit behavior use original material and not textbook explanations. Some of our descriptions of tube-powered and SCR sweep circuits have become classics of corrected theory.

Fortunately, the choice is not "theoretical or practical" but it can be "**theoretical** *plus* **practical.**" You should have the best of both.

Effects of solid-state

Unfortunately, many of the quick-and-dirty techniques we used successfully with tube circuits are useless when applied to solid-state circuits. One reason is that solid-state circuits are not standardized as much as tube circuits were. A helpful shortcut for one brand and model of solid-state product probably won't work right if applied to another model and brand.

Another reason is the inability of solid-state devices to tolerate overloads (a transistor will blow before its protective fuse can open). I am not foolhardy enough to attempt some unproven shortcut that might ruin a whole string of transistors. Nor will I recommend such methods to you.

Plug-in modules have reduced the amount of troubleshooting by allowing a choice of total replacement or diagnosis plus repair.

Too much information

One of the answers for successfully servicing these new-technology machines is for technicians (who already know how the circuits work) to use *better* test equipment while making many *more* tests.

However, a common discouragement for techs who try this kind of upgrading is when their tests give them information they can't handle. As one tech said, "My new scope tells me more than I want to know." He meant that he could not interpret the confusing readings. If you keep trying and learning, eventually you'll advance to where these sophisticated tests are clearly understood. They *then* will be valuable and indispensible to you.

We believe **Electronic Servicing** can help you reach this desirable goal.

Space-age information

In early 1976, we began a continuing series about the circuits and servicing of modular color TVs. Our coverage of seven different models has been quite detailed, with *original* explanations of all major circuits, including actual voltage readings and special waveforms (some never printed before). Many discussions went beyond the immediate circuit, so you could adapt the information to other circuits and models.

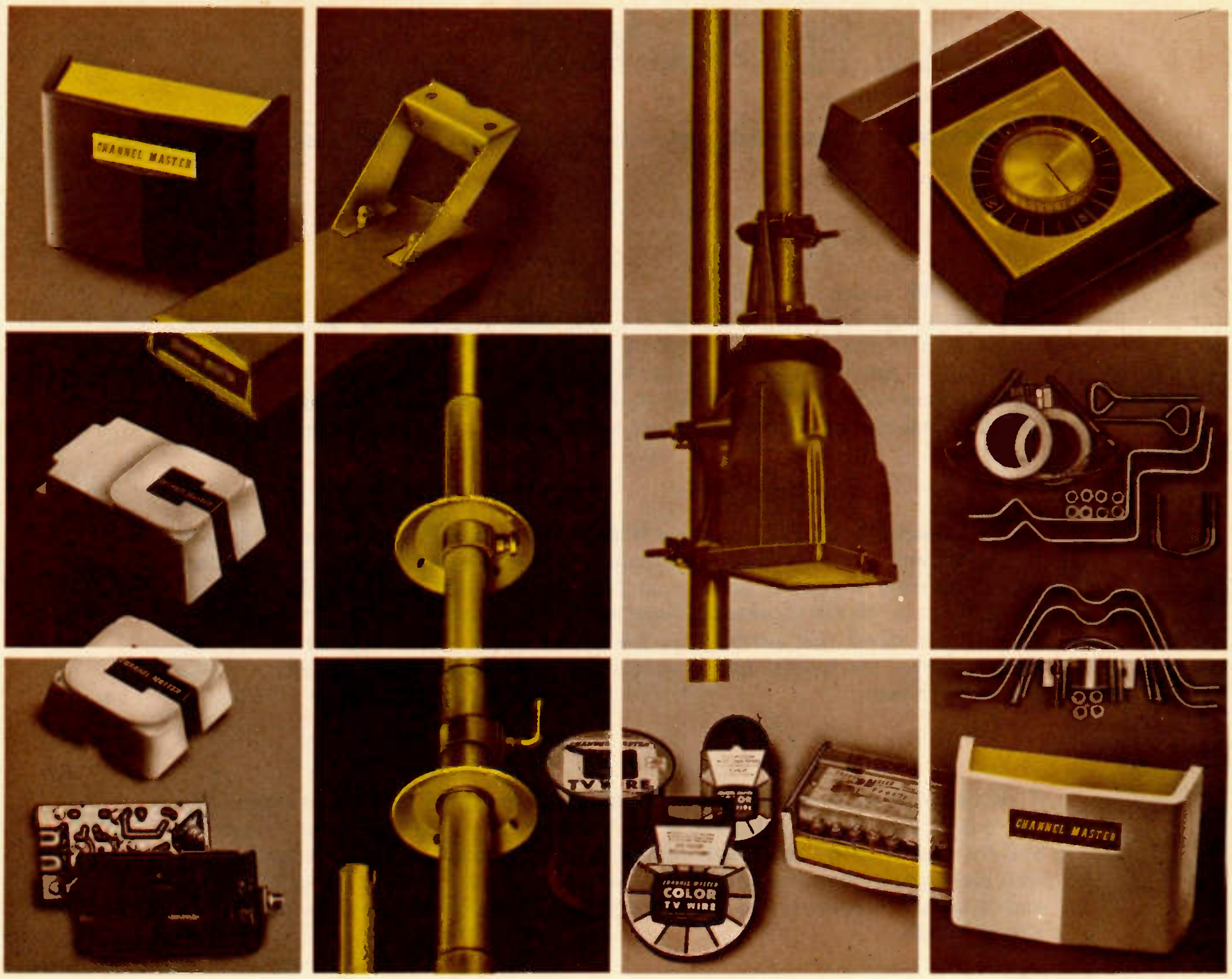
Two unusual training devices we have emphasized are *current waveforms* and *dc waveforms*. These dc waveforms included a line marking the average-voltage or zero-voltage point. One reason tube theory can't be used also with transistors is that silicon transistors ignore any forward bias of less than 0.5 volt. These low voltages do *not* cause C/E current.

Dc waveforms also are essential to our clear understanding of digital circuits. **Digital signals are pulses of dc voltage**. Therefore, proper measurements must include the positions of zero and supply voltages in relation to the pulse waveform.

In short, we at **Electronic Servicing** have been attempting to prepare you for successful and profitable servicing of whatever circuits the future may bring.

Our efforts have not always been appreciated. One technician, whose address was obliterated, commented that even the engineers who designed these circuits could not understand our explanations. He wanted "practical" information he could use at his bench each day. Of course, we **believe a correct knowledge of circuit operation is the first** (and probably the most valuable) **step in any kind of troubleshooting.**

What kind of articles would you like to see in **Electronic Servicing**? Write to the editor at P.O. Box 12901, Overland Park, Kansas 66212. □



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Circle (8) on Reply Card

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news of the industry

Zenith will spend $7 million to expand and modernize its Chicago-area manufacturing facilities. Part of the expanded capacity is to be used for production of the "Extended-Field Lens" (EFL) 100-degree in-line color picture tube. This is the type used in the Zenith "System 3" color TVs. The "Color Sentry" tuner system and the "Triple-Plus" chassis are the other two features. There is no conventional chassis. The modules are connected by cables and plugs.

A new helmet for fire fighters has a bone-conduction microphone that is pressed firmly against the forehead. According to an article in *Electronics*, noise-free pickup of voice sounds is possible in locations as noisy as a subway platform. Other features of the Grumman Aerospace helmet are a public-address system and a radio signal that permits location of a fireman who is injured or trapped. With batteries, the helmet system weighs 1.5 pounds and transmits over a 5-mile line-of-sight path.

A videotape player system for autos has been demonstrated by Sony in Japan. The tape player has no TV tuner, and it can't record. The weight is about 17 pounds and the size is about one-fourth that of home Betamax machines. A power unit with rechargeable batteries, a 5-inch color TV, a case for holding the various units and a speaker comprise the remainder of the system. Price of the package is almost $2500.

Blood tests without drawing any blood may be possible. In West Germany, on experimental electronic method has been demonstrated for measuring the levels of ethanol, glucose, cholesterin and uric acid in human blood. The method is based on infrared spectroscopy, according to *Electronics* and requires a carbon dioxide laser that emits infrared toward a reflective plate which evenly distributes it over the lips of the patient. When the infrared frequency is varied, the amount of the substance under test causes peaks and valleys in beam current of the infrared detector. These waveforms are recorded on a moving strip chart, and are compared to a standard which provides a readout figure. Each substance produces a different waveform. High accuracy is claimed. For example, measurement of alcohol in the blood is said to be accurate to within 0.001%.

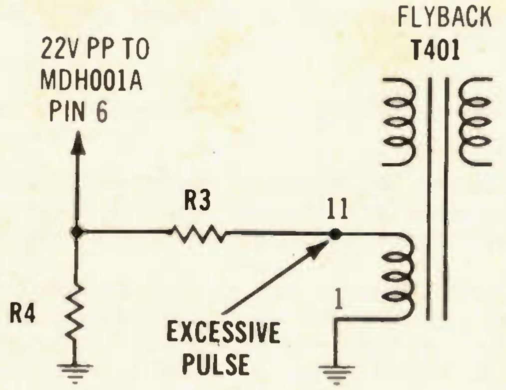
RCA plans to bring back "Nipper." For more than 70 years, the drawing of a fox terrier listening to "His Master's Voice" (from a wind-up acoustic phonograph) was the popular RCA symbol. Beginning in March, RCA color TVs again will show this trademark.

Courtesy of RCA

symcure

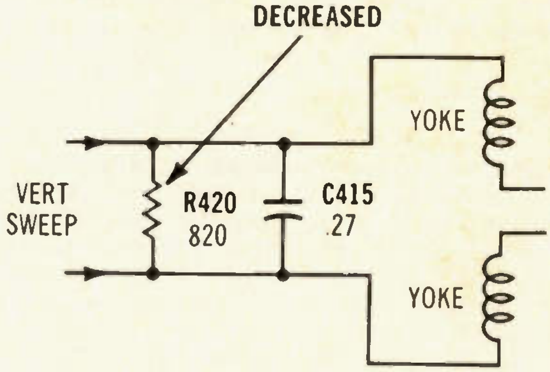
Symptoms and cures compiled from field reports of recurring troubles

Chassis—RCA CTC90
PHOTOFACT—1710-2



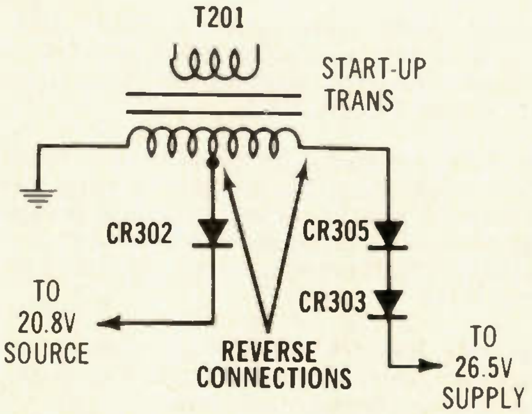
Symptom—Intermittent loss of horizontal locking
Cure—If no parts check as defective, replace T401 flyback

Chassis—RCA CTC78
PHOTOFACT—1628-2



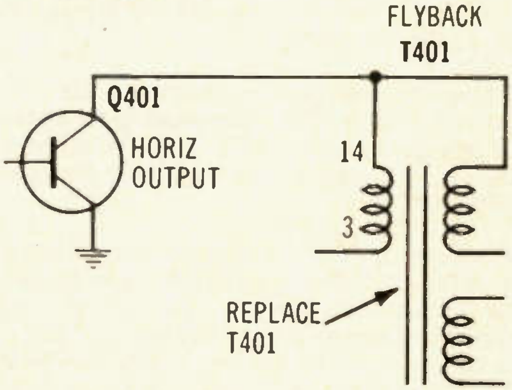
Symptom—Insufficient height with retrace lines
Cure—Check resistor R420, and replace it if reduced in value

Chassis—RCA CTC90
PHOTOFACT—1710-2



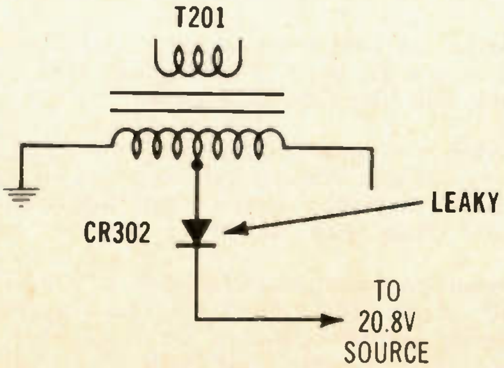
Symptom—Hum bars move up through the picture
Cure—As a test, interchange the pin 5 and pin 6 connections on T201

Chassis—RCA CTC71
PHOTOFACT—1435-3



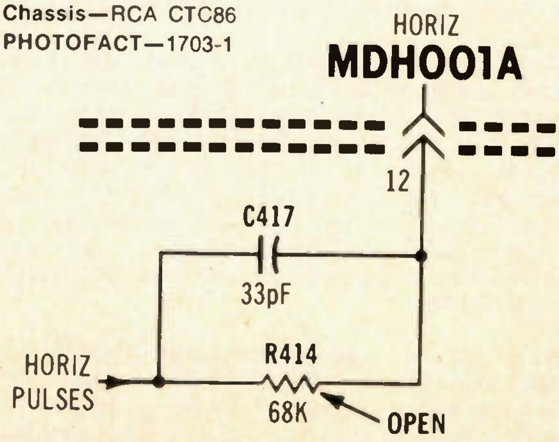
Symptom—Repeated failure of horiz-output transistor Q401 and regulator transistor Q103
Cure—If no parts check out defective, replace flyback T401

Chassis—RCA CTC90
PHOTOFACT—1710-2



Symptom—A stationary horizontal bend in the picture
Cure—Check diode CR302, and replace it if leaky

Chassis—RCA CTC86
PHOTOFACT—1703-1



Symptom—Picture locks with horizontal-blanking bar about 2 inches from left edge of raster
Cure—Check resistor R414, and replace it if increased or open

reader's exchange

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

For Sale: B&K-Precision model 280 digital multimeter, used only two hours, complete with box, leads and instruction manual, $60 or best offer. Also, Archerkit range-doubler VOM, 43 ranges, 50K ohms-per-volt, DC and 10K ohms-per-volt, AC, 4.5-inch mirrored meter, complete with box, leads and instruction manual, $25, or best offer. *Rick's Television, 3731 West 55th Place, Chicago, Illinois 60629.*

For Sale: New B&K-Precision sweep/marker generator with books, cables and carton, $350. Have other parts, tubes, etc. Send for list. *Leonard Elgart, Educated Electronics Services, 3510 Avenue H. Brooklyn, New York 11210.*

For Sale: Assorted Photofacts up to about 800. Write for list and prices. *John H. Falk, 813 7th Street, West Fargo, North Dakota 58078.*

Needed: Schematic and service information for a First Dimension model FD-3000W video game manufactured by Video Design Industry. Will buy, or copy and return. *Frank C. Champlin, 8647 Abilene, Rosemead, California 91770.*

For Sale: Master control TV and audio course by NRI; and first semester of Grantham School of Engineering. Or, trade for Motorola Institute 2-way radio course; NRI complete communications course; or NRI CB repair course. *M.R. Roseman, 11900 Lawnview, Cincinnati, Ohio 45246.*

For Sale or Trade: 26 items of laboratory type equipment including a Coulter model A counter, with visual size distribution; John Fluke VAW meter; and EMR square wave generator, model 43-A. Will trade for TV test equipment or a drill press. *Kenneth Miller, 10027 Calvin, Pittsburgh, Pennsylvania 15235.*

For Sale: Sams Photofacts 2 through 495 (some numbers missing) $1 each; Hickok 695 sweep generator, $50; Hickok 691 marker adder, $10; Heathkit IO-12 lab scope, $45; Heathkit T-3 signal tracer, $10; Mercury 101 tube tester with AD-4 adapter, $10; Precise 630 marker generator, $35; and Sencore SS-105 sweep circuit trouble shooter, $20. All in excellent condition with manuals—you pay freight. *Frank N. Sachs, 6803 Navajo Drive, Baltimore, Maryland, 21209.*

For Sale: Function generator using XR205s and printed-circuit board, complete with cabinet, $23; dual-voltage power supply 9-18V 1A, $24; SWTC-model 205C function generator, almost new, complete and calibrated, $35; Knight KG201 motor speed/light control, $8; RCA TV bias supply WG307B, $7; Heathkit IOA4510 scope time-base generator, $10; Radio Shack frequency counter with time base, complete but without cabinet, $35; Heathkit IMD 202-2 digital multimeter, $40. All prices include postage; first check or money order takes item. *Frank B. Longenecker, 6 Cranberry Road, Buzzards Bay, Massachusetts 02532.*

Needed: Schematic with repair and alignment information for Superior Instruments Genometer model TV50A; and Approved Electronic Instrument model A200. Will buy or copy and return. *Frank B. Longenecker, 6 Cranberry Road, Buzzards Bay, Massachusetts 02532.*

Needed: 7-pin selective-divider module ICs, made by Elka Electronics for Unicord and Panther Duo Organ (around 1967 or later). Will buy ICs, or complete circuit boards. *Gary D. Jones, Route 3, Box 362-A, Boonshoro, Maryland 21713.*

Needed: Audio transformer for ERLA radio model S-11; RCA service notes 1923-1928; and Rider's Radio Volumes 1 and 2. *J. Stephens 2275 Gray Hiway, Apt. L-1, Macon, Georgia 31211.*

For Sale: Air King wire recorder and 78-RPM disc player combination in a portable carrying case. Rare 30-year-old gem in perfect working condition; looks like new; museum piece; best offer over $100. *Jack Stollman, 132-02 Jamaica Avenue, Richmond Hill, New York 11418.*

For Sale: B&K-Precision cathode rejuvenator/tester, model 445, new, never used, $100. *E.R. Shipley, 3008 Revlon Drive, Dayton, Ohio 45420.*

Needed: AC and DC high-voltage test probes (5000V or higher) for Simpson 260 VOM. *E.R. Shipley, 3008 Revlon Drive, Dayton, Ohio 45420.*

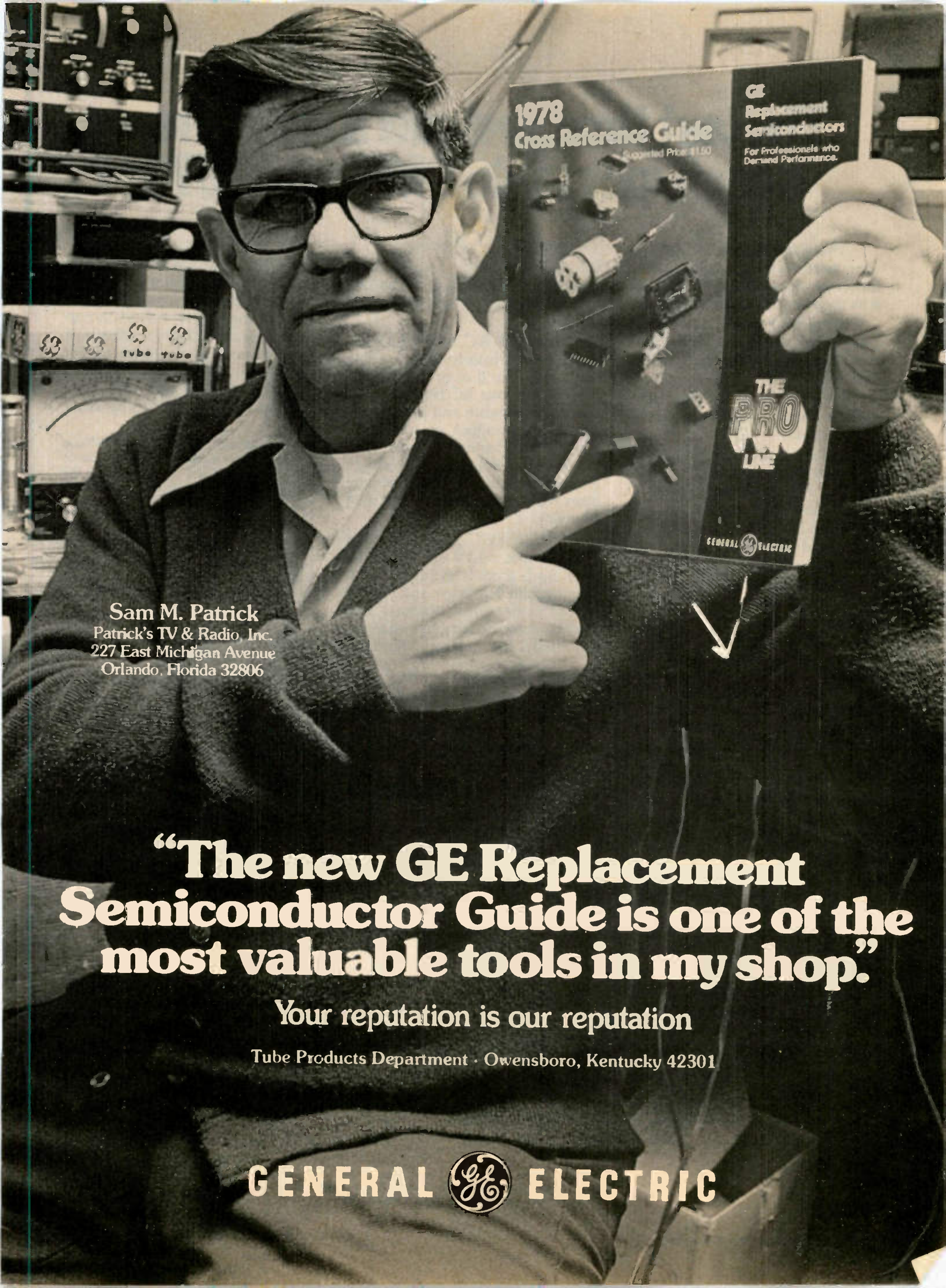
Needed: Schematic and service information for model DT360 Data Technology digital multimeter. *Ron King, 551 East North Avenue, Flora, Illinois 62839.*

