For industrial maintenance and consumer servicing professionals
July 1981 □ $2.25

Electronic Servicing®

Digital multimeter roundup

Replacing relays and solenoids

Synchronous demodulation

Electronic Servicing

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Electronic Servicing®

July 1981 ☐ Volume 31, No. 7

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About the cover

The cover photograph is courtesy of Keithley Instruments Inc. For more information about this and other digital multimeters, see the "Digital multimeter roundup," beginning on page 28, and "Audio indications in digital multimeters," beginning on page 34.

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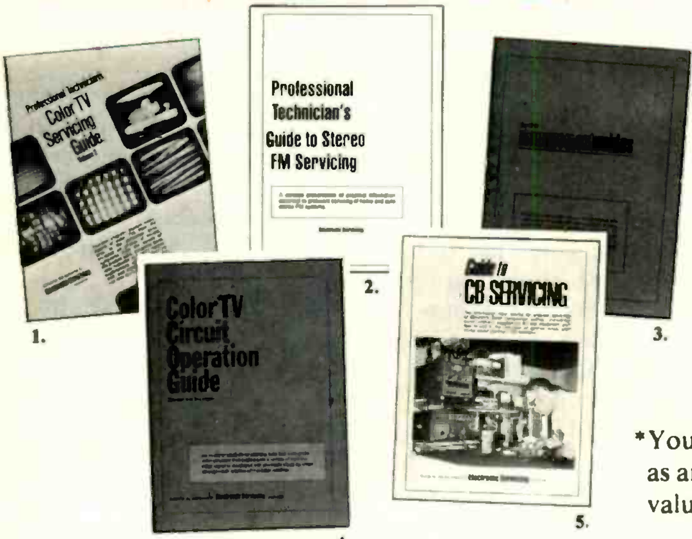

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electronic scanner

news of the industry

Comp-U-Card minority interest purchased

Comp-U-Card of America Inc., of Stamford, CT, announced that a venture capital affiliate of Merrill Lynch & Co. Inc. has purchased a minority interest in the privately held electronic shop-at-home service. The investment was announced by Walter A. Forbes, chief executive officer of Comp-U-Card. The amount of money was not disclosed.

Similar investments were disclosed in February 1981, by Equitable Life Assurance Society, and in October 1980, by Federal Department Stores.

Comp-U-Card is the nation's first electronic shop-at-home service offering home computer users, cable TV subscribers and conventional telephone customers access to product specifications, discount prices and home delivery for more than 30,000 name-brand items for the home.

With this program, consumers at home can shop, place an order and complete the transaction by charging it to a major credit card. Comp-U-Card's system, which has been tested in various forms nationwide for more than a year, is fully operational and compatible with all forms of electronic delivery, including home computers, cable TV, videodisc and satellite.

National Electronics Trade Show set for August 6

The 1981 National Electronics Trade Show will be held August 6 from 9 a.m. to 3 p.m. at Innisbrook Resort in Tarpon Springs, FL. The show will be held during the National Electronics Service Convention.

Reservations, costing $440, reserves a 10' x 10' booth with an 8-foot draped back, 3-foot draped sides, a draped table, a chair, sign and an electrical outlet. Two convention tickets, including all scheduled meals, are given with each space rented. Hotel accommodations are at Innisbrook.

NEPCON Northwest '81 set for Nov. 3-5

The National Electronic Packaging & Production Conference (NEPCON Northwest '81) will be held Nov. 3-5, 1981 at the San Mateo Fairgrounds in California. This second annual presentation showcases the latest developments in the machinery, equipment, tools, hardware and supplies used for prototype circuit design/packaging, PCB production, and PCB/Microelectronics testers, according to Cahners Exposition Group (CEG), organizer of the event.

"Over 9000 electronic engineers, buyers and specifiers attended the 1980 premier and we're expecting an even larger audience at this year's show," said Michael H. Martorano, CEG's general manager of domestic operations. Show visitors will evaluate more than 400 displays of equipment for the prototype design, fabrication, assembly and testing of printed circuit boards and microelectronics devices. The 3-day event covers artwork generation to final test and systems packaging.

A technical program detailing developments and advancements in the production and testing of printed circuits, multilayers and hybrid microelectronics devices supports the equipment display. Papers will be presented by industry experts sharing information on testing microcircuits, instrumentation for testing, functional testing and more. Tutorial courses and practical workshops will also be featured.

NEPCON Northwest '81 is open to all persons and firms actively engaged in the electronics, packaging and production industry. Complete details on exhibiting are available from Cahners Exposition Group, 222 West Adams Street, Chicago, IL 60606; (312) 263-4866.