Needed: H-P 150A scope for parts, also other H-P and Tek scopes for parts. *J. Allen Call, 1876 East 2990 South, Salt Lake City, Utah 84106.*

Needed: A schematic for Admiral TV model P17F2C, chassis 15A2C. Will buy, or copy and return. *50-50 Radio & Television Service, 1391 Sturdevant Road, Smiths Creek, Michigan 48074.*

Needed: Used electronic technology or TV/audio home study course, with training kits (NRI, Grantham, etc.) reasonably priced. *Caswell Davis, Jr., 601 Delmar, Apt. 2, San Antonio, Texas 78210.*

Needed: An assembled TV typewriter with schematics, or all parts with instructions. Also, the PET home computer with schematics, and service data for an ID Ideal cassette tape recorder, code 96081. Michael



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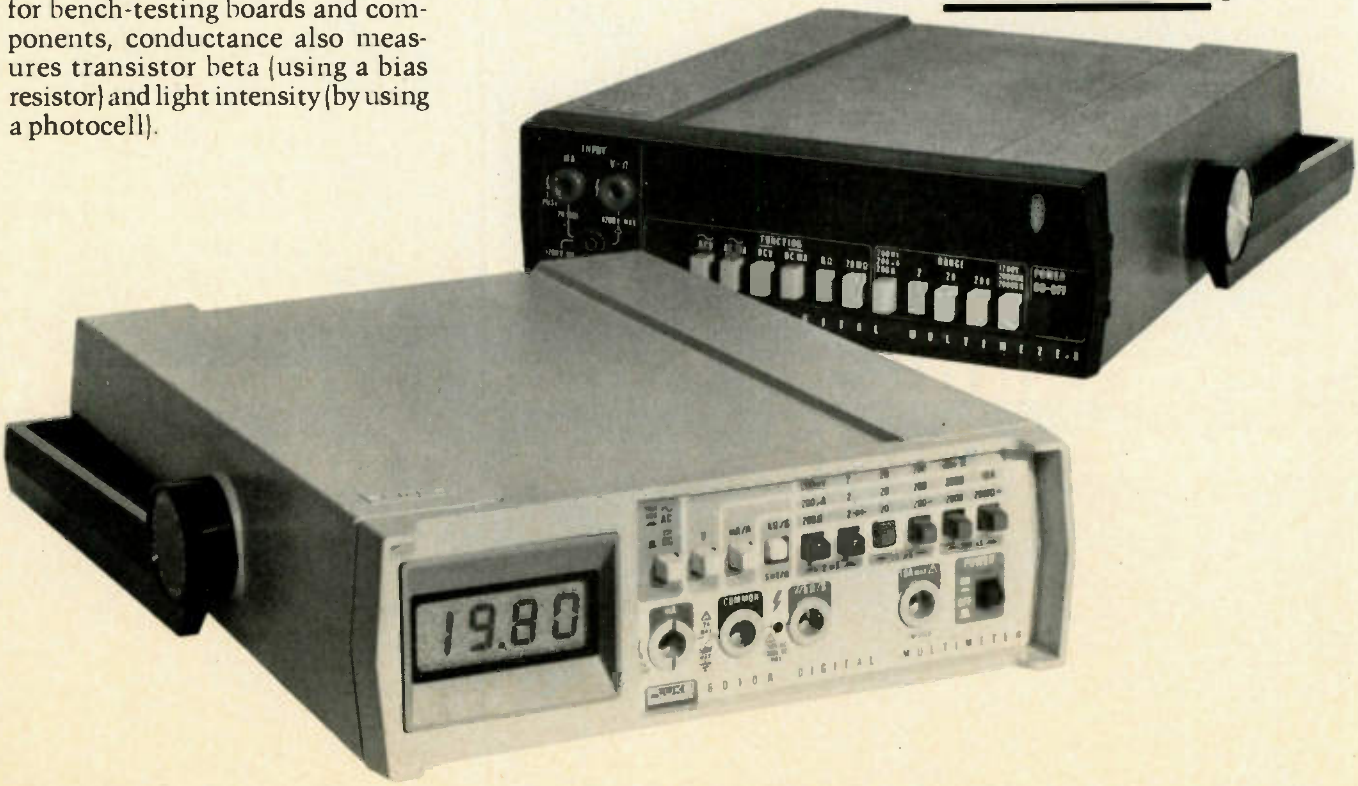

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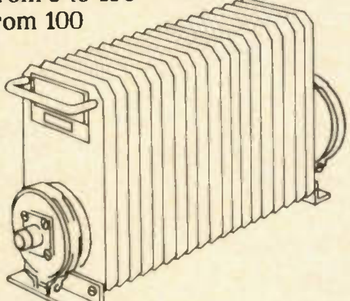

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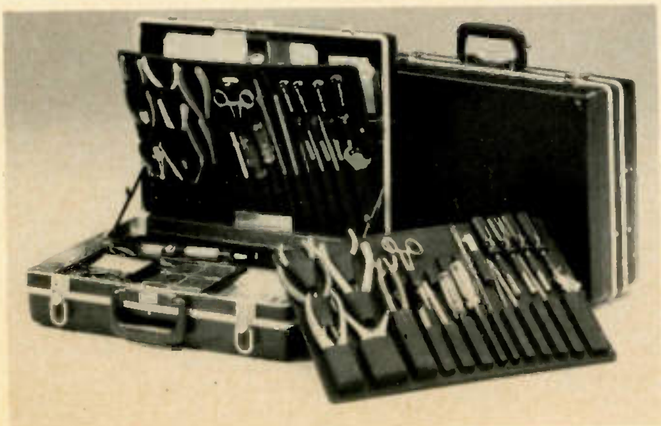

Circle (21) on Reply Card

Reader's exchange

Benton, 342 North Orange Drive, Los Angeles, California 90036.

Needed: Capstan wheel for Mayfair tape recorder model FT-1024, or where one can be purchased. *Herman J. Kaufman, 8310 Arnoldtown Road, Louisville, Kentucky 40214.*

For Sale: RCA color test jig model 10J103, $75. *Sam Lasky, 1023 E. 101 Street, Brooklyn, New York 11236.*

For Sale: Sencore DVM36 digital meter, new, with manual and instruction tape, in original carton, $70. *Norm Palus, 303 East, Lutton, New Castle, Pennsylvania 16101.*

For Sale: Tektronix 561-A scope with A3B3 delayed-sweep time base and type 63 differential amplifier, $250; also, a Telequipment D67 dual-channel, delayed sweep, $300. Both scopes were calibrated by Tektronix last June. Cart available for the 561-A, $50. *Paul Sherbine, 716 Quarry Road, Harleysville, Pennsylvania 19438.*

Needed: Two each type 1A5, 1C5 and 1D8 tubes; please quote price. *Unitronix, 2409 Avenue N, Galveston, Texas 77550.*

For Sale: Twenty-three years of *PF Reporter* and **Electronic Servicing**, to date. Best offer. *John Southard, 6066 Flora Villa Drive, Worthington, Ohio 43085.*

For Sale: Bell & Howell color TV course with scope and TVOM, $250. *Q.S. Hoshal, 1513 Hillside Drive, Bel Air, Maryland 21014.*

Needed: Parts for power supply and chassis of Victor radio "Electrola" RE-45 console radio-phono. Parts from RE-75, RE-32 or R-42 will substitute. *Jim Lowry, 4117 Arroyo Trail, Fort Worth, Texas 76135.*

Needed: Schematics and service information for Sylvania TV lab scope model 404, TV scope model 400, and TV sweep generator model 500. Also, for Tektronix TV adapter model 124. *Clyde N. Smith, 11 Brown, Reynoldsville, Pennsylvania 15851.*

For Sale: The following RCA Institute study courses: color TV, 8 studies, $40; communication electronics, 18 studies, $27; transistor course, 12 studies, $36; FCC first phone, 14 studies, $28; and electronics at work guide, 90 lessons, $25. *William D. Shevtchuk, 1 Lois Avenue, Clifton, New Jersey 07014.*

Needed: One 15VAETCO1 used color picture tube. *Joe Mehalko, 324 4th Street, Blakely, Pennsylvania 18447.*

For Sale: Heath AA-11 stereo preamp, $60; Heath AJ-41 stereo tuner, $65; 2 EICO HF-50 hi-fi amps, $120; Craig 2408 open-reel tape recorder, $125; Conar CW/AM 20-watt transmitter, $25; EICO 955 capacitor checker, $25; Knight KN-701 reverberation unit, $10; Superior TW-11 tube tester, $15; Heath GD-212 solid-state ignition system, $10. All are operational and have spec sheets; you pay for shipping. *O.M. Voelkel, 4102 South Park Drive, Belleville, Illinois 62223.* □

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"I'm dead serious about wanting to help you increase your service by isolating trouble to specific TV stages in minutes."
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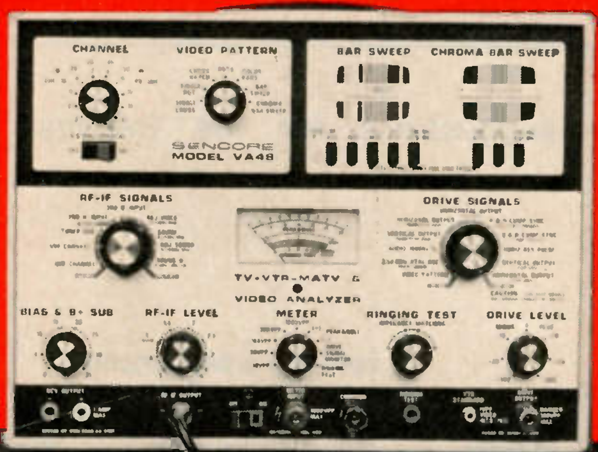

Your VA48 is practically jumpin' out of the box in the Sencore stockroom, anxious to help you increase your color TV, black and white TV, VTR, or closed circuit TV service by as much as 50 percent. The VA48 will help you double your shop income next year and build a service reputation that will never go away.

How can I help you and your VA48 get together? Just drop a note to the Sencore Customer Service Department or call our toll-free WATS number 800-843-3338 today and ask for Rich Brockway. I will see that your VA48 is delivered to you immediately, on a 30-day money-back guarantee that it will do just what we say it will do. How can you lose? The only way you can lose is by not picking up the phone right now. Need financing? Perhaps I can help you there.

The VA48 TV-Video Analyzer is like having a miniature TV station at your fingertips for troubleshooting.

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PART 8 Roundup of videotape servicing

Here are symptoms and troubleshooting suggestions for the Betamax videocassette tape recorder.

By Harry Kybett

Troubleshooting and servicing Betamax

All servicing is done best by the use of a logical method. For videocassette tape recorders, this sequence should be followed:

- You should understand how the machine operates. At the minimum, you must know the areas that should *not* be disturbed (generally, the video heads and certain mechanical assemblies).
- Ideally, you should have a service manual for reference.
- Tools and essential test equipment should be available.
- Attempt to playback and record for yourself. Don't depend too much on a customer's description of the problem. Make a note of any troubles.
- Visually examine the entire machine and write down any secondary defects, for repair after the main problem is eliminated.
- Determine from these preliminary tests what function is affected, and try to localize the defect to a certain circuit board or mechanical assembly.
- Using test equipment and the service manual, pinpoint the bad component.

As you can see, general servicing methods for videocassettes are not much different from those for repairing color TVs or stereo audiotape recorders.

Tools and test equipment

A dual-trace triggered-sweep scope having at least a 10-MHz bandwidth, an accurate frequency counter and a good digital multimeter are the major items of test equipment needed for video recorders.

One essential small item is the Sony SL-0001 alignment tool. It has a screwdriver blade at one end, and a noninductive bit at the other end, for adjusting coils.

You MUST have an alignment tape for the type of machine needing repairs or adjustments. These tapes are expensive and should be treated with care. *Never* insert this tape into a machine before all *defects* have been eliminated. For example, a machine with a tape-tension problem or a serious trouble with the tape guides or treading ring can totally ruin an alignment tape.

In addition, you should keep handy for constant use a "test tape" and a "work tape."

The *test* tape should have good material recorded on it, for checking the playback system and the servos. Recordings to check the record quality should be made on the *work* tape.

Use the test and work tapes during troubleshooting and servicing, then switch to the alignment tape for final alignment tests *only*.

Locate the bad function

First determine if the problem affects the playback or the record operation. Play your test tape. If it does not play correctly, then the machine has playback troubles.

If the machine does play correctly, record a short section on the work tape and play it back. If there is a problem, then the recording circuit has a defect. Also, play the customer's tape on a good machine to prove whether the customer's tape is good or bad.

After a machine is fixed, record a section on the work tape. Play it back on the repaired machine and also on a good machine. If the tape plays normally on both machines, you have eliminated the problem.

Another excellent test is to determine if the defect is in the luminance or the chrominance section.

Diagnosis by adjustments

Many defects can be located and identified by attempting to follow a complete adjustment series or an alignment process.

Locate in the service manual any adjustments or alignments in the suspected area.

Go through the alignment or adjustment sequence, staying alert for any result that's abnormal. Any step that can't be completed properly points toward the problem source.

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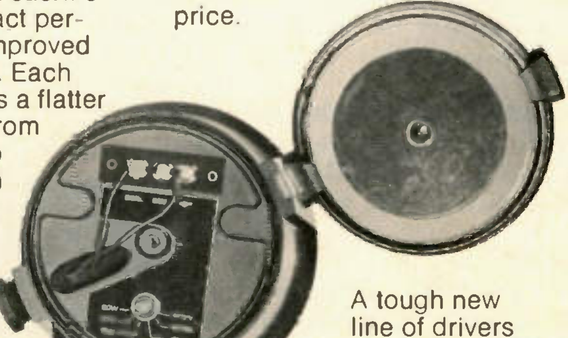

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Betamax

No video and no audio

A complete failure of both video and audio—giving a black TV screen and complete silence—usually will be caused by system faults common to both audio and video circuits. Often, this occurs in all modes (neither record or play produces anything, and the EE picture can't be seen in the rewind, fast-forward and stop modes).

First, look to see if the tape is threaded, and if it is moving. When it's threaded but not moving, check the capstan belt. See if the heads are rotating. If not, check the head belt and the ac motor. If the tape will not thread, test as advised in an earlier article about mechanical problems.

If none of these obvious mechanical faults is there, the likely trouble is the speed detect and the muting sections of the capstan servo. One quick test is to use a scope to look for playback control-track pulses on the RS board at slide switch S501-2 (pin 2 of S501). If the switch is open, the CTL pulses can't get to the capstan servo, causing the mute to remain active. As a test, the video can be unmuted quickly by grounding the base of Q7 on the YC board. Normally, it has zero volts when the video is seen and +5.7 volts when the video is muted.

Audio, but no video

A blank screen rarely occurs while the audio remains good. Check for a bad video transistor, a video IC, or the video-muting transistor.

Trace the video circuits with a scope, noticing where the signal disappears.

If the video is missing on playback, scope TP3 on the YC board. Then, scope pins 4, 12, 14 and 21 on IC3 (CX135) for video, and also pin 1 for FM. If the signal is lost between two IC pins, then check the components between the pins, since these are more likely to be defective than the IC.

If the machine plays back a tape, but will not record video, check the video coming from a connector at the rear. It might not be connected to a cable having video. Next, check IC1 (CX131A) for video input and FM output. Scope IC3-7 for an EE signal. On the RS board, see if the FM signal reaches TP1 and TP2. Other trouble spots might be the slide switch S1 on the RS board, and the record-level control.

Noisy picture

When the picture is noisy or has excessive snow with little video, first check the wiring and connections between the Betamax and the TV set used as a playback screen.

However, the most likely problem is the video head that needs cleaning. Or perhaps the head is worn or broken, needing replacement. But don't be in a hurry to change video heads. They have a working life of about 1000 hours, and will not shatter under normal use.

Check to make certain a good recording is on the customer's tape. Also, check slide switch S1 on the RS board.

If the trouble seems to be in the record mode, check the video heads and the record current (as shown in the alignment procedure).

Some unlikely problems might be broken leads between the heads and the rotating transformers, or from the head drum to the PC boards. Rotary transformers rarely go bad.

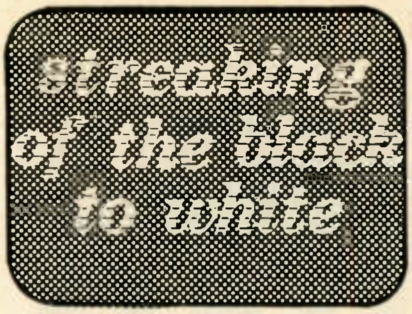


Figure 1 Dirty or defective video heads are the most likely cause of black streaking into white areas of the picture.

Streaking in picture

Streaking usually shows in the picture as black lines in the white areas, as shown in Figure 1. If it occurs during playback, the heads are becoming dirty or worn, so clean the heads first. Another cause is wrong equalization of the playback preamplifier.

In the record mode, the heads can cause streaking. Also the white clip, FM deviation and recording current should be checked.

White flashes

Excessive white flashes are evidence of dropouts where the tape oxide is thin or missing. Adjust the drop-out compensator for minimum white flashes.

Herringbone patterns

Varying herringbone patterns can be caused by wrong adjustments. If

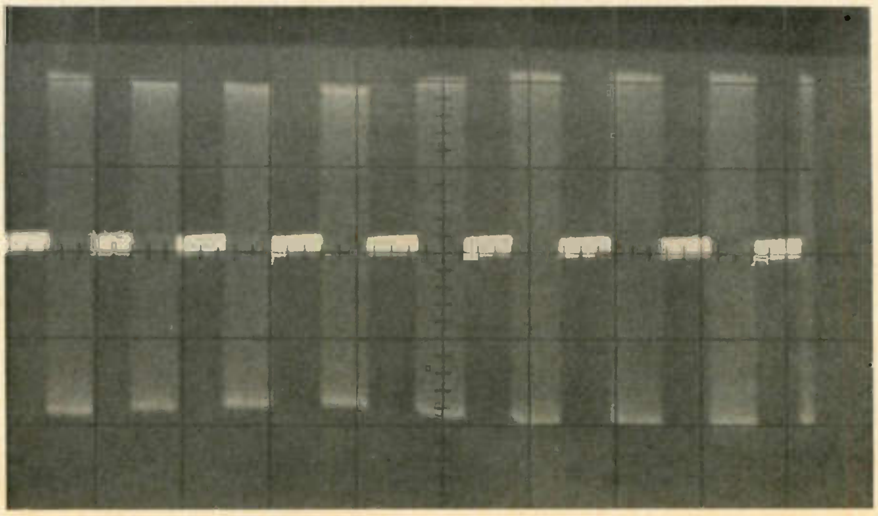
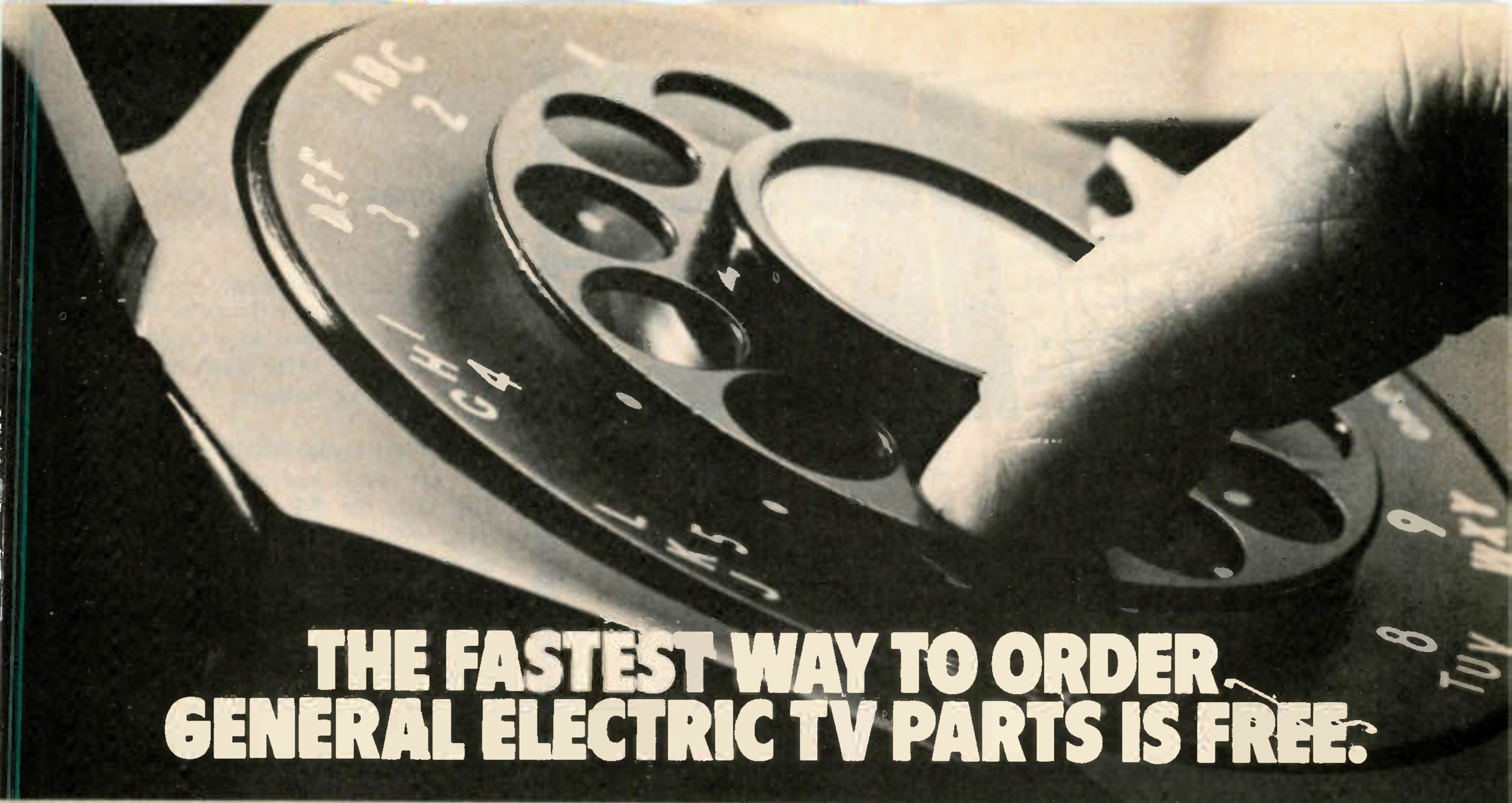


Figure 2 This is the correct waveform obtained during a test of phase switching.



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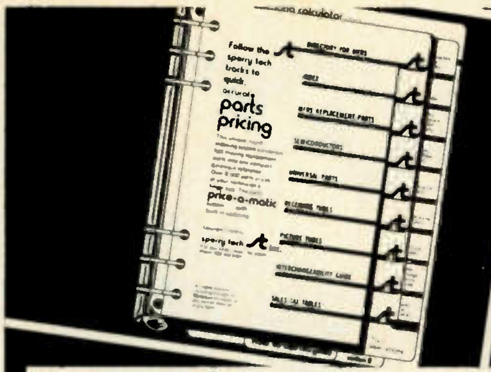

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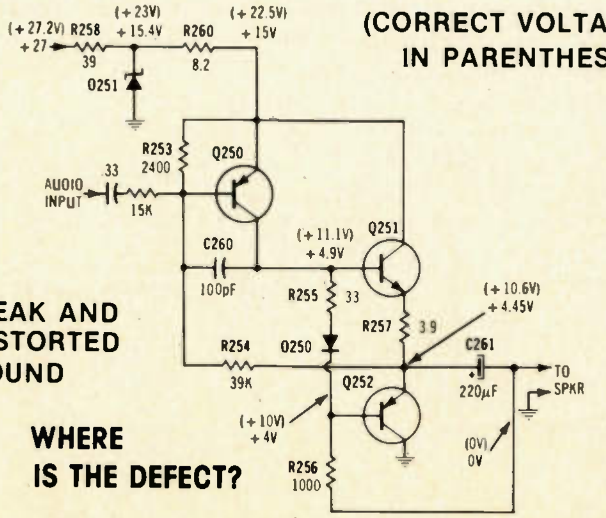
QUICK-QUIZ

#3

By Wayne Lemons

(CORRECT VOLTAGES IN PARENTHESIS)



WEAK AND DISTORTED SOUND

WHERE IS THE DEFECT?

ANSWER ON PAGE 50

they appear in playback, check the carrier balance and the comb filter. If they are recorded on a tape, then check the 3.58-MHz traps and the FM modulator balance.

Distorted audio/distored video

When both audio and video is distorted, the RF modulator unit (that feeds the TV used as a monitor) usually is bad. But first check the TV receiver, making certain it's on the right channel and has correct fine tuning.

If the RF modulator is bad, **do not attempt to repair it.** These are made to FCC specs, and might cause interference when repaired wrongly. Replace the RF modulator, if you are sure it's defective.

Chroma problems

Color problems can occur, although the b&w picture appears to be normal. These various problems can be caused either by component defects or by misadjustments. Therefore, first go through the chroma alignment. if this does not cure the symptom, a component probably is bad.

No color

Check the TV receiver fine tuning, and make certain the program is in color. Play the customer's tape on another machine to be sure it is recorded in color.

On the YC board, check for the 688 kHz signal at pin 15 of IC4 and CN1001-10.

The color-killer voltage at IC2-1 should be +4 V for color, and zero for monochrome. Measure this voltage, and reset the killer if necessary.

Additional check points are listed in the service manual.

Weak color

Usually weak color is caused by misadjustment of the level controls. It most often appears after replacement of component parts and can be cured by doing the alignment.

Color flicker

Color flicker can occur *only* during playback. Sometimes, it's difficult to distinguish color flicker from luminance flicker.

The most common cause is failure of the ACC to switch as the heads are changed during tape playback. Check for the 30-Hz square wave at IC4-7 on the YC board.

Another possible cause is a leaky capacitor at a pin of IC7.

Intermittent color

Most intermittents are caused by faulty connections in the circuit. Typical places are PC-board solder joints, and cables broken near a plug.

Intermittent chroma might result from a poor adjustment of the 692-kHz oscillator in the heterodyne circuits. If the color remains unsatisfactory after the alignment, just adjust the color for maximum output.

Color banding

Color banding appears as thin horizontal bands of color. It's caused by failure of phase reversal in the 688-kHz signal to the "A" head. The fault will be common to both record and playback.

Check for 692 kHz from the VCO at IC5-11, for 3.57-MHz at IC5-13, and for phase switching (as shown in the service manual). The waveform of Figure 2 should be obtained for phase switching.

Also, check for sync at IC7-4, for 30 Hz at IC7-10, and for chroma at IC7-2.

Servo servicing

The servo problems show up as alternate periods of good and bad video. Therefore, the symptoms are not like luminance and chrominance defects.

Figure 3 One symptom of a servo problem which allows a video head or capstan to run at erratic speed is a band of noise that either jerks up and down or remains stationary. Servo problems usually show on the TV screen as alternate periods of good or bad video.

Usually the trouble will be seen as a vertical jitter in the picture, or as a band of random noise which either might remain stationary or jerk up and down through the picture (Figure 3). The cause is a head or capstan not running at the correct speed, thus producing mistracking.

For this kind of mistracking, adjust the tracking control in an attempt to improve the picture. If the tracking control can't remove the symptom, use your test tape (*not* the alignment tape) to determine whether the trouble is in the machine or with the customer's tape.

Playback problems can be identified easily by playing a test tape. Servo problems during recording are proved by recording a short section on a work tape, and then playing back the section both on the suspect machine and on a good machine.

One difference between head and servo speed problems is the effect on the audio. Capstan problems usually cause "wow" in the sound, while the head servo won't do that. When the head servo won't lock-up, you can hear a rising and falling of the whining note it makes as the head revolves while it "hunts" for locking.

Most servo problems are caused by defective circuits or wear and aging of mechanical parts, such as brake pads.

Remember that processed sync pulses are used as keying pulses. Therefore, make certain the incoming video signal is clean of noise and smear.

The majority of servo problems can be repaired by changing the head-drive belt, the capstan-drive belt, checking the tape tension, and then doing the servo alignment.

End of the series

This is the final part of the Betamax series of articles. Please write to the editor if you have suggestions or comments regarding future articles about servicing videocassette tape recorders. □

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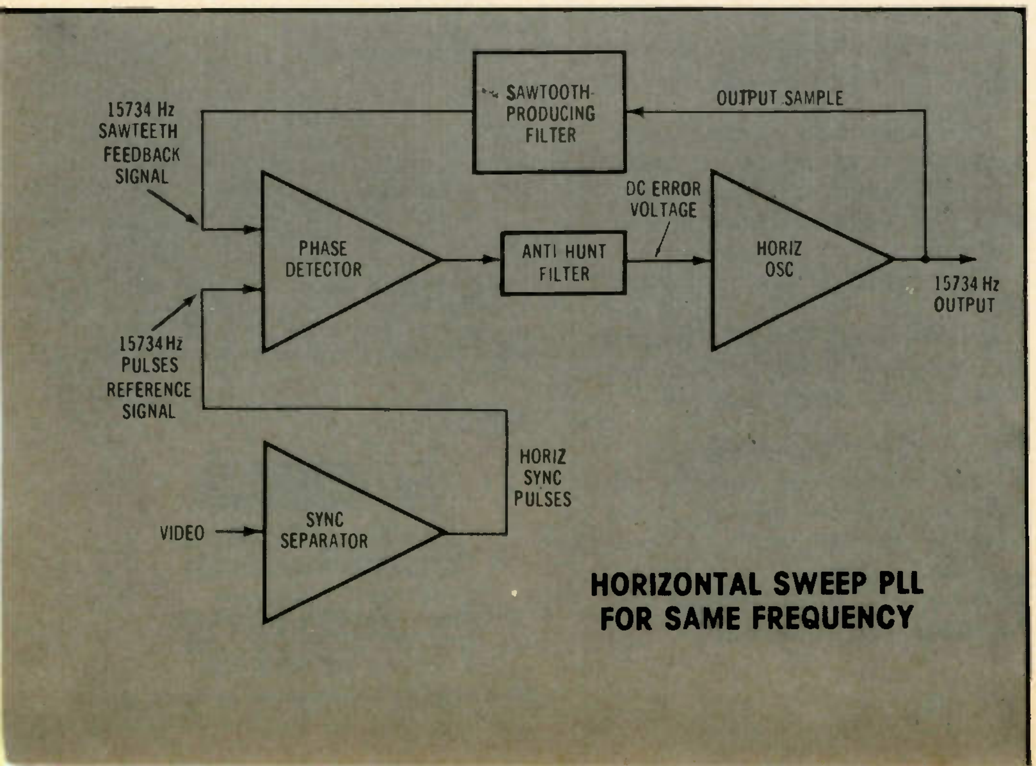
Exploring Quasar's Compu-Matic Touch

All of the new crystal-controlled TV tuners rely strongly on digital circuits, and many operate with phase-locked loops. This is true of the new Quasar Compu-Matic Touch Tuning system, which is described here. Because these sophisticated circuits have phase-locked loops, we have included additional general information about PLLs.

Microprocessor control of a phase-locked loop allows direct-access dialing of all VHF and UHF TV channels in Quasar models equipped with Compu-Matic Touch Tuning. Manual fine tuning and AFT can be switched in to accommodate video games, or other signals that don't operate on the exact broadcast frequencies.

Figure 1 The AFC circuits for horizontal locking of TVs are a type of Phase Locked Loop (PLL). A filtered-dc error voltage from the phase detector controls the oscillator frequency. This PLL is designed to do only one function: It varies the oscillator frequency so the sample at the feedback input has the same repetitive frequency *and phase* as the phase-detector reference signal has.



By Wayne Lemons, CET

Although the Quasar TV Compumatic all-electronic tuning system has many refinements (microprocessor control, digital station selection, and digital channel display) the heart of this sophisticated circuit is a Phase-Locked Loop (PLL). Therefore, we need to review PLLs before trying to understand the overall system.

Basics of phase-locked loops

Phase-locked loops have been known and used for decades. However, modern *digital* frequency dividers were necessary to transform the simple pioneering PLLs into the complicated, stable, and wide-range frequency-control circuits that are found in late-model CB radios and now in VHF/UHF high-accuracy TV tuners.

Simple PLLs

From the beginning of TV, phase-locked loops have been used as horizontal AFC for locking the horizontal oscillator to the picture. Later, the principle was extended to control the color oscillators as well.

All PLLs operate by comparison of a standard (reference) frequency against the frequency of the oscilla-

Tuning

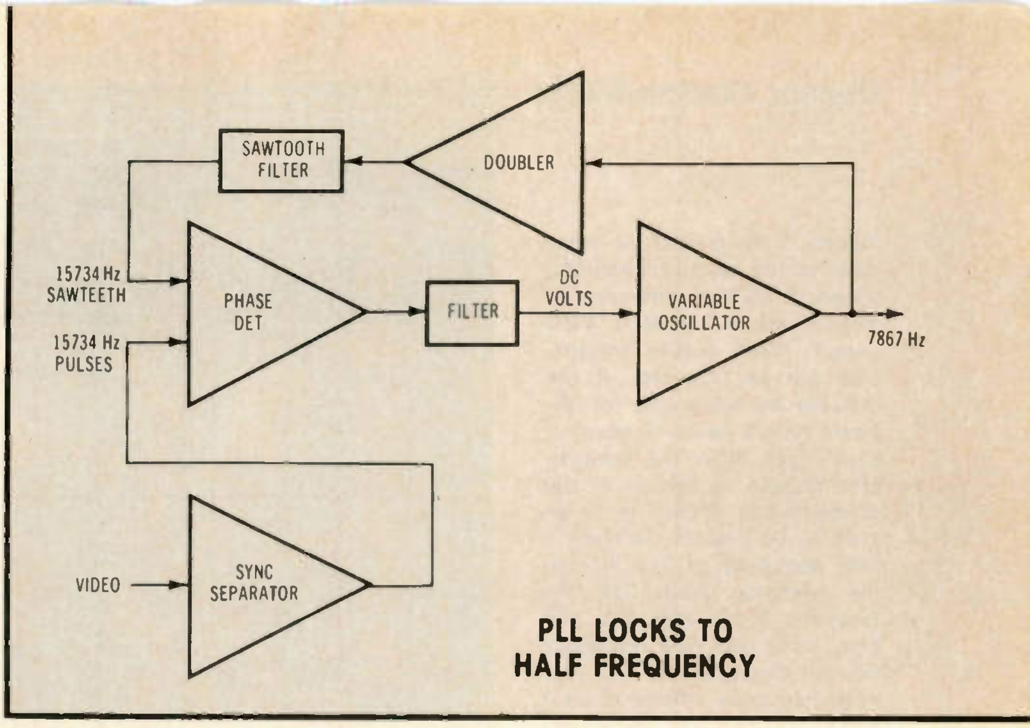


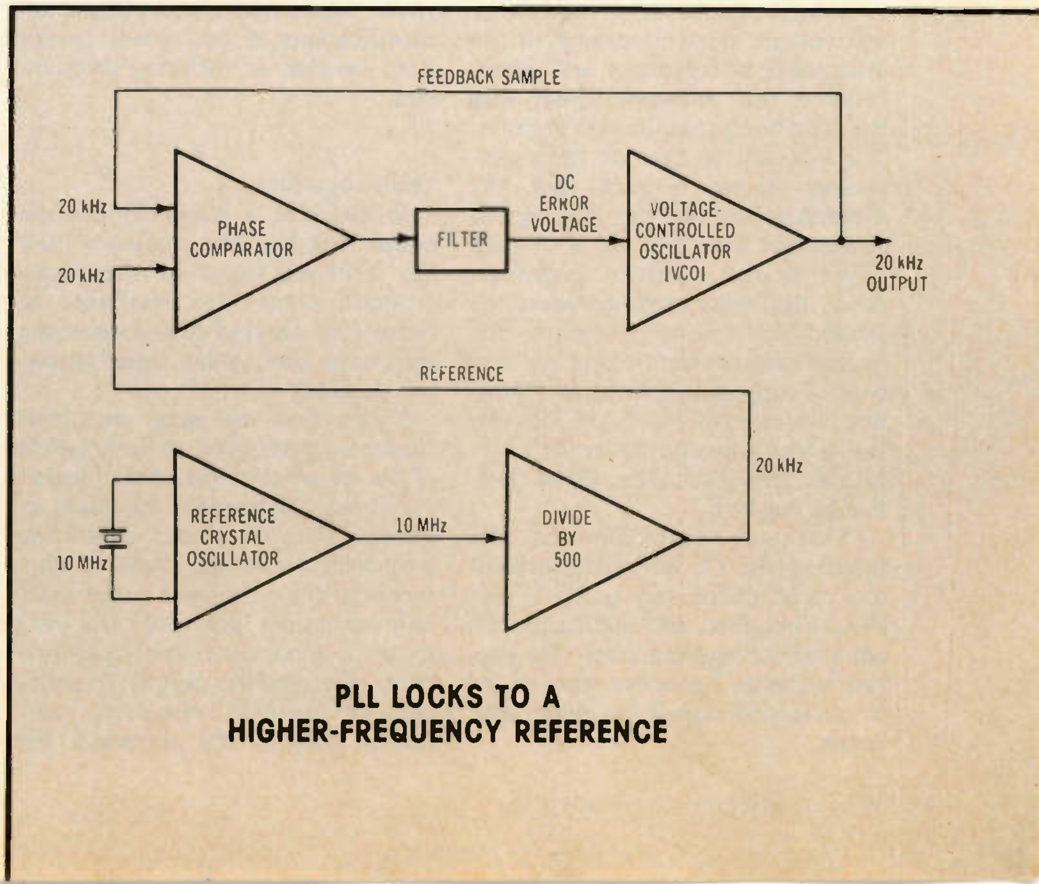
Figure 2 Addition of a frequency doubler in the feedback path between oscillator and phase detector forces the oscillator to operate at half of the reference (sync) frequency. Again, both phase-detector inputs have the same frequency of repetition.

tor that needs to be controlled. **From this frequency comparison, a dc voltage is produced.** It varies according to the frequency and phase difference between the standard and the controlled oscillator. This is called the correction (or error) voltage, and it's filtered and fed to the oscillator to correct for any frequency change or drift.

Figure 1 is the block diagram of a horizontal-oscillator PLL. Notice that the block diagram has been changed from squares to triangles which point in the direction of the signal flow.

For horizontal-sweep oscillators, the reference signal consists of horizontal-sync pulses, obtained from the sync separator in the TV receiver. These are differentiated and then delivered to one input of a phase detector. A sample of the horizontal-oscillator output signal is integrated and supplied to the other input. Many of these phase detectors are of the twin-diode type where the two input signals are rectified simultaneously by both series and shunt peak-reading action. Incidentally, smoother locking control is obtained when the reference signal has pulses, and the sample of

Figure 3 Notice the change of names. The PLL circuit is identical to the one in Figure 1, except for the divider in the reference-frequency path. If the divider were adjustable, each divider ratio would deliver a different frequency to the reference input of the phase comparator. Then, the closed loop (phase comparator and VCO) would vary the VCO frequency until the same frequency is present at both comparator inputs. Phase comparators and phase detectors have widely-different circuits. The output signal from most comparators consists of dc pulses. After filtering of the pulses to produce pure dc voltage, this tuning voltage often ranges between about zero and +30 V. It is used to control the VCO frequency.



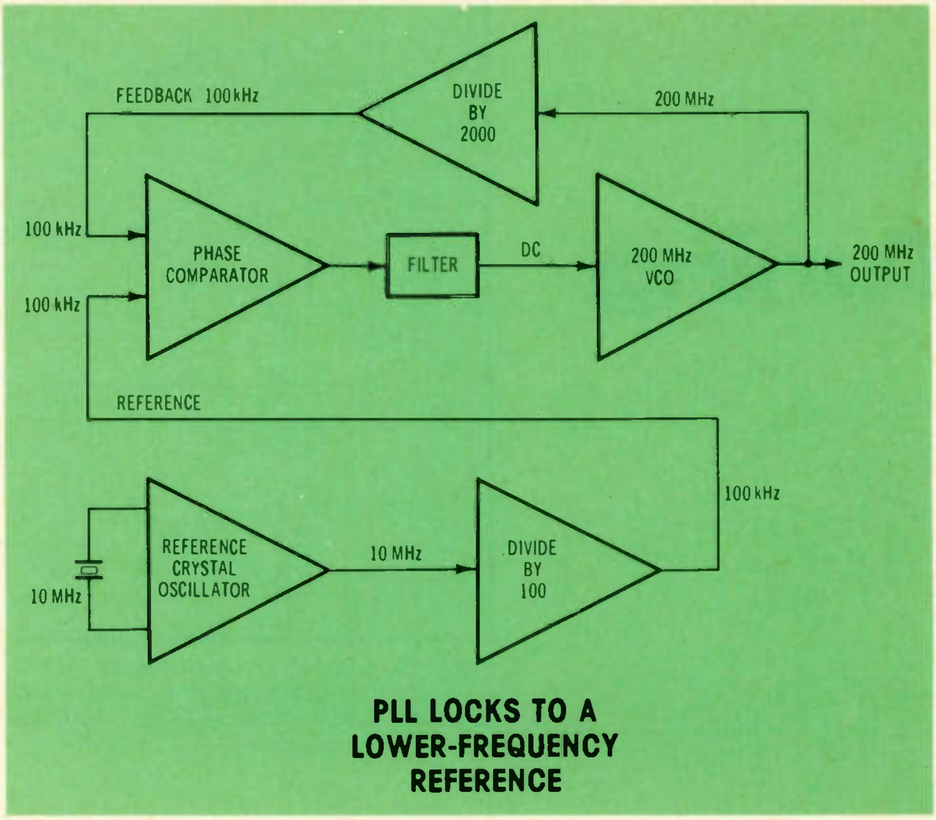


Figure 4 A divider at each input of the phase comparator allows a 10-MHz reference to phase-lock a 200-MHz VCO output. Many output frequencies can be obtained, if the dividers are adjustable for different divider ratios. Starting at phase lock (with the frequencies shown), a change of the divide-by-100 divider to a divide-by-90 divider delivers a new frequency of 111 kHz to the reference input. But, the feedback input still has 100 kHz, since the VCO frequency has not changed yet. This is a huge frequency difference for a phase comparator, one that seems to require a *large* increase of tuning voltage. But, the filter action slows down changes of tuning voltage, making all frequency changes less than instantaneous. So, as the tuning voltage pulls the VCO to a higher frequency, the frequency difference is reduced at the comparator inputs (which also reduces the need for that extra amount of tuning voltage). By the time a correct 222-MHz VCO frequency is attained for the new phase-lock, the dc tuning voltage measures only slightly higher than the original reading with the ÷100 divider. But, notice that *each* successive VCO oscillator frequency requires a matching new dc tuning voltage to maintain the phase-lock.

oscillator signal (called feedback) has a sawtooth shape.

From the phase detector comes a dc voltage which varies in polarity and voltage value according to the differences of frequency and phase between the reference (sync) and the feedback (oscillator) signals. The polarity of this dc error-correcting voltage is such that any difference between the two signals causes the oscillator to be forced *nearer* to the reference frequency. Also, the error voltage must be filtered by a network having the proper time constant to permit fast control without overshoot or "hunting." In most of these AFC circuits the error voltage is zero when locked. Otherwise, it's either positive or negative.