Picture tube sales figures released

U.S. sales of color TV picture tubes, excluding imports, increased 13.7%, from 10.6 million units in 1979 to 12.0 million units in 1980, according to statistics recently released by the Electronic Industries Association's Marketing Services Department.

Within this total, sales to the initial equipment sector rose 16.4%, while renewal sales and exports each decreased 3.4%. Imports showed a 66.4% gain, resulting in 15.4% expansion of the U.S. market for color TV picture tubes.

Companies interested in participating in and receiving EIA statistics should contact the Marketing Services Department, Electronic Industries Association, 2001 Eye Street NW, Washington, DC 20006.

Distributor shipments up 6% in May

Industrial distribution's May shipments registered an increase of 6% from April, according to the latest NEDA Distribution Business Index data released by the National Electronic Distributors Association.

Bookings growth was a more modest 1%, suggesting that much of the shipments growth came at the expense of backlog. The book-to-bill ratio slipped from April's 1.1 to 1, to 1.05 to 1.

The May shipments level stood 12% higher than May 1980, while this May's bookings exceeded last May's level by 13%. Virtually all the net increase in both the shipments and bookings rates occurred during the first five months of 1981, according to the NEDA data. The bookings rate has not registered a month-to-month decline since October 1980. Shipment levels have been steady or increasing since December.

The May NEDA report marked the first month that booking and shipment levels were compared with those of the same month a year ago. The comparison will be a regular feature of all future monthly reports.

The DBI data is collected from a nationwide sample of industrial distributors accounting for nearly $1 billion in annual sales from more than 130 locations in every major trading area in the United States.

1981 CES sets attendance record

The 15th Annual International Summer Consumer Electronics Show was hailed by exhibitors as highly successful, according to Jack Wayman, senior vice president of the Electronic Industries Association's Consumer Electronics Group.

The attendance of 60,892, a Summer CES record, included major stores and quality retailers. Several exhibitors, even on the Concourse level, observed that each of the "Big Six" department stores visited their booths.

The show opened May 31 and closed June 3.

The attendees moved through 950 exhibits, which used 550,000 square feet at McCormick Place (all three levels plus outdoor exhibits), McCormick Inn, and the Pick Congress Hotel.

The EIA/CEG Board of Directors, which met during the show, voted to continue holding two shows annually, in winter and summer. The dates are: 1982 International Winter CES, Thursday, January 7—Sunday, January 10, and 1982 International Summer CES, Sunday, June 6—Wednesday, June 9.

EIA announces fiber-optics working group

A P-6.1 working group on fiber-optics systems has been announced by the Electronic Industries Association. The group was formed to provide guidelines from a systems need viewpoint on requirements and priorities for the development of fiber-optics component standards by other EIA P-6 working groups.

Under the chairmanship of Hank Dorris of Bell Laboratories, the group is comprised of representatives from the industrial fiber-optics equipment manufacturing community, the DOD user and other members of the government and academic community.

Further information may be obtained by contacting Hank Dorris at (202) 949-4590 or Steve Forish at (202) 457-4969.

The Electronic Industries Association is the full service national trade association representing companies involved in the manufacture of electronic components, equipment and systems for consumer, industrial and government application.

TV receivers, VCR sales continue to climb

U.S. market sales to retailers of TV receivers and videocassette recorders in May continued at the fast pace set in the first four months of the year, according to the Electronic Industries Association's Consumer Electronics Group.

Sales of color TV sets in May 1981, were 747,609 units, an increase of 38.7% over 538,969 units sold in the same month a year ago. Color TV sales in the first 21 weeks of 1981 were 4,136,031, up 23.5% over 3,350,276 units sold in the comparable period of 1980.

Monochrome TV receiver sales in May 1981, amounted to 434,709 units, a rise of 37.4% above 316,372 units sold in the same month a year ago. Sales of monochrome TV sets in the first 21 weeks of 1981 amounted to 2,250,188 units, a gain of 17.8% over 1,910,105 units sold in the comparable period last year.

Videocassette recorder sales to retailers in May 1981, were 87,013 units, an increase of 93.5% over 44,975 units sold in May of 1980. Sales of VCR in the first 21 weeks of 1981 rose to 434,098 units, up 85.1% over 234,525 units sold in the same comparable period a year ago.

Sprague Products Company named EDS Exhibitor of the Year

The Exhibitor of the Year Award at the 1981 Electronic Distribution Show was presented to Sprague Products Company in Atlanta by Lewis Shuler, Dixie Electronics, president of the Electronic Industry Show Corporation. Sprague's overall promotional and attendance program was deemed the most outstanding among the 277 manufacturing companies participating in the annual Show.