It is not desirable for the frequency of TV horizontal oscillators to be varied very much by the PLL. Therefore, the oscillators are adjusted for approximately the correct scanning frequency when there is no station signal to suppy sync pulses.

The limitation of this PLL circuit is that **both the reference and feedback signals must have the same repetition rate.** However, modifications of the circuit permit it to operate at differing frequencies.

Divider operation

In Figure 2, a frequency *doubler* added between the oscillator and the feedback input of the phase detector forces the oscillator to operate at one-half of the reference frequency (horizontal sync pulses, in this case).

Notice that the same repetition frequency is supplied to both inputs of the phase detector. This "fools" the phase detector into operating as though the VCO and reference frequencies were the same. Unfortunately, analog circuits can extract only harmonics (2nd, 3rd, 4th, etc.) from the oscillator output, and this limits the possible output frequencies to one-half, one-third, one-fourth, etc., of the reference frequency.

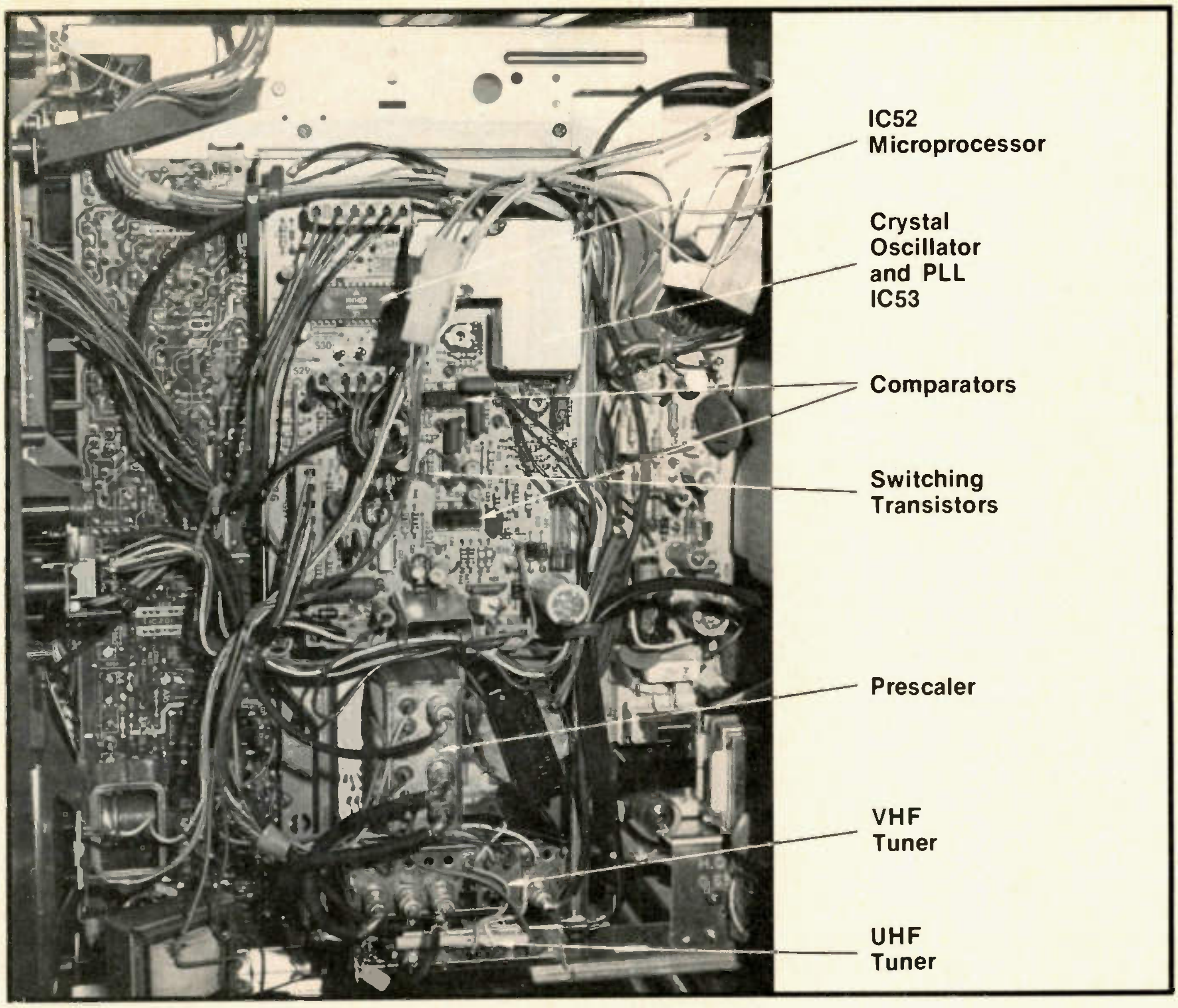
Other circuit variations that permit frequency multiplication also are extremely useful. They operate with frequency dividers.

Locking to a higher-frequency reference

Figure 3 is a basic phase-locked loop circuit containing one divider. But this time, *the divider is following the reference oscillator.*

Some of the names have been changed. Phase detectors are called "phase compatators," because the operation and internal circuitry is different. Usually the two signals at the comparator are not filtered and the oscillators are named VCO (voltage-controlled oscillator). These VCOs usually are varactor tuned, and operate over a wide band of frequencies.

Digital electronics has made possible a multitude of frequency dividers. Small ICs can be preprogrammed to divide by almost any number. Or others can be pro-



Arrows point out major components of the Quasar Compu-Matic tuning system. An extra circuit board on the "works-in-a-drawer" chassis contains most components, except for the prescaler divider, and the two tuners.

grammed *at any time* for many different divisions that are selected by external switches or signals (keyboards or computers).

The divide-by-500 IC of Figure 3 changes the 10-MHz crystral-oscillator signal to 20 kHz, before it is delivered to one input of the phase comparator. However, the other input doesn't *always* have a signal of the same frequency as required for proper operation.

Now, notice an important principle: **the circuit operates to change the VCO frequency, varying it higher or lower as needed, until BOTH inputs have the same frequency and phase.** At the beginning of the search for locking, the VCO frequency might be any between 12 kHz and 29 kHz. The error-correcting dc voltage eventually forces the VCO to operate at the desired 20-kHz frequency, and lock is complete. But remember, **only after lock is achieved does the phase comparator have signals of the same frequency at both inputs.** Those nice frequencies on all schematics represent the end product of the locked phases.

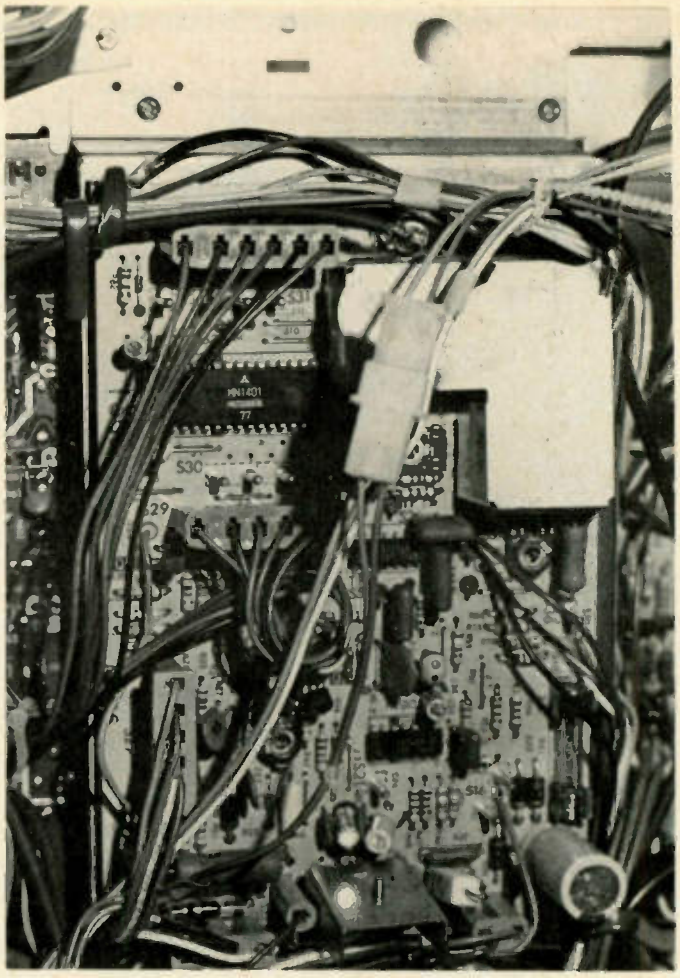
Programmable dividers for other frequencies

If we want other output frequencies from the circuit of Figure 3 instead of 20 kHz, we can substitute a programmable divider for the divide-by-500 IC.

Adjust the programmable divider for a division of 499 and the divider output is 20.04 kHz. For phase-lock the other comparator input also must have 20.04 kHz. Therefore, the error voltage changes to speed up the VCO for an output frequency of 20.04 kHz.

Adjust the divider for a division of 250 and the output frequency becomes 40 kHz. Later we'll explain how to anticipate the frequency. By using other divider ratios many output frequencies can be obtained.

Did you notice that correct frequency at the phase comparator reference input was determined *both* by the reference frequency and by the division ratio of the divider? Therefore, defects either in the reference oscillator or in the divider can cause a wrong frequency at the VCO output. The frequency of either can be checked by use of an accurate frequency counter. However, when the entire PLL works



Here is a close-up view of the microprocessor and PLL areas. The PLL is under the shield.

correctly, the frequency drift and accuracy will be identical with those of the reference oscillator.

PLL from a lower-frequency reference

PLLs can be controlled also from reference signals of *lower* frequency than the desired VCO output frequency, as shown in Figure 4. If only this one output frequency is desired, the divide-by-100 could be eliminated, and the crystal-oscillator frequency changed to 100 kHz. However, the use of programmable dividers in both the feedback and reference signal paths (rather than in one alone) gives the possibility of producing many more output frequencies, as we shall see.

Effects of various dividers

There is an easy way of calculating what the VCO output frequency should be, when dividers are used in both the reference and feedback paths.

In Figure 2, did you notice that a *doubler* in the feedback-signal path forced the oscillator output to half of the reference frequency? Therefore a ÷1 (no division) would have produced 15,734 Hz; a ÷2 would give 31,468 Hz; or a ÷3 would force the output to 47,202 Hz (assuming the oscillator was capable of that much change). In other words, higher feedback division ratios increased the VCO output frequency.

In Figure 3, a decrease in the reference-input divider ratio increased the VCO frequency. These examples give us two valuable rules for understanding PLLs. They are:

- **Higher** divide-by numbers for the divider in the comparator feedback signal path produces a **higher** output frequency from the VCO (also, a lower division in the feedback path produces a lower VCO frequency); and
- **Lower** divide-by numbers for the divider in the comparator reference signal path produces a **higher** output frequency from the VCO (conversely, a higher division in the reference path produces a lower VCO frequency).

Now, let's test these statements with the conditions of Figure 4. Suppose the divide-by-100 was changed to divide-by-50. The reference input to the phase comparator would become 200 kHz (10,000 kHz ÷ 50 = 200 kHz). To obtain 200 kHz at the comparator feedback input through the ÷2000, the VCO frequency must become 400 MHz. The output frequency has increased in inverse proportion to the change of the reference divider ratio.

Conversely, if the refernce divider is changed to a divide-by-200, the phase comparator inputs must be 50 kHz which requires the VCO output to become 100 MHz. This is one-half of the original VCO frequency when the division was 100. Again, the change was in inverse proportion to the change of division.

Going back to the feedback signal, a change from the original divide-by-2000 to a divide-by-1000 (a decrease) requires a VCO output of 100 MHz to produce 100 kHz at the phase comparator. If the division is increased to 4000, an increased VCO frequency of 400 MHz is required to satisfy the phase comparator. These frequency shifts are in direct proportion to the change of the feedback divider ratio.

PLL frequency analysis

These previous facts make possible a logical sequence for anticipating the PLL output frequency. Follow this list:

- **Divide** the reference frequency by the reference-divider ratio. This is the frequency needed at both phase-comparator inputs for phase-lock.
- **Multiply** the reference comparator input frequency by the "divide-by" ratio of the feedback divider.
- The last figure is the correct

output frequency of the VCO and the PLL.

Note: when several dividers are used in series, they must be *multiplied* together to yield the total division.

Apply those statements to Figure 3 and Figure 4. Figure 3 has no feedback divider, so the divide-by number is 1 (unity). Check my previous figures for various divider ratios, by using the schematic of Figure 4.

TV PLL comments

Without any horizontal sync fed to a TV AFC circuit, the horizontal oscillator is adjusted so it idles near the correct 15,734 Hz sweep frequency. When a station is received and sync reaches the AFC circuit, the oscillator signal momentarily is not locked (that is, does not match the sync repetition rate). Then, the AFC circuit develops a filtered dc voltage to force the oscillator either higher or lower (as necessary) until the two AFC signal inputs have the same frequency. Whatever dc error voltage was required to achieve this phase lock remains steady (at least until something else changes). If minor oscillator drift occurs or you use the hold control to vary the oscillator-output phase (without breaking lock), the AFC voltage will swing in step with the change.

Other PLL comments

Without any reference signal, a modern VCO (perhaps in a CB radio) will idle at a frequency that's near the center of its operating range. Then when a reference signal is applied to the phase comparator, the feedback frequency from the VCO momentarily does not match the reference frequency at the comparator. A dc error voltage is developed by the phase comparator, and it forces the VCO frequency either higher or lower (as necessary) until the feedback input frequency is the same as the reference frequency at the comparator. Whatever dc error voltage was required to achieve this phase lock remains steady (except for minor drift). Any VCO minor defect which would change the VCO frequency slightly if it were not locked merely causes the circuit to produce a different dc voltage which provides the correct frequency.

A dangerous analogy

Did you notice that these two PLL comments were almost identical, except for the difference of terminology? Well, this similarity often is discussed as an explanation of modern PLLs. The premise is valid to a degree. New facts are easier to learn when contrasted to facts already known. If modern PLLs operated at only one frequency, the explanation would be perfectly satisfactory. But they don't. And that brings the danger of misunderstandings.

Error voltage versus tuning voltage

In TV PLL AFC circuits the error voltage should vary only enough to correct minor drift. The voltage value is the same for all channels and usually is centered around zero.

In modern frequency-synthesis

Original Japanese Replacement Parts for TV, Stereo and CB

	25-UP	10-24	1-9
2SA102	.29	.34	.39
2SA473	.45	.55	.60
2SA484	1.85	2.05	2.35
2SA495	.25	.30	.35
2SA497	.90	1.15	1.25
2SA509	.30	.35	.40
2SA562	.25	.30	.35
2SA564A	.29	.34	.39
2SA634	.35	.40	.45
2SA636	.80	.85	.90
2SA643	.30	.35	.40
2SA673	.30	.40	.45
2SA678	.40	.50	.55
2SA683	.40	.50	.55
2SA684	.40	.50	.55
2SA695	.40	.50	.55
2SA699A	.50	.60	.65
2SA706	.85	.95	1.05
2SA720	.30	.35	.40
2SA733	.25	.27	.30
2SA747	4.15	4.35	4.85
2SB22	.45	.50	.55
2SB54	.30	.35	.40
2SB77	.30	.40	.45
2SB175	.35	.40	.45
2SB186	.20	.27	.30
2SB187	.20	.27	.30
2SB324	.25	.35	.40
2SB367	1.10	1.20	1.35
2SB405	.25	.30	.35
2SB407	.70	.85	.95
2SB463	1.00	1.05	1.15
2SB474	.70	.80	.90
2SB507	.70	.80	.90
2SB511	.70	.75	.85
2SB557	2.05	2.45	2.75
2SC183	.40	.50	.55
2SC184	.40	.50	.55
2SC372	.20	.27	.30
2SC373	.20	.27	.30
2SC380	.20	.27	.30
2SC382	.30	.40	.45
2SC387A	.30	.40	.45
2SC394	.25	.30	.35
2SC458	.20	.27	.30

	25-UP	10-24	1-9
2SC460	.45	.50	.55
2SC481	1.25	1.35	1.45
2SC482	1.25	1.35	1.45
2SC485	1.25	1.35	1.45
2SC495	.45	.55	.60
2SC509	.30	.40	.45
2SC517	2.90	3.10	3.25
2SC535	.30	.35	.40
2SC620	.45	.50	.55
2SC632A	.35	.40	.45
2SC634A	.40	.45	.50
2SC697A	3.20	3.50	3.90
2SC710	.20	.27	.30
2SC711	.20	.27	.30
2SC712	.20	.27	.30
2SC717	.35	.40	.45
2SC730	2.95	3.15	3.35
2SC732	.20	.25	.30
2SC733	.20	.25	.30
2SC734	.20	.25	.30
2SC735	.20	.25	.30
2SC756	1.45	1.75	1.95
2SC756A	2.00	2.10	2.20
2SC778	2.80	3.10	3.30
2SC781	1.95	2.15	2.45
2SC784	.30	.35	.40
2SC789	.75	.85	.95
2SC793	1.95	2.15	2.45
2SC799	1.95	2.15	2.45
2SC828	.20	.27	.30
2SC829	.20	.27	.30
2SC839	.30	.35	.40
2SC867A	4.00	4.25	4.50
2SC900	.20	.27	.30
2SC930	.20	.27	.30
2SC945	.20	.27	.30
2SC1000BL	.35	.40	.45
2SC1013	.45	.60	.65
2SC1014	.50	.60	.65
2SC1018	.70	.75	.85
2SC1030	1.80	2.05	2.35
2SC1056	4.50	4.70	4.90
2SC1060	.65	.75	.85
2SC1061	.70	.80	.90
2SC1096	.45	.50	.55

	25-UP	10-24	1-9
2SC1114	3.40	3.60	3.80
2SC1116A	3.20	3.45	3.80
2SC1124	.80	.85	.95
2SC1127	.80	.85	.95
2SC1162	.70	.75	.85
2SC1166	.25	.35	.40
2SC11728	3.10	3.50	3.85
2SC1173	.50	.65	.70
2SC1177	10.90	12.40	13.80
2SC1209	.25	.35	.40
2SC1226	.50	.60	.70
2SC1226A	.50	.60	.70
2SC1237	1.70	1.90	2.15
2SC1239	2.10	2.65	2.85
2SC1306	1.25	1.65	1.85
2SC1307	2.15	2.65	2.85
2SC1318	.30	.40	.45
2SC1364	.30	.40	.45
2SC1383	.30	.40	.45
2SC1384	.30	.40	.45
2SC1424	2.75	2.85	2.95
2SC1448A	1.00	1.10	1.20
2SC1475	.65	.85	.95
2SC1509	.55	.60	.65
2SC1567A	.60	.65	.75
2SC1675	.25	.30	.35
2SC1678	1.25	1.40	1.55
2SC1687	.40	.45	.50
2SC1727	1.20	1.25	1.30
2SC1728	.90	.95	1.00
2SC1760	.85	1.00	1.10
2SC1775	.30	.35	.40
2SC1816	1.45	1.70	1.95
2SC1908	.25	.35	.40
2SC1909	2.00	2.55	2.75
2SC1945	4.40	4.90	5.50
2SC1957	.60	.70	.80
2SC1969	3.50	3.90	4.30
2SC1973	.60	.65	.70
2SC1974	1.25	1.65	1.85
2SC1975	1.25	1.65	1.85
2SC2009	.75	.80	.85
2SC2021	.55	.60	.65
2SC2028	.50	.60	.65
2SC2029	1.45	1.75	1.95

	25-UP	10-24	1-9
2SC2072	3.55	3.75	3.95
2SC2076	.45	.60	.65
2SC2091	.85	1.05	1.15
2SC2092	1.75	1.95	2.20
2SC2098	3.00	3.20	3.45
2SD72	.50	.60	.65
2SD91	1.30	1.40	1.55
2SD92	1.40	1.55	1.75
2SD180	1.55	1.75	1.95
2SD187	.30	.40	.45
2SD218	2.95	3.20	3.45
2SD234	.60	.70	.80
2SD235	.60	.70	.80
2SD261	.30	.35	.40
2SD287	2.50	2.65	2.85
2SD291	2.05	2.45	2.75
2SD313	.60	.65	.70
2SD315	.60	.70	.80
2SD325	.60	.65	.75
2SD330	.69	.79	.89
2SD356	.70	.75	.80
2SD358	.70	.80	.90
2SD359	.75	.85	.95
2SD427	1.75	1.95	2.20
2SD525	.70	1.05	1.15
2SD526	.60	.70	.80
2SK19	.45	.50	.55
2SK23	.80	.95	1.05
2SK30	.40	.45	.50
2SK33	.60	.65	.75
2SK34	.50	.55	.60
2SK41	.50	.55	.60
2SK55	.60	.65	.75
3SK22Y	1.60	1.70	1.80
3SK35	1.20	1.35	1.50
3SK37	1.70	2.00	2.30
3SK40	1.25	1.40	1.55
3SK41	1.25	1.40	1.55
3SK45	1.25	1.40	1.55
3SK48	3.30	3.40	3.70
3SK49	1.25	1.40	1.55
AN115	2.00	2.15	2.25
AN2140	1.55	1.65	1.85
AN228	4.10	4.30	4.50
AN239	4.10	4.30	4.80

	25-UP	10-24	1-9
AN247P	2.40	2.60	2.90
AN274	1.50	1.70	1.90
AN313	4.20	4.40	4.60
AN315	1.75	1.95	2.20
BA511A	1.70	1.90	2.15
BA521	1.85	2.05	2.35
HA1151	1.45	1.70	1.85
HA1156	1.60	1.75	1.95
HA1306W	1.90	2.10	2.40
HA1322	2.40	2.60	2.90
HA1339	2.45	2.65	2.95
HA1339A	2.45	2.65	2.95
LA1222	2.10	2.30	2.50
LA3101	3.45	3.60	3.75
LA4031P	1.75	1.95	2.20
LA4032P	1.75	1.95	2.20
LA4220	2.25	2.40	2.55
LA4400	1.85	2.05	2.35
LD3141	1.70	1.80	1.90
M5115P	4.85	4.90	4.95
M51513L	1.95	2.15	2.45
MN3001	13.20	14.85	16.50
MN3002	9.25	10.40	11.55
MN3003	5.64	6.34	7.04
PLL01A	4.00	4.15	4.55
PLL02A	4.95	5.20	5.80
PLL03A	7.50	7.90	8.70
SG264A	7.00	7.40	7.80
SG609	4.10	4.30	4.50
SG613	5.05	5.45	5.85
SM5104	7.90	8.40	8.90
STK011	3.55	3.95	4.35
STK013	8.90	10.00	11.10
STK015	4.10	4.30	4.80
STK050	23.10	25.98	28.86
STK415	7.10	7.60	8.10
STK435	4.45	4.95	5.55
STK439	8.00	9.00	10.00
TA7045M	1.95	2.15	2.45
TA7055P	1.95	2.15	2.45
TA7060P	.85	1.05	1.15
TA7061P	.85	1.05	1.15
TA7062P	1.05	1.20	1.35
TA7063P	1.25	1.35	1.50
TA7074P	3.70	3.85	4.00

	25-UP	10-24	1-9
TA7089P	1.95	2.15	2.45
TA7092	4.40	4.90	5.40
TA7120P	1.45	1.65	1.85
TA7139P	1.55	1.75	1.95
TA7153P	5.70	5.90	6.10
TA7203P	2.45	2.60	2.85
TA7204P	1.95	2.10	2.45
TA7205P	1.55	1.75	1.95
TA7214P	3.90	4.20	4.50
TA7310P	1.25	1.40	1.55
TA7607P	5.80	6.00	6.20
TA7609P	4.40	4.60	4.80
TBA8105H	1.85	2.05	2.35
TC5080P	4.80	5.00	5.60
TC5081P	2.90	3.10	3.30
TC5082P	3.30	3.45	3.80
UHIC001	4.90	5.10	5.60
UHIC002	4.90	5.10	5.60
UHIC003	4.90	5.10	5.60
UHIC004	4.90	5.10	5.60
UHIC005	4.90	5.10	5.60
UHIC006	4.90	5.10	5.60
UPC20C	2.00	2.40	2.70
UPC141C	2.30	2.40	2.50
UPC157A	3.25	3.45	3.65
UPC554C	1.60	1.70	1.80
UPC555H	1.60	1.70	1.80
UPC572C	3.70	4.10	3.69
UPC574C	.90	1.08	1.20
UPC575C2	1.25	1.40	1.55
UPC576	1.85	2.05	2.35
UPC592H2	.75	.85	.95
UPC1001H2	1.85	2.05	2.35
UPC1008C	4.85	5.15	5.75
UPC1020H	1.85	2.05	2.35
UPC1025	1.85	2.05	2.35
UPC1028	1.40	1.62	1.80
UPC1031H	2.52	2.74	2.98
UPC1032H	1.70	1.85	2.10
UPC1152H	2.90	3.10	3.30
UPC1156	1.85	2.05	2.35
UPD277C	8.70	8.90	9.10
UPD857C	7.90	8.30	9.40
UPD858C	7.00	7.10	7.20
UPD861C	8.70	8.90	9.10

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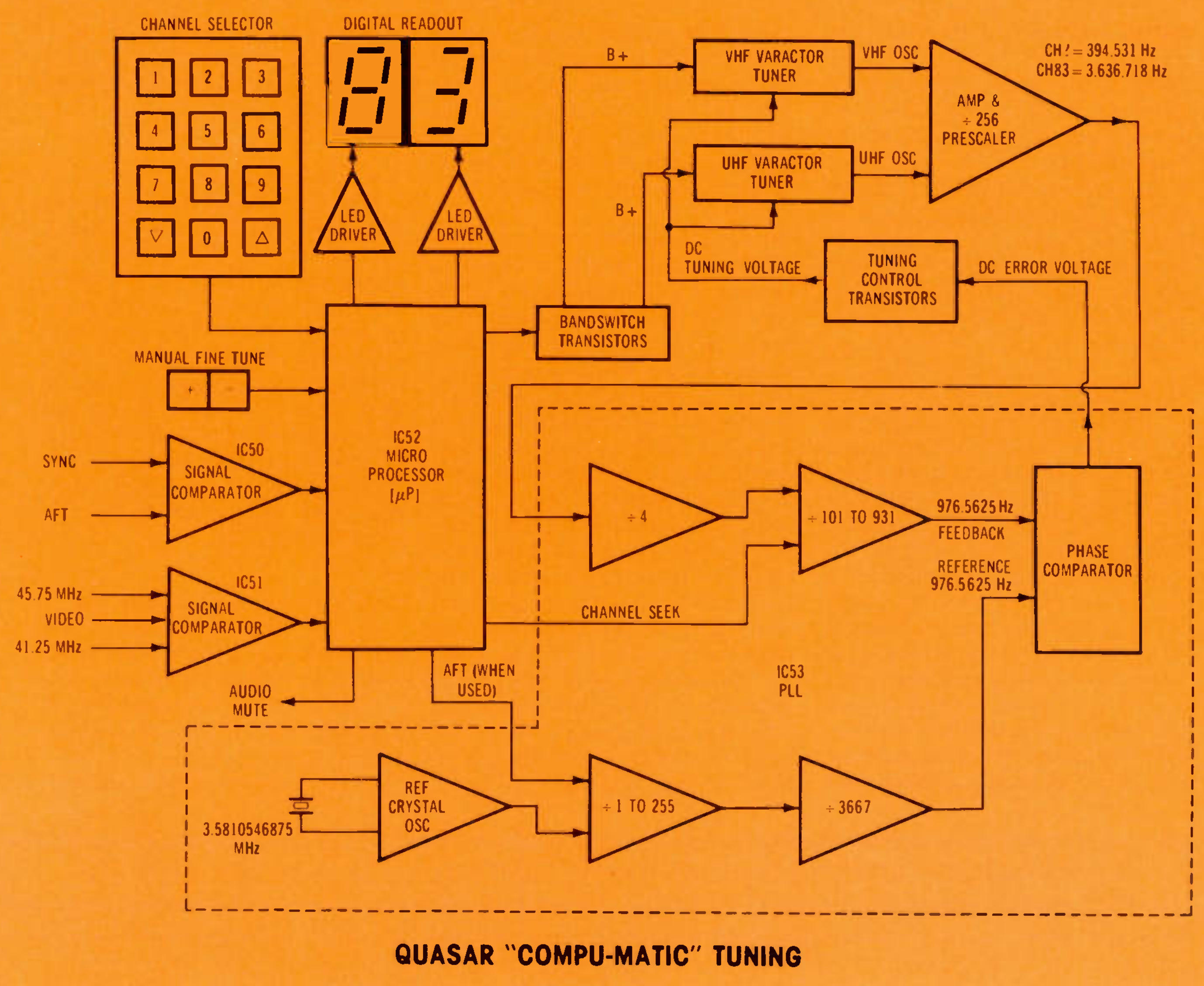


Figure 5 This is a block diagram of the Quasar Compu-Matic Touch Tuning system. *Any* TV channel can be obtained by pressing two front-panel buttons. Up or down channel search, manual fine tuning, and AFT control of non-standard frequencies can be selected, also. For the search modes, signal comparators monitor various station signals, so the sweep stops only at channels with a TV signal. The tuners are conventional varactor-tuned types, except for the oscillator samples brought out for use with the phase-locked loop. No memory or special setup is required.

Quasar Compu-Matic

PLL circuits, **the error voltage is better called tuning voltage, and it is (and must be) different for each frequency.** As a divider is reprogrammed for another ratio, the tuning voltage (formerly called error voltage) from the comparator changes to (and remains at) a new dc voltage. The usual range is between +2 and +30 V.

How much dc voltage?

The precise value of this tuning (error) voltage that controls the VCO frequency is *not very important!* The circuit will keep on trying until the *correct frequency* is obtained, regardless of the dc tuning voltage that's produced.

In other words, the dc error voltage is only incidental to the generating of the desired frequency through phase-lock with the reference frequency.

As stated before, the fundamental action of the PLL is to produce identical phase of the two frequencies at the phase-comparator inputs. The tuning (error) voltage merely is the tool for attaining that condition. So, the PLL output frequency (which is different from those at the comparator) is the result of the PLL working to "correct" the "wrong" frequency that's introduced by the programmable divider. This vaguely is comparable to an oyster producing a pearl to relieve the irritation caused by a sharp bit of sand.

Drift

Not only do PLLs generate the correct frequency that's needed, but all frequency drift is corrected also. Normal thermal frequency drift of the VCO and any moderate variation of the supply voltage for the tuning (error) voltage are corrected.

Therefore, no special precautions must be taken to provide precise voltage regulation of the tuning voltage.

Quasar Compu-Matic tuner control

Several models of the latest color TV receivers have PLLs at the heart of sophisticated tuner-control systems. This is true of Quasar models that incorporate the Compu-Matic circuit.

The name "Compu-Matic" seems to be made up from the two words "computer" and "automatic." This correctly suggests that the system has a computer (actually, a microprocessor) combined with some automatic means of tuning directly to any VHF and UHF TV channel.

Follow the block diagram in Figure 5, as the Compu-Matic features, functions, and components are discussed.

Developing the channel tuning

Varactor diodes in both tuners are controlled by tuning voltages from the PLL circuit in IC53. However, *the actual oscillator frequencies are monitored and adjusted by the PLL.* The method of obtaining correct oscillator frequencies is totally different from older methods of supplying a fixed DC voltage for each channel and relying on AFT to make corrections.

Both tuners are of conventional design, except the provisions for bringing out a sample of each oscillator frequency. The VHF tuner has two bands, and the UHF tuner has just one band. During station selection, the required band is selected by dc voltages from the microprocessor, and these are amplified to operate band-switching diodes inside the VHF tuner and external B+ switching transistors.

Phase-locked loop tuning

Although the microprocessor, sensors and optional remote control circuits add features and conveniences, **the PLL circuit of IC53 is the heart of the Quasar tuning system.**

As shown in Figure 5, IC53 contains the phase comparator, two fixed frequency dividers, and two programmable dividers. For most functions, both inputs of the comparator must have 976.5625 Hz. This is supplied to the reference input from the 3.5810546875 MHz crystal oscillator and the ÷3667 divider (the programmable 1-to-255 divider is used only for manual fine tuning and for cable TV or video games that do not have correct frequencies).

One difference from other PLLs is that **the VCO is the VHF oscillator or the UHF oscillator,** depending on which is in operation.

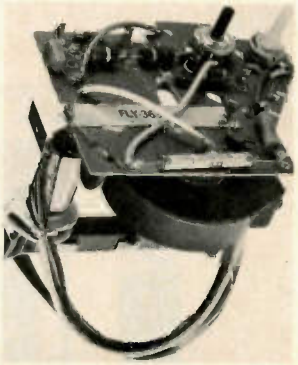
Loop frequencies

It's possible to start with 101 MHz, the correct oscillator frequency for Channel 2, dividing through the ÷256 prescaler and the ÷101 programmable divider, before finally obtaining 976.5625 Hz at the feedback input of the phase comparator. I tried it on the calculator, and the frequencies were correct. But, **that's starting with the end product** and such reverse thinking only can confuse the true PLL operation.

Instead, do the calculations by

I wish I had nothing to do but look at a TV set all day!

To Be More Than Exact . . .



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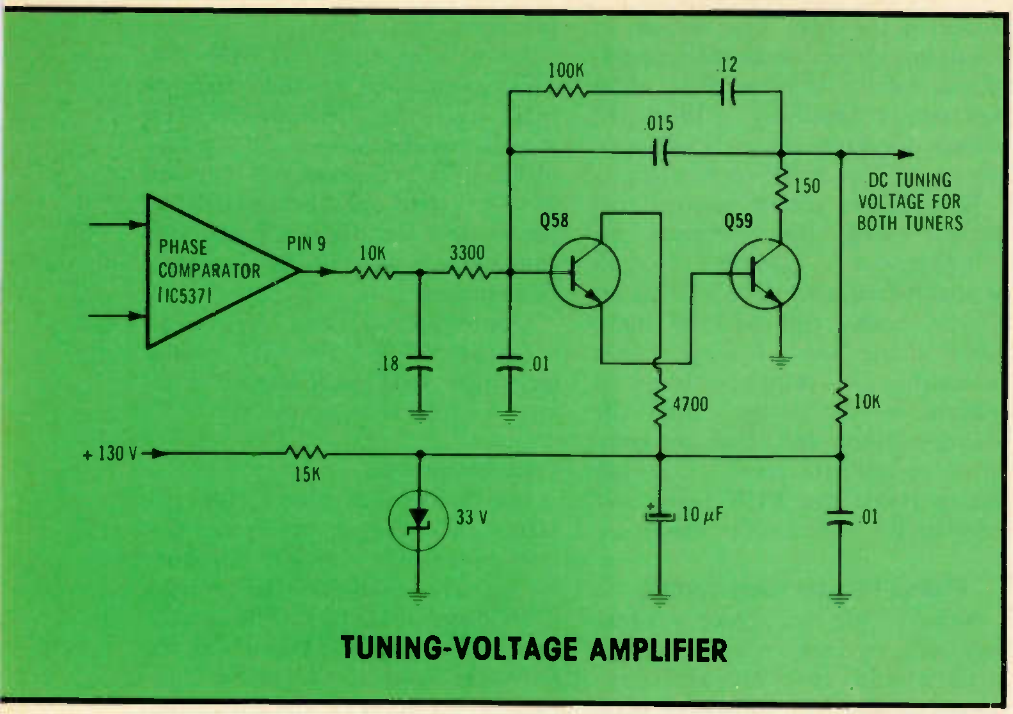
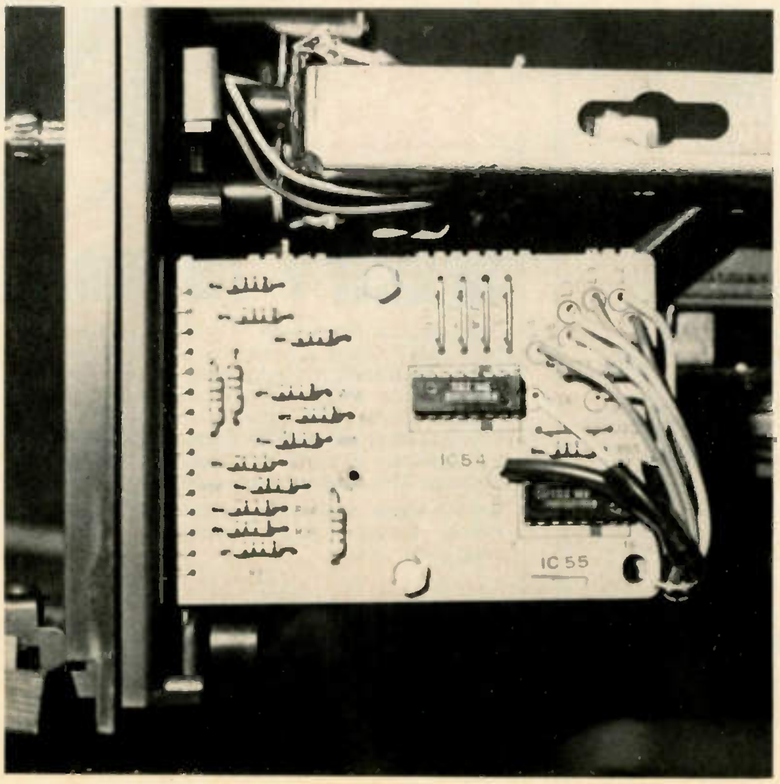


Figure 6 Variable dc pulses from the phase comparator in the PLL IC53 are filtered by the 10K/.18 and the 3300/.01 time-constant networks. The pure dc that results is amplified by Q58 and Q59, thus applying a tuning voltage (that varies between about +2V and +20V) to the two tuners. Extreme stability is not required, since **the system locks according to frequency,** and not from a specified dc voltage.

IC and other components of the decoder/driver circuits are mounted at the chassis top near the LED readouts.



starting with the 3.5810546875 MHz reference crystal oscillator, and dividing by 3667 for the second divider (the first programmable divider is set for ÷1, at this time).

Then, beginning with the 976.5625 Hz phase-comparator feedback frequency, multiply by 101 (the feedback programmable-divider ratio for Channel 2), multiply by 4 (for the ÷4 divider), and multiply again by 256 for the prescaler. A calculator will show the Channel 2 oscillator frequency as 100.999997 MHz. (Of course, this would be 101 MHz, if the calculations had used more decimal places at each stage.) The same method can be used for all other channels, changing only the divide-by number of the feedback programmable divider.

Did you notice that the Channel 2 divide-by number of the feedback programmable divider was the same as the oscillator frequency in megahertz? Well, it wasn't an accident. Quasar has worked out the frequencies so this is true of *all* channels. For example, Channel 83 has an oscillator frequency of 931 MHz, and the feedback divider must be programmed for 931.

Incidentally, the 1-to-255 divider is used only for manual fine tuning or for signals (such as video games or some cable channels) that don't use the exact broadcast frequencies. Each position changes the channel frequency by 976 Hz. When two dividers are used, multiply the divide-by numbers together to obtain the total division.

Tuning voltages

The PLL error dc-pulses voltage comes out of IC53 at pin 9, but it does not directly supply the tuning voltage for the two tuners. Instead, the two transistors of Figure 6 control a sample of voltage from the +33 V zener-regulated power source.

Controlling by microprocessor

Manual adjustment of external switches *could* have been used to program the dividers in the IC53 PLL, and thus produce accurate and drift-free oscillator frequencies for each channel. However, Quasar has added a microprocessor IC to control many of the tuning functions.

In addition to decoding signals from the direct-access keyboard and supplying BCD signals and multiplexing for the LED-readout decoder and the PLL dividers, the microprocessor (IC52) also controls the bandswitching transistors for the tuners.

Other control functions include manual fine tuning; channel seeking, either up or down; and AFT, when needed.

Special comparators accept sync, AFT, 45.75 MHz picture carrier, 41.25 MHz sound carrier and video. When these sensor comparators prove a TV station is tuned in, the microprocessor removes the audio muting, and allows the up or down seeking to stop (when that feature is used).

To tune in regular TV stations, it is necessary only to **push two keyboard buttons** in the proper sequence. For example, buttons 0 and 4 tune in Channel 4.

The tuner-control system does not require any programming and battery memory power is not needed. All 83 channels can be selected in any sequence.

Incidentally, the PLL IC has 1,153 transistors, and the microprocessor IC contains 11,029 transistors. Therefore, functions are explained rather than analyzing the internal IC circuits.

Troubleshooting the Compu-Matic

Repairing the Quasar Compu-Matic system should not be very difficult after you become familiar with the system and the physical layout.

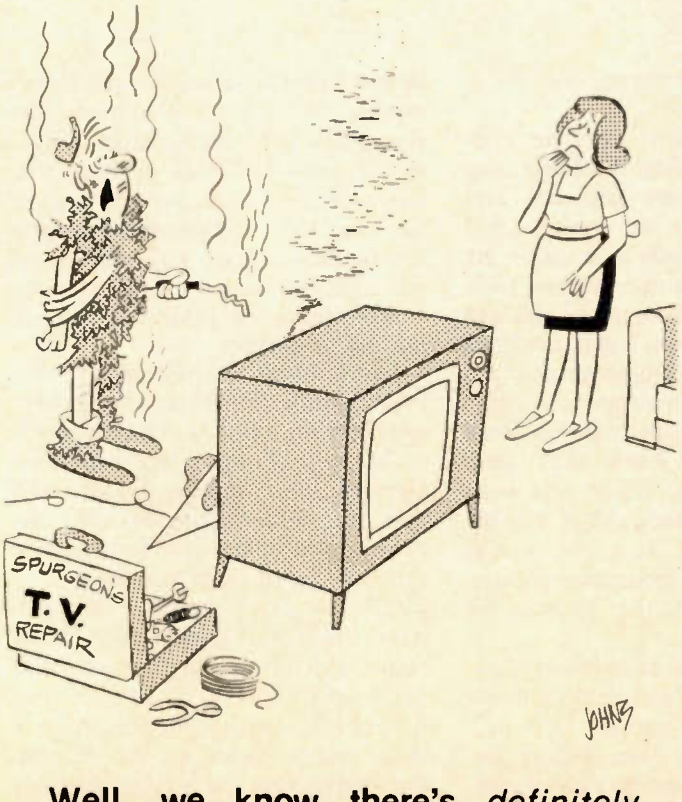
For example, you can use a frequency counter at the output of the prescaler. The frequency there should be the channel picture-carrier frequency plus 45.75 MHz divided by 256. Channel 2 has a picture carrier of 55.25 MHz. Add this to 45.75 MHz, which yields 101 MHz, and divide by 256 giving 394,531 Hz. If some channels have correct frequency, but others don't, probably the feedback programmable divider is bad.

If the VHF tuner works okay, but the UHF is dead, check first to see whether or not B+ is being fed from the bandswitching transistors to the UHF tuner. Otherwise, the trouble either is in the bandswitching circuitry or is in the microprocessor. Dc-voltage checks should locate the defect quickly. However, if B+ is reaching the UHF tuner, then the tuner itself must be dead.

Either the UHF or the VHF tuner can be replaced, if necessary. And the prescaler comes out as a unit. The control board (including the microprocessor, the PLL circuit, and most of the other tuner-control circuits) is available as a complete replacement unit at a price that is lower than the replacement of individual chips alone.