In addition to the Exhibitor of the Year Award, seven Gold promotional awards and seven Bronze promotional awards were presented to EDS exhibitors for excellence in pre-Show and at-Show promotion programs.

Winners of Gold award were: Amp Special Industries, John Fluke Manufacturing, Methode Electronics, Tektone Sound & Signal, Thordarson Meissner, Triplett Corporation and Vaco Products Company.

Winners of Bronze awards were: Chicago Case Company, Dearborn Wire & Cable, GC Electronics, Grayhill Inc., National Controls Corporation, Perma Power Electronics and Shape Magnetronics.

Southeast Electronics branch to handle Logitek products

Logitek Electronic Systems Inc., of Houston, TX, has appointed Southeast Electronics Inc. as exclusive representatives for Logitek broadcast products in Mississippi, Alabama and Georgia, and has renewed Southeast's representation agreement for Florida. The added states will be handled by Southeast's new branch in Mobile, AL, under sales representative Ron Burks.

Southeast's Mobile branch joins branches in Tallahassee and Jacksonville, FL, in providing full broadcast equipment sales and service for the Eastern Gulf Coast and South Atlantic regions. Southeast plans to soon open another branch in Pennsicola, FL. This branch will also be an authorized outlet for Logitek products.

Tronics 2000 enters 10 metro markets

Ten major metropolitan areas in the United States are under development by Tronics 2000, a national franchise organization aimed at the independent consumer electronics service industry.

Active since September 1980, Tronics 2000 is a Bloomington, IN based corporation involved in franchising consumer electronics repair shops. The goal is to create consumer-oriented repair networks within each geographical area capable of handling all consumer electronic products.

The areas under development, consisting of a population of roughly 9 million persons, are Dallas, sections of greater Chicago, Minneapolis/St. Paul, Cleveland, Cincinnati, Louisville, Tampa/St. Petersburg, Orlando, Sarasota, and Daytona Beach. These areas could support approximately 300 service centers, according to R. W. Lay, director of internal operations.

Tronics 2000 offers to independent franchises professional advertising, volume buying discounts and assistance in running a business.

"The idea," said David J. Hagelin, president, "is to help independent service shop owners compete more effectively in a rapidly changing and highly complex marketplace and simultaneously to assure consumers of a professional service network where they can have their complex home electronics equipment serviced at fair and equitable prices."

Electronics trade show slated for Taiwan

A trade show for U.S. electronics firms is scheduled for Jan. 11-16, 1982 at the American Trade Center in Taipei, Taiwan.

The Commerce Department's International Trade Administration (ITA) will assist the American Institute in Taiwan in presenting the exhibition, which will feature electronic components and production and testing equipment.

The growing Taiwan market for electronic products is projected to reach $1.2 billion by the end of 1981, most of which will be for components. The market for production, test instrumentation and special materials for components is expected to be more than $80 million by the end of this year.

Interested firms should contact David L. Kelson, OEP/IPD Room 6015, U.S. Department of Commerce, Washington, DC 20230; (202) 377-2433.

Electronic newspaper uses Radio Shack computer, terminals

Radio Shack, a division of Tandy Corporation, has announced a pilot project in cooperation with the "Advertiser-Tribune," Tiffin, OH, to provide an "electronic newspaper" to its subscribers, the first such private electronic edition.

Subscribers to the "Advertiser-Tribune" will see the newspaper's electronic edition via videotext, a method of electronic communications that transfers information over standard telephone lines for display on standard TV sets. Users will require videotext terminal, or a personal computer equipped with the simple hardware and software necessary to permit it to act as a videotext terminal.

photofact bulletin

SHARP
19D82A 2011-1

TRUETONE
GEC3008A-18,B-18 (24-3008-0) 2011-2

ZENITH
Chassis 12MB11X 2011-3
Monitor M129P,
Camera VSC-100 .... 2011-3-A

HITACHI
CT1906 2005-1

PHILCO
B750MWH/55MWA 2005-2

SEARS
564.44050050 2005-3

SEARS
564.48610050/8611050/8660050/
8661050/8710050/8711050 2006-1

TOSHIBA
Chassis TAC010 2006-2

HITACHI
CT1907 2007-1

SONY
KV-1221R 2007-2

REALISTIC
12-1519B (CHRONODATE 209) 2007-3

SEARS
564.42221901/02 2008-1

WARDS
GGV-17650A,B/660A,B/670A,B/680A,B 2008-2

SHARP
19E83 2009-1

SYLVANIA
Chassis E51-1/-3/-4/-5/-6/-7/-9 2009-2

TRUETONE
GEC3007A-18,B-18 (24-3007-2) 2010-1

ZENITH
SM1961W,WXS,W1,X/1971P/2511W/
2523E/2525M/2527DE,P/2531E/2533PN/
2535X/2541X/2543E/2545M/2549E/2593P/
2597P/4529E,SS2511B 2010-2