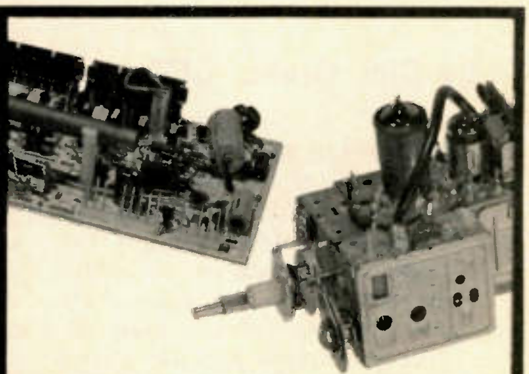
As shown in one of the pictures, the digital LED readout and driver decoder ICs can be replaced as a unit.

With logical troubleshooting and the several options for replacement parts that are available, you should not have many unusual problems when servicing the Quasar Compu-Matic tuner-control system. □



Well, we know there's *definitely* nothing wrong with your high-voltage transformer.

TUNERS•MODULES



The next time you need a tuner repaired or module rebuilt:

Remember
FAST SERVICE
Remember
PROFESSIONAL QUALITY
Remember
ONE-YEAR LIMITED WARRANTY
Remember
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PTS ELECTRONICS, INC.

SEE THE YELLOW PAGES FOR THE PTS SERVICENTER LOCATION NEAREST YOU

Circle (15) on Reply Card

Analyzing True Costs

Service Management Seminar, Part 12

By Dick Glass, CET

Evolution of your accounting

Thousands of servicers have discovered to their dismay that technical electronics ability alone is not enough to produce a successful repair business. In fact, *many sharp technicians have failed in business.*

To a well-trained tech who enjoys finding and repairing the causes of electronic defects, it seems reasonable that his reward of an abundant income will follow automatically, as he becomes faster through experience, and his competence becomes well known to his potential customers.

At first, the plan appears to work. His shop becomes very busy, perhaps having more work than he can finish. But his 60 or 70 hours of work per week seem to bring in only enough for mere existence.

He wonders what is wrong. *Perhaps he should hire an accountant to keep his books in order.* That would give him more hours to do extra repairs. And, after all, he much prefers electronics over keeping books.

The bookkeeping firm he contacted was helpful, by explaining why he must keep accurate and adequate records of income and disbursements. Their accountant set up a system for him to record each day's business transactions, fill out payroll information, keep track of inventory and equipment, and account for his own draw of money. Although these steps required some time to do, he knew they were necessary. Also, his mind was relieved of all worry about trouble from the IRS. Now, he could concentrate on technical repairs, and finally earn the amount of money he needed.

However, as the months went by, his profits still lagged behind. What could possibly be wrong?

If this typical case history describes your situation accurately, then read on. There's hope for you.

Always remember this statement: **Accurate bookkeeping for tax purposes is not enough to give you proper financial-management information.** Most small electronic service shops have adequate tax information—the IRS sees to that. But, few have good *management* data of the kind that can prove where you are making money and where you are suffering losses.

Here are a few possible results of this bad situation:

- Some shop managers receive their annual business tax reports which show either a meager profit or a loss. Instead of becoming alarmed, they assume (incorrectly) that the accountants have somehow hidden part of the real profits, and shrewdly saved them tax money.
- Others receive monthly or quarterly Profit-And-Loss (P&L) statements which have varying costs and net-profit figures. These varying figures make little sense. Perhaps a shop owner looks at the bottom line, but takes no action because the percentages appear unreliable (even though he assumes that the accounting system has made them technically correct).

DICK'S TV SERVICE, INC.
PROFIT AND LOSS STATEMENT
FOR QUARTER ENDING 9-30-78

INCOME			
Parts	$8624		
Labor	5254	$13878	100
COST OF SALES		5143	37
GROSS PROFIT		8735	63
OPERATING EXPENSES:			
Advertising	223		2
Amortization & Depreciation	102		1
Auto Expenses	229		2
Maintenance & Repair	195		2
Dues & Subscriptions	...		...
Insurance	180		1
Legal and Professional	100		1
Office Expense	97		0
Rent	900		6
Salaries	1018		7
Taxes	352		2
Telephone	653		5
Utilities	213		2
TOTAL EXPENSES		4262	31*
NET PROFIT		4473	32
RETAINED EARNINGS— Beginning of Year		1008	
Less: Dividends		(900)	
RETAINED EARNINGS— End of Period		$ 4581	

*Fractions have been omitted, so expenses do not add to 31%.

Figure 1 This is a typical Profit-And-Loss statement, as produced by a CPA or an accountant.

- Parts sales, parts costs, merchandise sales and merchandise costs are all combined, thus preventing any identification of the relative profitability of these various segments. There is no opportunity to reduce or eliminate a low-profit category of business, or to take advantage of another that's highly profitable.
- The owner's salary might or might not be included in the costs. If it isn't, the profit picture looks fine. If it is, the business probably is showing a net loss.

Service management

Analysis of true costs

To solve this real problem, you must be able to read and to *understand* your financial reports. For example, you must know these facts:

- the percentage of your parts cost relative to the selling prices;
- your cost of labor, including your own time when you do repair work.
- the value of other items, which are not included on your financial records. These include the value of rent for your own building where the shop is located; depreciation, which is not figured except at tax time; and the value of work performed by any unpaid employees, such as your wife.

Rework your P&L

You should take your P&L and pencil in some revisions based both on facts and on your knowledge and intuition. This can produce a monthly "true costs" analysis which gives you a more realistic picture of your business, and one you can understand easily.

Add all of the real costs—as you know them to be—and discount any unusual income or expense items which occasionally distort the P&L. Then, you will have the facts needed to establish proper prices, or to head off problems before they become more severe.

Information from CPA

Figure 1 is a close representation of a typical quarterly P&L given by a CPA firm to a service shop. From this P&L statement, try to calculate the parts costs, the labor costs, and whether or not the owner made a profit.

Quiz of the P&L

Fill in your answers to the following quiz, marking "T" for true and "F" for false in each space:

(1)__________Percentage of parts cost is 37%.

(2)__________Owner drew $300 per month as his salary.

(3)__________A part-time technician and a clerk (wife) *together* drew about $340 per month in salary.

(4)__________This firm had no "product" sales, such as TVs, radios, etc.

(5)__________If business retains the same level, the firm could expect to increase its NET WORTH (retained earnings) by more than $12,000 during the remainder of the year.

(6)__________The 32% NET PROFIT shown here is an unusually high return for a service business.

(7)__________The taxes shown under "operating expenses" are primarily sales taxes.

(8) __________ Compared to other types of businesses, the 63% gross profit is excellent.

(9)__________Labor costs were approximately 20%; an excellent percentage.

(10)__________Although the parts gross profit should be improved, the overall operation appears to be profitable and very efficient.

Quiz answers

Check the answers you gave against these. If you have half (or more) correct, you are very good at analyzing P&L statements.

(1) FALSE Parts costs should be shown as a percentage of PARTS SALES, not TOTAL SALES, as given in Figure 1. If the accountant has not included some merchandise sales and costs in the figures, the parts cost percentage is 59%. If he has included other items, no one can know what the true parts cost is.

(2) TRUE The owner drew only $300 per month, totalling $900 for the quarter, and it was shown as dividends.

(3) TRUE Salary for the technician is included under OPERATING EXPENSES, and not under COST OF SALES. The total was $1018, and the clerk was unpaid.

(4) TRUE According to the P&L, the firm had no product sales. Actually, about 10% of sales was of products, but parts and merchandise sales were lumped together to make the accounting easier.

(5) FALSE The P&L misleads you into believing the statement. But, when figured by true-cost analysis, the $4443 quarterly net profit is found to be a NET LOSS for the year.

(6) FALSE The 32% NET PROFIT is wrong, Probably the 32% will tend to soothe the owner into believing he is doing fine, when the business actually is nearing bankruptcy.

(7) TRUE Sales of more than $8000 in PARTS (and merchandise) would require more than $300 (at 4%) in sales taxes. The remaining taxes might be withholding, unemployment or some other taxes; it's not clear.

(8) TRUE If it were a true figure, the 63% GROSS PROFIT would be very outstanding. Unfortunately, in service businesses, the COST OF SALES must include the costs of getting the repair work done. This is not included in Figure 1, resulting in a false and misleadingly high GROSS PROFIT, which fooled the owner, while being satisfactory to the IRS.

(9) FALSE In the Figure 1 P&L, the labor costs don't include the major producer of labor income in this business, the technician/owner. There is no practical way of reducing labor costs to 20%. For proper analysis of costs and prices, the true cost of labor should include an *equivalent* salary for the owner/technician. At the $300 monthly rate of draw, the salary would have been $3600 per year. But, he would have had to pay a technician about $6 per hour to do the same work. So the salary equivalent should have been more than $12,000 per year.

(10) FALSE It appears from the P&L that the business is sound and solvent. Actually, it suffered a net loss for the year, even after paying the owner a very low salary and paying nothing to the clerk. Both parts and labor prices must be raised drastically, to cover all costs and to produce a reasonable income for the owner.

Change the P&L for "true-cost" analysis

To demonstrate the recommended analysis, we'll begin with the Figure 1 P&L, then amend the figures so they display the real costs. The "true-cost" analysis is shown in Figure 2, and it includes some letters that are tied to the following conclusions:

(A) The $6 per hour is what the owner/technician *should* have been paid, but wasn't. Some might

DICK'S TV SERVICE, INC.
TRUE-COST ANALYSIS
FOR QUARTER ENDING 9-30-78

TOTAL SALES		$13878
COST OF SALES		
Parts sales	8324	
Parts costs	5143 (59%)	
Parts gross profit	3481	
Labor sales	5254	
(C) Direct labor salaries	1018	
Labor payroll expense. W/H etc.	120	
(A) OWNER'S wages (if paid) for 600 hrs. at $6 pr. hr. plus 10% benefits	3960	
Labor gross profit	156	
Sales tax col.	300	
Sales tax pd.	260	
+ or - sls. tax	+40	
ESTIMATED DIRECT COSTS		10501
GROSS PROFIT		3377
OVERHEAD EXPENSES		
Actual overhead	4262	
Less items included in cost-of-sales	1318	
(B) Add clerical salary for 400 hrs at $3	1200	
(D) Shift $300 from telephone exp. to advertising expense	...	
TRUE-COST OVERHEAD EXPENSES		4144
(E) NET PROFIT		(767) loss

Figure 2 The P&L, after additions and changes, becomes a "true-cost" analysis, which shows the real condition of the business.

believe the $900 draw (as dividends) should be subtracted from the (A) figure, but we will consider the $900 as a return-on-investment, and not part of the owner's wages.

(B) We have listed the clerk's salary at only $3 per hour. While some clerks can be obtained for the minimum wage, dedicated ones (such as family members) should receive more.

(C) Probably the technician only works part time. However, if the tech is understood to be underpaid, you should (in a true-cost analysis) include an additional "insufficiency" expense to value the employee's contribution properly.

(D) If it is to properly express this business cost, the advertising expense should include costs of "Yellow Pages" ads, which account for the major portion of most phone bills. Many accountants merely lump them together. Both are legitimate deductions, so the IRS doesn't care.

It's not easy to be precise about assigning parts and merchandise costs to the proper month, since invoices from distributors traditionally are paid 30 days or more later. Therefore, the owner should use adjusted amounts, based on his knowledge of parts sales and purchases, and movements of the merchandise.

(E) To correct the inadequate profits problem used in this example, the owner needs to begin the remedy by recognizing that his labor costs are disastrously high compared to the income from labor. He must raise the prices and attempt to produce income of at least twice as much as his "true-cost" total labor costs.

Comments

Try making a "true-costs" analysis of YOUR business. It will give a true picture of your business health and allow you to make decisions that are based on fact—not fiction.

This is the last article of the Service Management Seminar series. If you have suggestions about other business areas that should be covered, write to the editor. Or, write to Dick Glass (Dick Glass and Associates, 7046 Doris Drive, Indianapolis, Indiana 46224), if you have individual questions. □

Vertical Troubleshooting

Servicing GE 13" color TV, part 4

By Gill Grieshaber, CET

Vertical troubleshooting methods

Traditionally, the first step of vertical-sweep troubleshooting is a careful examination of the raster. This should be done also for the General Electric AA-D chassis. Notice how much height (if any) there is, and any non-linearity. Later we'll show some raster symptoms that result from specific component failures.

A stable crosshatch pattern is recommended highly for this visual analysis. Of course, an experienced technician can estimate the vertical linearity by checking the spacing of all scanning lines. But a crosshatch pattern reduces the diagnosis time while providing better accuracy. A helpful feature of some generators (such as the American Technology ATC-10 used here for our picture symptoms) is identification of the center and each corner of the crosshatch pattern. This is especially valuable with solid-state vertical circuits, where defects can move the picture up or down—and sometimes completely off of the screen! With the AA-D chassis, for example, one wrong diagnosis might be, "Lack of height at the bottom," when the defect has only moved the normal-height picture upward by several inches.

HV or vertical?

One type of vertical problem might seem to be a horizontal-sweep/HV defect. Any trouble that biases either output transistor into full conduction can load down the horizontal sweep. In turn, the horizontal overload can ruin sweep components there or blow the 1-amp fuse.

Therefore, one of the steps for troubleshooting horizontal overloads is to unplug both vertical-output transistors. If this relieves the horizontal overload, the vertical sweep is at fault.

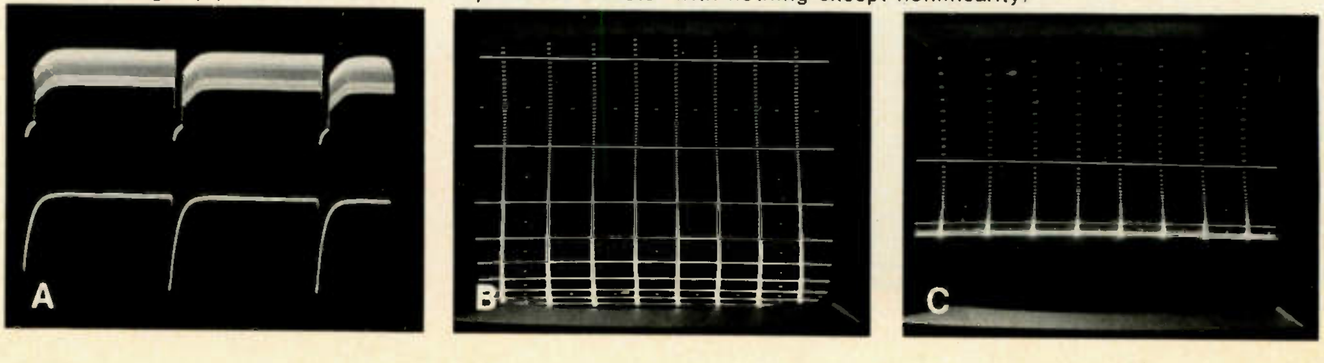
A collector-to-emitter short in Q640 (see Figure 3A of last month) grounds the +13.8 V supply through the yoke coils. Similarly, the -12.8 V supply is overloaded if Q645 shorts.

If unplugging the two vertical-output transistors eliminates the horizontal overload, all of the plug-in transistors should be removed (one at a time) for testing. Replace any bad ones, and try the set again.

DC-voltage tests

Measurement and analysis of dc voltages in the vertical system is one of the standard steps. But don't begin by checking dc voltages a

Figure 1 An open Y610 diode eliminates all vertical sweep, and leakages cause serious height and linearity problems. (A) Top trace of this scope picture shows the sweep-output waveform, while the bottom trace shows the Y610 waveform, when Y610 is shorted. (B) The raster is expanded at the top and compressed at the bottom when Y610 has about 7K of internal leakage. (C) A shorted Y610 diode produces a raster with nothing except nonlinearity.



and Sync Separation

Vertical-sweep symptoms and troubleshooting methods are described. Also, special waveforms are used to explain the true operation of the noise-cancellation and sync-separation circuits.

random. You'll succeed only in wasting time.

Three quick measurements will prove whether or not the defect can be found by dc-voltage analysis. First, check for +13.8 V at the cathode of diode Y946 (see location last month), and for -12.8 V at the anode of diode Y942. Obviously, correct vertical sweep can't be obtained without these essential supply voltages.

Then, measure for a dc voltage at the output of the vertical sweep. The cathode of Y635 is a convenient test point. If the dc reading is more than one volt of either polarity, there is a good chance the vertical sweep has a defect. Higher voltages indicate a more-serious defect. In such cases, further dc voltage tests are called for.

If the dc voltage at the output is less than one volt, **any further dc voltage tests probably will be useless** (the voltages are right, already). But one more test should be done. Use your scope to see if a waveform is at the output, and if so, how it is different from the correct one. An open yoke (or other open in that circuit) will not upset the dc voltages very much, but the output will have large square waves. This will be discussed again.

Analysis by scope

An analysis of scope waveforms often is essential for finding vertical problems. Waveform analysis is much easier in the AA-D chassis because the oscillator stage can function correctly, even when the following three stages are dead.

First, scope for the sawtooth waveform that is expected at the junction of C615 and Y615. If there is one and it has normal amplitude, good linearity, and the correct 59.94-Hz frequency, then the entire oscillator stage is okay. It needs no further dc-voltage or scope tests.

If any of these characteristics is wrong, there's a problem in the oscillator stage.

After the oscillator is repaired—or is proven to be okay—then use your scope to search each of the following stages for *some kind* of waveform. All three stages which follow the oscillator amplify either voltage or power. So, a bad stage usually shows a signal at the input, but none at the output or in any stage behind it.

Of course, **if any of the three stages is dead, the waveforms will be abnormal in all three.** Without yoke current, there's no negative feedback to reduce and control the gain. Without feedback, the excessive gain will overload any normal stage and distort the waveform there. *That's why you should look (at first) for any kind of signal*

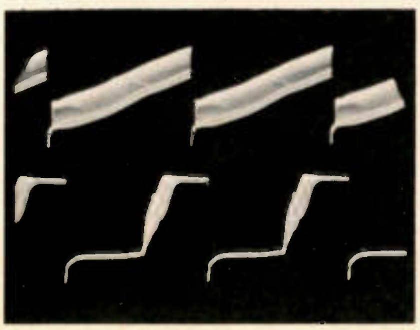


Figure 2 A shorted R641 resistor or an open C640 remove all negative feedback, giving excessive height and widely-spread scanning lines. Top scope trace shows the normal vertical output waveform, and the bottom trace is the waveform with R641 shorted.

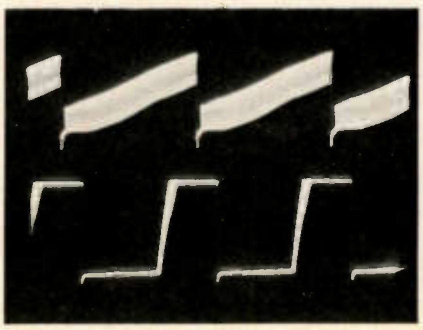


Figure 3 An open yoke eliminates all vertical deflection, and gives an output waveform similar to the one in Figure 2. The normal output waveform is shown by the top trace, and the bottom trace output square waves are produced by an open vertical-yoke coil.

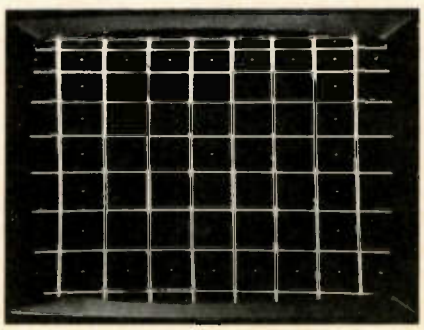


Figure 4 Reduced resistance value of R643 causes expansion at the bottom and compression of sweep at the top of the raster.

without expecting correct waveforms. All stages must operate right, before the waveforms will be normal.

Symptoms from defective parts

Here are a few symptoms caused by component defects, as they appear either on the TV raster or in scope waveforms.

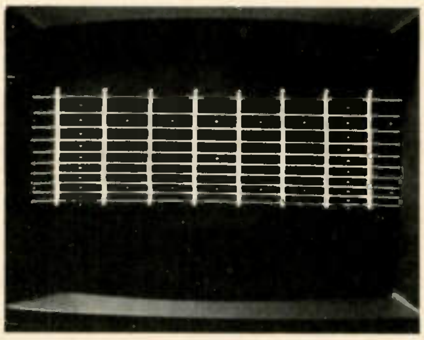


Figure 5 Leakage in C610 reduces the height. The crosshatch picture shows the effect of 500-K leakage.

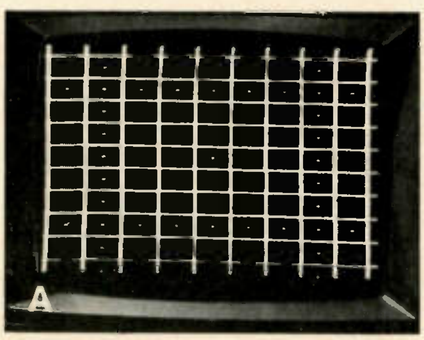
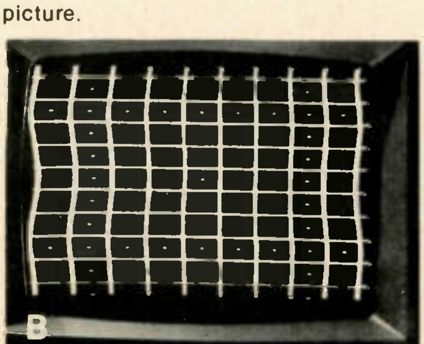


Figure 6 Reduction of the +147-volt main supply causes the picture to be small on all sides. (A) Line voltage of only 95 volts reduced the picture size, but caused no other problem. (B) An open C910 first filter capacitor also reduced the B+ voltage and the picture size. In addition, the resulting 120-Hz hum produced bending of the picture.



When diode Y615 shorts, there is no vertical sweep. However, a shorted Y620 causes little change. The slight center compression is corrected by negative feedback.

If Y610 shorts, there is no height below a horizontal line located about 3 inches from the bottom of the screen, and the scanning lines above the white line are spaced wide apart (see Figure 1).

Reduced values of R641 increase the height and degrade the linearity, but a shorted R641 eliminates *all* negative feedback, causes overload of the output stage, and spreads the scanning lines far apart. Also, look at the scope waveform (in Figure 2) of the output signal to the yoke. Figure 3 shows a similar square-wave output signal when the yoke circuit is open.

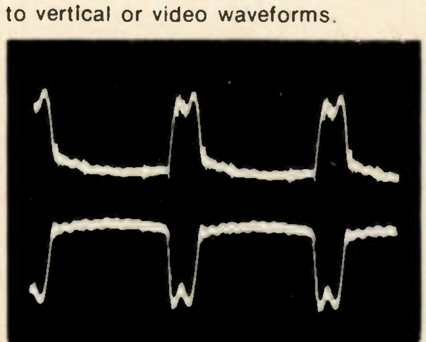
If the value of R643 and R644 in parallel is less than 100 ohms, the top of the picture is compressed, while the bottom of the sweep is expanded (see Figure 4).

Leakage in C610 (the sawtooth-producing capacitor) reduces the scan more at the bottom than at the top. Figure 5 shows the effect of a C610 leakage of 500 kΩ.

These previous defects changed both height and linearity, or they changed the linearity more than the height. Other kinds of problems change the height without disturbing the linearity. The negative feedback helps prevent linearity changes, in those cases.

For example, any variation of the R612 or R611 resistances will change the height in proportion, without degrading the linearity. Any reduction of the +147 V supply reduces the total height. The first raster picture in Figure 6 shows the effect of a 95 Vac power. An open C910 (first power-supply capacitor) also produces a small picture without linearity problems, but the vertical lines are bent by the resulting 120-Hz hum (Figure 6).

Figure 7 These 0.25 VPP horizontal waveforms were found at two GROUNDS on the chassis. Therefore, careless connection of scope grounds to some points of the chassis and circuit board will add horizontal pulses to vertical or video waveforms.



Tips

I wasted several photographs that unexpectedly had excessive amounts of horizontal sweep mixed with the desired waveforms. At first I suspected capacitive pickup of horizontal sweep by the shielded scope cable and probe. I moved the scope probes farther away from the horizontal end of the TV. There was no change. Finally, I remembered the low amplitudes of signals in all solid-state sets and wondered about sweep pickup from common grounds.

In audio amplifiers, a section of the ground system can have a voltage drop across it either from raw 60-Hz current or from 120-Hz filtering current of the power supply. If this same ground path also has audio signals flowing through it, the ac voltage drop of the hum current is added to the audio signal, thus causing hum mixed with the music. *No amount of shielding or B+ filtering can remove this type of hum.* The action is called "common-ground coupling."

So it was in this case. But instead of hum currents, some **horizontal sweep flowing through the various grounds was being introduced into the scope waveforms.**

For example, the horizontal pulses of Figure 7 were obtained from two *grounds* on the TV. The scope ground lead was connected to a ground near the *center* of the TV module, one probe was slipped to a *ground* near the horizontal transistor, and the other probe was clipped to the *grounded* VHF-tuner frame. The result was dual-trace horizontal waveforms of 0.25 VPP each.

Therefore, when I clipped the scope ground near the horizontal-output transistor, I had unknowingly added 0.25 V of horizontal pulses to each vertical waveform. Since some of these waveforms were as low as 1 VPP and 1.7 VPP, the added sweep pulses distorted the true waveforms.

Minimize such unwanted signals by grounding your scope as near as possible to the circuit you are scoping. Also, use the scope ground that's at the end of the probe (if your scope has one). Without these simple precautions, some video and vertical waveforms will have horizontal sections of the waveshape thickened by horizontal pulses brought in through common grounds.

And, speaking of grounds, when the TV is plugged into line power, *don't* attempt to solder anything on the AA chassis by using one of the new soldering irons that has a third-wire ground. Even if the power switch is off, sparks can fly, and fuses can blow—along with other components. I'm *not* going to tell you how I learned this important lesson!

Vertical comments

Troubleshooting the vertical-sweep circuit in a General Electric AA chassis should not be very difficult. Space is a bit cramped. But the large module can be released and slid back several inches, thus giving more room for meter and scope probes during measurements.

All vertical transistors (except the two oscillators) plug into sockets, making removal and testing easy. Both output transistors are mounted on a metal panel beside the module (see last month), and their sockets are connected to the module by long wires. So, a fast test to locate a bad transistor can be made without dismounting the transistor if you pull off the socket and plug the new one into the socket. Of course, the socket and test transistor are free to move and have no heat sink, so don't operate very long with them in this temporary condition. The extra heat might ruin the test transistor.

Stable frequency

Very few defects can change the vertical frequency enough to prevent locking. None of the misadjustments or simulated defects described before changed the frequency or locking. For example, the height control can be rotated from end to end while the locking remains rock-solid. This is a large advantage during troubleshooting. By contrast, think of the old tube receivers where *moderate* adjustments of either height or linearity controls would upset the locking, and any *large* change of height or linearity (from a defect) would drive the frequency beyond the ability of the hold control to restore it.

Vertical convergence

In Figure 8, the assembly that resembles a conventional convergence yoke is not one. It's use will be given later. Instead, correction signals from the simplified convergence board (pictured in the September issue) are sent to a special winding that's buried out of sight with the usual vertical and horizontal sweep coils in the deflection yoke.

However, for those rare cases where the vertical lines won't quite converge dynamically, GE has provided an extra vertical convergence-coil assembly (Figure 8). Although it has the center-convergence adjustable magnets and the appearance of convergence yokes used with delta-gun picture tubes, the purpose is different. By means of four fixed lugs (see the schematic in Figure 9) and two wires with insulated clips, current from the vertical deflection yoke can be directed through either or both of the windings that are inside this extra convergence assembly. Seven different connections are possible

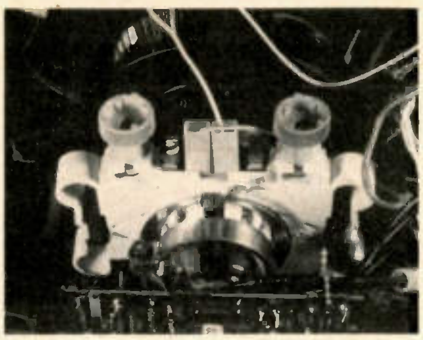


Figure 8 This is not the usual convergence yoke, although it does have the centering magnets. Connectors and terminals permit adding *more* vertical-convergence correction.

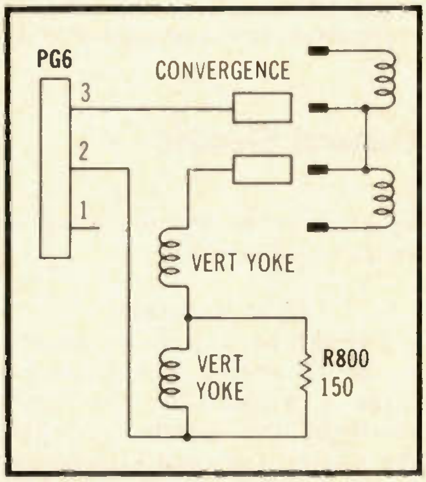
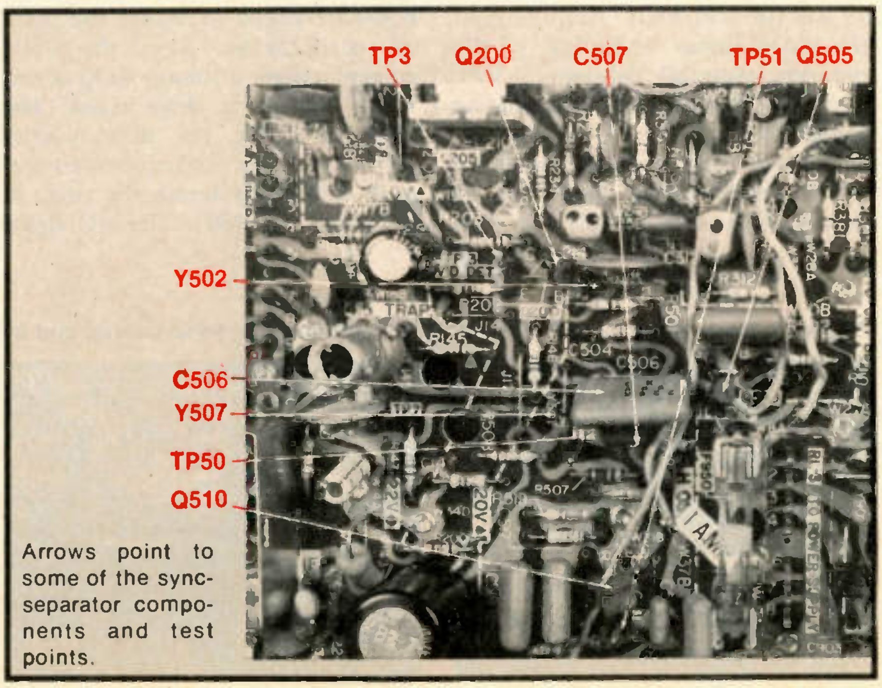


Figure 9 This is the schematic of coils that add more "amplitude" correction to the vertical dynamic convergence. (A coil inside the deflection yoke performs conventional convergence.)



Arrows point to some of the sync-separator components and test points.

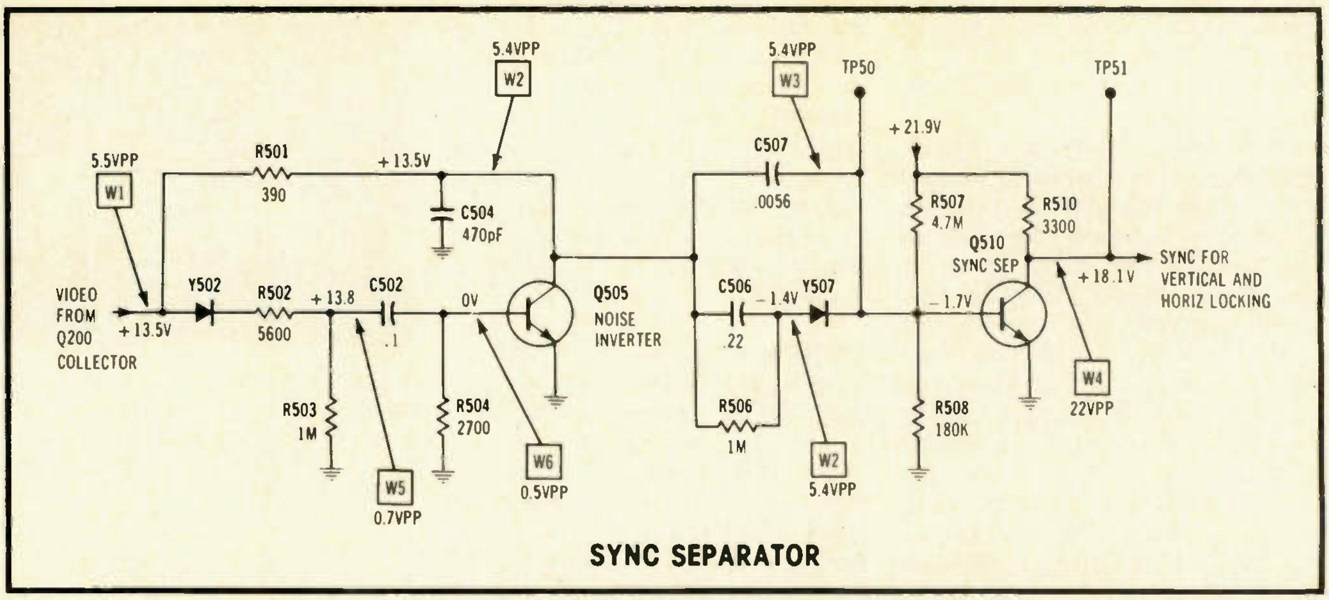


Figure 10 The noise-inverter and sync-separation functions are conventional. However, you should refer to the next two illustrations for special waveforms that explain the operation more clearly.

General Electric

by attaching the clips to the lugs in various combinations.

Sync Separator

The next basic circuit for analysis is the IF system. But that's too large a project for the space remaining this month. Therefore, the noise-inverter and sync-separator stages will be examined now.

Noise-inverter operation

Positive-going video goes through the noise-inverter stage before it is sent to the sync separator. Figure 10 has the schematic. Amplitude of the video varies according to the program material between 5 VPP and 6 VPP (see the waveforms in Figure 11).

Resistor R501 isolates the input of the noise-inverter stage from its output, while also providing a path through to the sync separator for the video signal after noise cancellation.

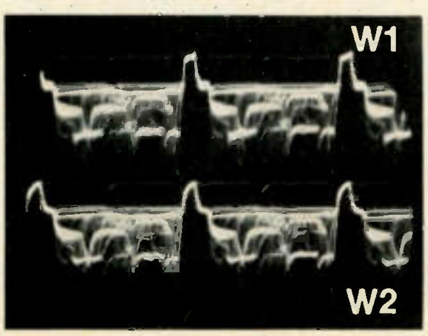
Diode Y502 rectifies the incoming video, in a circuit that *appears* to be a half-wave type. However, C502 functions *somewhat* as the peak-reading first filter capacitor for the horizontal-sync pulses. Actually, the truth is in between those extremes. Half-wave rectification would allow too much of the blanking pulses and video information to come through. But true peak-reading operation would not leave enough ripple. Alone, neither type is sufficient.

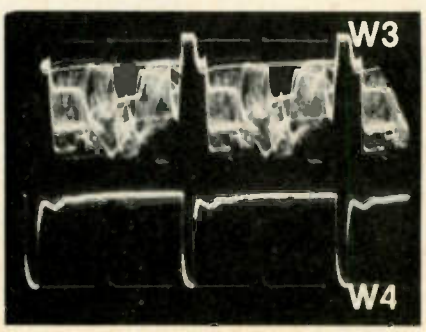
Therefore, resistors R502 and R504 are added to change the point of rectification. Also, the C502 current causes a voltage drop across R504, and it is drive signal and bias for Q505, the noise-inverter transistor. The collector-to-emitter path of Q505 is across the video at the output of R501. The AC signal at the base has little amplitude, and there is no path for DC bias, so normally Q505 is cut off, and has no effect on the video signal that finally reaches the sync-separator transistor.

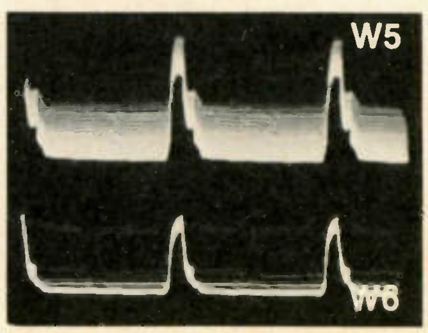
If a noise pulse (which has an amplitude higher than the sync pulses) enters with the video, it will apply more than +0.5 V of forward bias to the Q505 base. For moderate-intensity noise, the transistor amplifies the noise pulse, inverts the polarity, and delivers it to the output of R501. Both the original positive-going noise and the inverted negative-going noise from Q505 are at the output of R501, so the noise is cancelled.

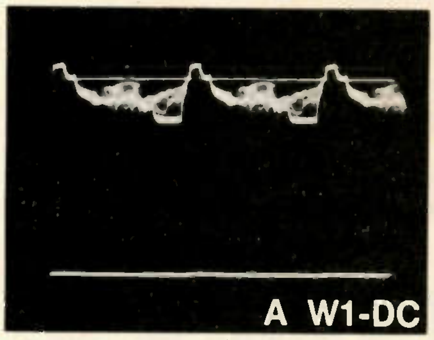
When the noise pulses have a very-high amplitude, Q505 is driven into saturation, and the C/E path *shorts out* both video and noise at the output of R501. Loss of a narrow section of sync pulse, when the noise occurs during sync time,

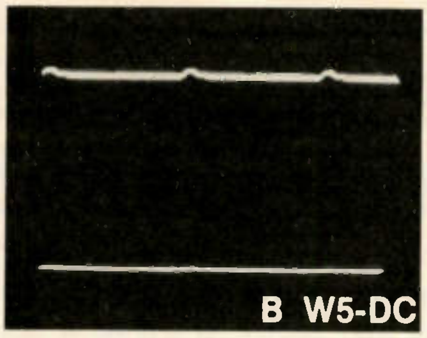
Figure 11 These are the usual waveforms of the Figure 10 noise-inverter and sync-separator circuits.











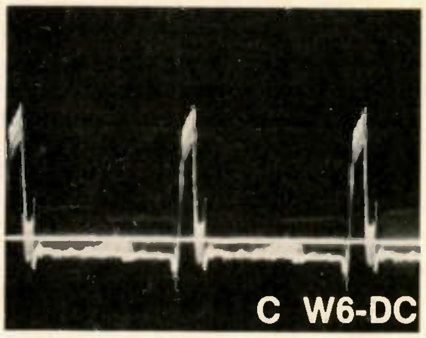


Figure 12 Noise-inverter waveforms help us understand the true circuit action, when the zero-voltage line is added to each. (A) This waveform is the same as W1 in Figure 11 with a zero line. Amplitude of the waveform and the DC position both *change* according to the TV scene. Therefore, it's almost impossible to assign definite voltages. Also, such extreme variations make necessary some kind of automatic circuit to maintain the proper level for noise inversion. (B) At the output of rectifier Y502, there is a small amplitude of sync and blanking shoulder riding on top of a larger DC voltage. The semi-peak-reading rectification maintains proper clipping even with variations of the incoming video level. (C) Here the zero line shows that the base of Q505 has about 0.4 VPP of sync pulses. This is not sufficient to cause Q505 to conduct. However, noise pulses of higher amplitude do provide enough bias for Q505 conduction. Any Q505 amplified collector signal is subtracted from the complete video signal; thereby, cancelling strong noise pulses.

is not detrimental. (Notice that the noise is not removed from the picture, but it's cancelled in the sync.)

Producing inverted noise pulses

For proper noise cancellation, only noise waveforms with amplitudes exceeding that of the sync pulses should be applied to the base of Q505. The problem is that the noise is mixed with video which varies in level constantly.

So, the solution is similar to sync separation. Video is rectified in such a way that only the sync tips and a small section of the horizontal blanking survive the clamping. This section of the composite video rides on top of a much larger dc voltage. The dc voltage comes from rectification of the video; therefore, it varies in step with all variations of the video amplitude. Without this automatic tracking, video level changes would change the clipping level, leaving too much or too little sync pulse amplitude.

Next, the dc is removed by a coupling capacitor, which adds a zero-voltage point near the bottom of the pulses that reach the base of Q505. These pulses supply *almost* enough amplitude to bias-on Q505. Therefore, only a very-small noise-pulse amplitude added to the sync pulses is sufficient forward bias for Q505 to produce noise cancellation.

The only proper way to visualize these actions is with the dc waveforms of Figure 12, which apply to the Figure 10 schematic.

Sync separation

Sync separation by Q510 is conventional by solid-state standards. A small positive voltage (from R507, and R506 through Y507) is applied to the base of Q510. Without this small forward bias, an insufficient amount of the sync tips would survive the B/E rectification.

Diode Y507 operates as a switch to pass only the sync tips through C506, a large capacitor, to the base. While smaller-value C507 couples all of the video signal to the base. This provides better vertical sync.

Video at the base of Q510 has come through C506 or C507, and the level far exceeds the small positive voltage there, so the base-to-emitter junction acts as a diode in a shunt-rectification circuit. Direct current from the rectification is negative, and this accounts for the strange sight of a NPN transistor apparently operating from reversed bias.

The DC waveforms in Figure 13 show that the dc clamping from this rectification produces a zero-voltage just below the shoulder of the blanking pulse in the video at the base. Therefore, *only* during each sync pulse time does the base have any positive forward bias from the input signal.

Next month

IF circuitry and typical operation will be examined in the next article. □

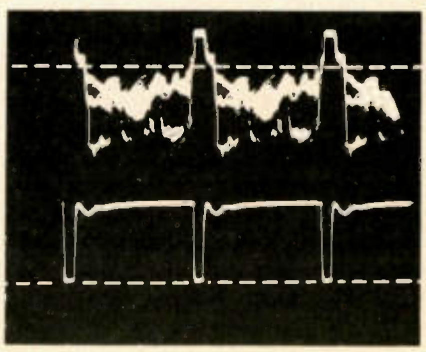


Figure 13 Dotted lines have been added to this dual-trace waveform (since the actual scope line would have obscured parts of the waveforms) to show zero voltage in base and collector signals of Q510, the sync separator. In the top trace, only the sync pulses and a bit of the blanking pulses are positive (above the zero line). Because silicon transistors ignore the first +0.5 volt of the positive bias, the sync pulses *alone* cause Q510 C/E conduction and amplification. Therefore, only amplified negative-going sync pulses appear at the collector (lower trace). Top of this waveform is the B+ supply voltage, and the tips are at zero volts. From this we can conclude: the transistor either is saturated, or is completely cut off. Since B+ is at the collector most of the time, the average DC (as read by a meter) is a large percentage of the supply voltage. **These are true DC pulses.**

Sam Wilson's Technical Notebook

CHANGES IN 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

Answers about capacitors

In the last Technical Notebook, I described some experiments that demonstrated a very important point about capacitors:

> **The voltage across a charged capacitor and the capacitance of a capacitor depend on the flux lines that start at the positive plate and end at the negative plate.**

I know there are some theory people who will argue that the number of flux lines depends on the amount of voltage. But, I've said here that the amount of voltage depends on the number of flux lines.

The reason is that the flux lines are established in the *dielectric* when the capacitor first is charged. However, when the charging voltage is removed, the voltage that *remains* across the capacitor is determined by the number of flux lines.

When I mentioned the relationship between voltage and flux lines, I was referring to the amount of the flux (and voltage) in a charged capacitor.

Weber-Ewing theory

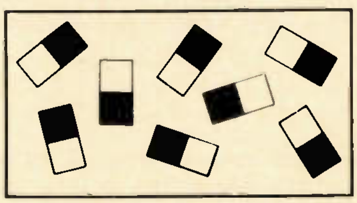
Before I explain what happens in a dielectric when a capacitor is charged, I want to review an old theory of magnetism. The Weber-Ewing theory assumes that a magnetic material is made of tiny magnets, as shown in Figure 1.

In the nonmagnetized state these tiny magnets are pointing in all directions at random, so there is no resultant (additive) magnetic field in the material.

Figure 2 shows what happens when all of the tiny magnets are aligned by a strong magnetizing force. The north poles are all pointing in the same direction. They produce a total magnetic field. Likewise, the south poles are aligned, and they produce a total magnetic field. The overall result is that the piece of material behaves as a large magnet having a single north and south pole combination.

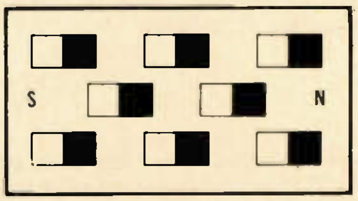
Surprisingly, the Weber-Ewing theory is so close to what actually happens in a magnetic material, that it can be used as an accurate model.

In a previous article, I discussed the domains in a magnetic material. You should recognize the tiny magnets of the Weber-Ewing model as examples of domains.



UNMAGNETIZED MATERIAL

Figure 1 According to the Weber-Ewing theory, magnetic material is made of a huge number of tiny magnets. The poles of these tiny magnets point in random directions when the material is not magnetized.



MAGNETIZED MATERIAL

Figure 2 When magnetic material becomes magnetized, the tiny magnets are shifted so the like poles point in the same direction. This gives the effect of one large magnet.

Faraday's dipoles

As an explanation of what happens in the dielectric of a capacitor when it is charged, Michael Faraday proposed a model which is very similar to the Weber-Ewing model. And this Faraday model also is so near to the actual truth that it serves as an excellent model for understanding capacitors.

First, I'll use the Faraday model, then later I'll explain what the dielectric dipoles really are.

Assume that the dielectric is made up of a large number of electric dipoles. Each dipole has one positive and one negative charge (see Figure 3).

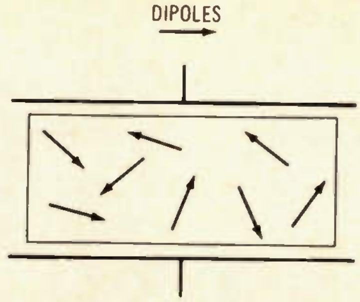
When the capacitor is in an uncharged condition, these dipoles are pointed in random directions.

After the capacitor is charged, the dipoles all point in the same direction (Figure 4). Remember this very important point:

When the capacitor is charged, the dielectric goes through a physical change!

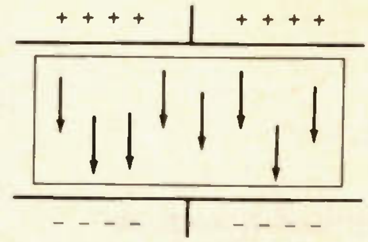
In some dielectric materials, the dipoles will **remain** aligned after the charging voltage is removed. Thus, the capacitor remains charged—with the voltage across it—after the charging step is over. This is the meaning, when we say a capacitor has become "charged."

When the capacitor is discharged, the dipoles again become oriented in random directions. As I stated before, this model for charged and discharged capacitors is quite accurate, and probably I'll refer to it again later.



UNCHARGED CAPACITOR

Figure 3 According to Faraday's theory, dielectric material contains a large number of electric dipoles, which point in random directions before the capacitor is charged.



CHARGED CAPACITOR

Figure 4 After the capacitor is charged, the dipoles all point in the same direction. Therefore, during charge, the dielectric undergoes a physical change.

True nature of dielectric dipoles

When a dielectric material is placed in an electric field, there are four factors to be considered:

(1) Voltage across a capacitor pulls the dielectric electrons out of their normal circular pattern, and into an elliptical orbit, as shown in Figure 5. This is called "electronic polarization of the dielectric."

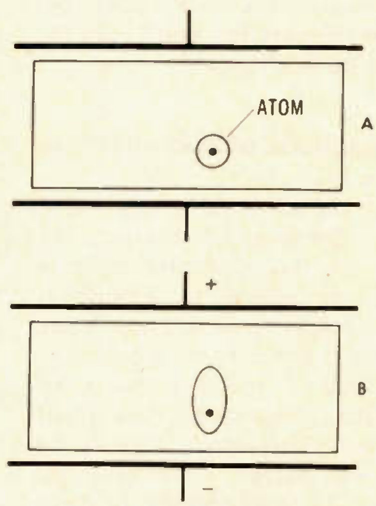
(2) When two atoms from two different elements combine to make a covalent bond, they do not share electrons equally. More electrons are captured by one of the atoms. Therefore, the two atoms acquire opposite charges. An external field—such as provided by a voltage at the plates of a capacitor—will change the equilibrium of the atoms (Figure 6). This is called "atomic polarization of the dielectric."

(3) Some materials have a natural "dipole moment." This is the dual (equivalent) of residual magnetism in a soft iron material. Theoretically, a piece of soft iron that becomes magnetized by current through a coil should lose all the magnetism when the current is eliminated. But a small amount of magnetism—called residual magnetism—still remains. The same thing happens in a dielectric, except the field that remains after the charging voltage is removed from the capacitor is electric rather than magnetic.

(4) Any dielectric material always has some charge carriers that are not attached to atoms. When the capacitor has a voltage across it, these carriers—both holes and electrons—gather at opposite sides of the material. Flux lines from the plates terminate at these charge carriers, thus reducing the total flux between the plates.

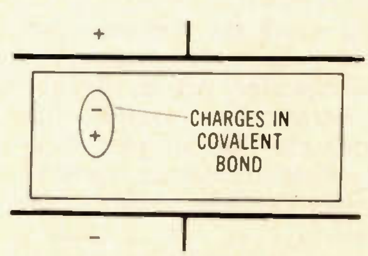
Now, what does this mean? It verifies the concept of dielectrics made up of many little dipoles (just like the ones Faraday guessed were there). Charging the capacitor forces the dipoles to align with the flux lines between the plates. And that brings us back to the illustrations in Figure 3 and Figure 4.

This discussion explains why there are dipoles in dielectrics. It now should be easier to go back to the more simple ideas of Faraday's model (which is very accurate).



ELECTRON ORBITS IN DIELECTRIC

Figure 5 (A) Without voltage across a capacitor, the electrons in the dielectric move in circular orbits. (B) Voltage across the capacitor pulls the electrons into eliptical orbits. This is called "electronic polarization of the dielectric."



ATOMIC POLARIZATION

Figure 6 Capacitor voltage changes the equilibrium of the atoms, and it is called "atomic polarization of the dielectric."

Technical notebook

Three quiz questions

It is possible now to use the theory of dielectrics and capacitors to explain several capacitor questions that don't fit the imcomplete "tech school" model.

Figures 7, 8 and 9 give the schematics, conditions and a choice of answers. Mark your choice beside the columns and don't read the answers until afterward.
ward.

Explanations of quiz answers

Question 1

When the assembled capacitor of Figure 7/Question 1 is charged, the dipoles in the dielectric become aligned, as shown in Figure 4. Those dipoles remain aligned as the capacitor is taken apart. Charges in the X and Y metal plates repel each other, and disperse throughout the metal. Therefore, there is no spark or current between the "plates." In fact, *nothing* happens when the two metal pails are touched together. (If the basic action of a capacitor were, as popularly believed from the student's incomplete model, an excess of electrons on one plate, and a deficiency of electrons on the other, then removal of the solid dielectric would have *increased* the voltage, and the short would have brought a giant and spectacular arc. Thus the incomplete model is disproved.)

If you touch the dielectric pail after it is removed from the charged capacitor, you can feel the static charges. For example, you can bring the back of your hand near the dielectric and see the hairs stand straight out towards the material.

Then when the capacitor is reassembled, the charge carriers in the metal pails regroup because of the flux lines now between the plates. Therefore, the reassembled capacitor exhibits a full charge, and it can be discharged.

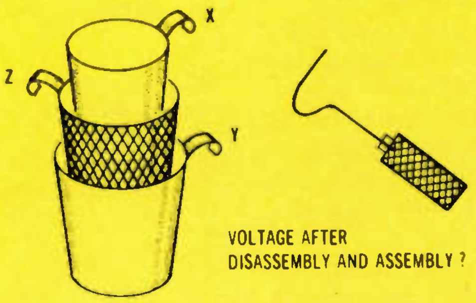


Figure 7

Question 1 Three pails are constructed so they fit snugly together, as shown. The center pail is made of dielectric material, while the two others are made of metal. After assembly, the capacitor is charged with about 500,000 Vdc. Then, by use of the insulated hook, the pails are disassembled **and the two metal pails are touched together.** After reassembly, which statement is true?

(A) The capacitor has no voltage, for it is discharged.

(B) The capacitor still has the same voltage.

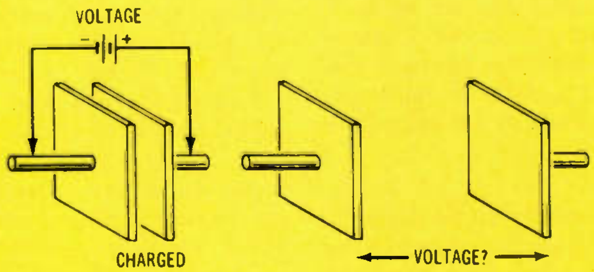


Figure 8

Question 2 A capacitor made of two flat plates (whose distance can be varied) is charged with high voltage when the plates are close together. After the plates are moved farther apart, which statement is true?

(A) The capacitor voltage decreased.

(B) The capacitor voltage increased.

(C) The capacitor voltage did not change.

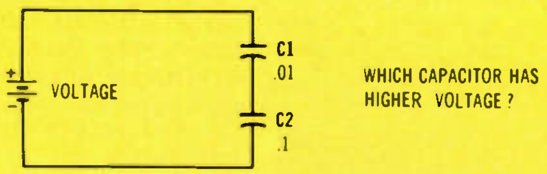


Figure 9

Question 3 Which of the two capacitors has the higher dc voltage across it? (neglect stray capacitances)

(A) Capacitor C1 has the higher voltage.

(B) Capacitor C2 has the higher voltage.

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103	1.05	172A	.72	224	5.08	293	1.08
103A	1.11	175	1.62	225	4.34	294	1.14
104	1.08	176	2.08	226	1.67	295	2.02
105	2.27	177	.49	228	1.38	297	1.13
106	.80	179	5.69	229	1.06	298	1.13
107	.79	180	5.86	230	3.60	299	2.02
108	.89	181	4.65	231	3.98	300	2.02
121	2.15	182	3.35	232	.70	302	2.80
123	.69	183	3.63	233	.74	306	2.80
123A	.79	184	1.37	234	.72	307	2.57
124	1.53	185	1.70	235	2.45	308	7.65
126	1.16	186A	1.46	236	5.75	309K	3.27
127	4.60	187A	1.46	237	5.07	310	7.85
128	1.37	188	1.59	238	7.95	311	2.13
129	1.58	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	.98	276	8.72	315	2.01
133	1.14	193	1.04	278	2.36	316	2.74
152	1.43	194	.82	279	5.85	317	24.20
153	1.85	195A	2.67	280	5.08	318	20.60
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	1.89	283	6.32	321	7.65
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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Question 2

In Figure 8, when the capacitor is charged, and then the plates are moved apart, you actually are doing work on the system. Work is defined as force times distance. Keep in mind the fact that the plates have opposite charges, so you must exert a force to get the plates apart.

Voltage is a measure of the amount of work done in moving a unit negative charge from a positive point to a negative point. Since the distance between the plates is greater, the work required to move the negative charge away from the positive plate and toward the negative plate will be greater. In other words, the voltage has been increased. However, the increased voltage was not obtained for nothing. Work was performed.

Actually, the principle of Figure 8 is the basis for understanding parametric amplifiers.

Question 3

The answer to Question 3 in Figure 9 is found in the equation: $Q = C \times V$, where Q is the charge, C is the capacitance, and V is the voltage across the capacitance.

Therefore, the charge for C1 is: $Q1 = C1 \times V1$, and the C2 charge is: $Q2 = C2 \times V2$.

But, the capacitors are in series, so the *same* amount of charge *must* be in each capacitor. In other words, the same number of electrons have to move into each negative plate.

Because Q1 equals Q2, then it follows that $C1 \times V1 = C2 \times V2$. After dividing each side of the equation by $V1 \times C2$, you have $C1/C2 = V2/V1$. This is a simple mathematical way of saying: **Voltages across the capacitors are inversely proportional to the capacitance values.** In other words, the larger voltage always must be across the smaller capacitor.

Next month

One more question of the four remains to be discussed next month. In the meantime, try to modify your capacitor "model" to include these ideas. □

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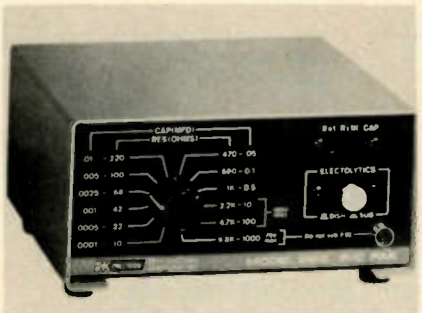
test equipment

Substitution box

B&K-Precision surge-protected substitution box, model 2910, is designed to eliminate problems of shock hazards, accidental discharges and the temporary healing of a defective electrolytic.



The initial surge is limited by putting a resistor in series with the substitute capacitor. After the capacitor is charged, a switch is moved to the substitute position, removing the resistor from the circuit. For added protection, an overload indicator lamp warns against substitution of a low voltage capacitor when applied voltage is over 75 VDC.

Model 2910 features 36 substitution components and is priced at $50.

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Multitester

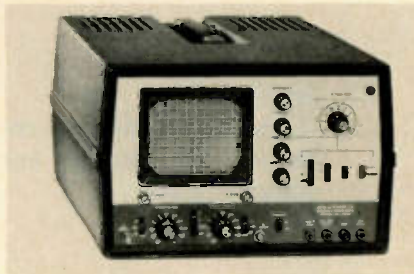
Model SP-160 VOM from **Sperry Instruments** features a rugged shock resistant ABS plastics case; a tilted case design for easier reading; an additional X1K resistance scale; and high 100 kΩ dc voltage sensitivity (10 kΩ for ac); and five resistance scales (X1, X10, X100, X1K and X10K).

Circle (31) on Reply Card

Dual-trace scope

Heath Company offers a low-cost, dc to 5 MHz dual-trace scope kit, the IO-4205. Features of the new scope include: a maximum vertical sensitivity of 10 mV/cm; a horizontal triggered sweep; seven calibrated time bases from 200 mS/cm to 0.2 uS/cm; and regulated vertical-amplifier and horizontal-sweep power supplies.

Other IO-4205 features include a partial mu-metal shield, an extra bright 5-inch flat-screen CRT and a lightweight durable cabinet with flush-mounted handle for easy carrying and stackability with other instruments.



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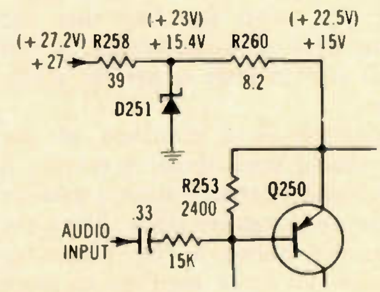
QUICK-QUIZ #3

ANSWER:



Voltage drop across R258 indicates a current of more than 290 milliamperes, while a current of only 48 mills is calculated for R260, the other supply resistor. Cause of the excessive current MUST be between R258 and R260.

DIODE D251 HAS INTERNAL LEAKAGE.

REFER TO PAGE 22

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Extension telephone

Pathcom, announces the Pace EZ Phone, a wireless extension telephone containing space-age technology.

The remote extension phone is in a handset that resembles conventional trimline telephones. It has a collapsible whip antenna, a touch-tone dialing pad and two special-function swtiches.

The base unit contains a molded compartment which accepts the remote handset for battery charging The same base unit can be used for either pulse (rotary dial) or touch-tone dial systems.

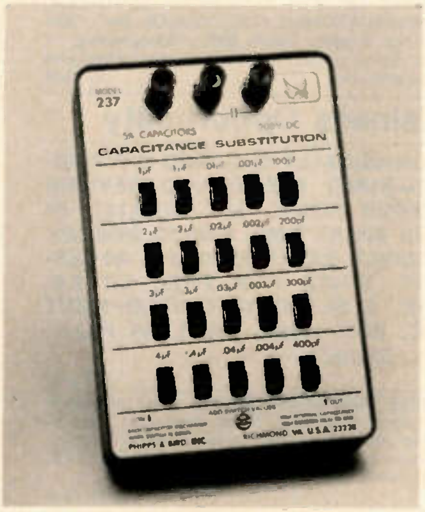
Useful operating range of the system is about 300 feet, and several remote phones can be used with the same base unit.

Manufacturer's suggested retail price for the EZ Phone is $169.96 per unit.

Circle (33) on Reply Card

Capacitance-substitution unit

Phipps & Bird has introduced the 237 slide-switch capacitance-substitution unit which offers a 5-decade range of capacitance from 100 pF to 10 uF and a special discharge feature.



The unit weighs one pound, and is in a metal case. It uses non-polarized 5% capacitors and features 5-way binding posts.

This unit sells for $95.

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Music on hold

DITTO'S offers a method of entertaining phone callers put on hold. The Music-on-Hold cradle plays AM or FM music into the phone until it is picked up.

The machine comes in black, yellow, white, beige or green and sells for $29.95.

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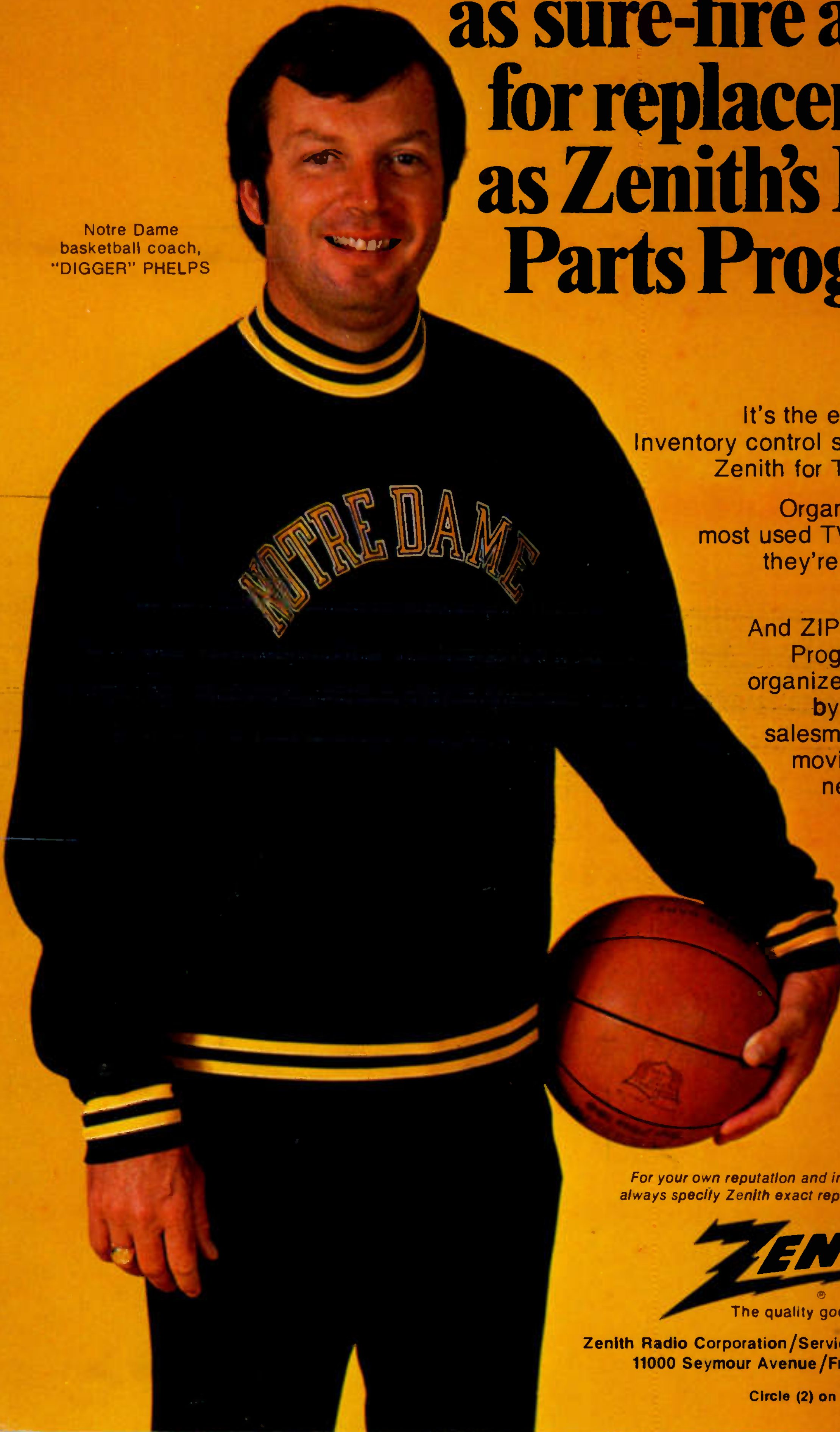

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