TEKNIKA
6301 2010-3

people in the news

GC Electronics has announced the appointment of **Owen R. Jackson** as director of sales and marketing. Jackson, manager of market development at GC for the last 2½ years, reports to **Wayne Timpe,** vice president and general manager. Jackson will oversee both distributor and OEM sales and be responsible for development and expansion in both markets.

Warren J. Dugas, Eastern region sales manager the past 3½ years, has been promoted by Jackson to the position of national sales manager. Dugas will supervise the GC sales force and be directly responsible for sales control to electronic distributors throughout the United States.

Also, GC Electronics has named **Michael A. Smith** advertising and sales promotion manager. With GC since 1978, Smith was most recently assistant promotion manager. His duties will include preparation of sales aids, space advertising and exhibits for national trade shows.

N. Dana Kellenberger, Northeast district sales manager for ITT Cannon Electric, has been named director, national field sales.

W. J. Clark, director of marketing/business development for this division of International Telephone and Telegraph Corporation, said Kellenberger is responsible for coordinating sales activities for all ITT Cannon units in North America, as well as foreign affiliates. He supervises 11 district managers, five manufacturing representatives and more than 60 sales engineers.

A 19-year employee of ITT Cannon, Kellenberger's past positions include product specialist, supervisor, application engineering and marketing manager of the Phoenix facility.

Gene Swanzy has been appointed to the new position of vice president/broadcast services of the Mutual Broadcasting System, **Martin Rubenstein,** president and chief executive officer, announced.

The 25-year broadcast veteran will oversee the network's technical operations, engineering, satellite engineering, traffic and production departments.

Swanzy comes to Mutual from the Public Broadcasting Service, where he helped design and implement the first broadcast satellite system. He was director of operations, vice president/operations and, most recently, vice president for pay television initiatives at PBS.

Stephen Fowler, 36, has been named general manager of REFAC Electronics Corporation's III-V materials department, **I. Thomas Saldi,** president, announced. Fowler will oversee the operations concerned with the manufacturing of GaP, GaAs and InP crystal products and LED chip manufacturing at the Edison, NJ plant, where REFAC's OPCOA LEDs and OPTEL LCDs are manufactured.

Before joining OPCOA in 1978, Fowler spent many years working with LED devices and materials for Monsanto Co. as project engineer, at Bowmar Canada Ltd. as chief engineer and manager of advanced technology, and at the Singer Companies CRDL as project manager.

Three senior management appointments have been made by Marconi Communications Systems Ltd., a GEC-Marconi Electronics company.

R.T.J. Baker has been appointed to the vacant post of manager, broadcasting division. Dick Baker returns to the company after a 2-year absence. He was previously in the studio group as chief of sales, broadcasting division.

B.M. Smith has been appointed manager, export department, responsible for the company's regional staff. Bryan Smith retains his responsibility for the Middle East area.

P.A.T. Turrall has been appointed publicity manager for the company, in addition to his administrative responsibilities in the export department.

Appointment of **Edward A. Boschetti** as division vice president and general manager, RCA Distributor and Special Products Division, has been announced by **Jack K. Sauter,** group vice president, RCA Corporation.

Boschetti succeeds **Donald M. Cook,** who was named division vice president, government services, RCA Service Company.

Boschetti was previously division vice president, marketing, for the distributor and special products division. He joined RCA's Victor Division in Camden, NJ, in 1951.

Vernon D. Heins has been named quality assurance manager for the Fountain Valley, CA, operation of ITT Cannon Electric.

Marvin Shults, quality manager for this division of International Telephone and Telegraph Corporation, said Heins will be responsible for quality assurance in the rectangular and circular departments.

A veteran of 23 years with ITT Cannon, Heins has worked as layout draftsman, product engineer, senior quality engineer and most recently was the quality assurance manager, circular division.

Switchcraft Inc. has named **Eugene Goldberg** as product manager for the company's electronic connector line, according to **Ed Larrabee,** director of marketing and sales. Goldberg has a strong background in electronic and electromechanical connectors. He was previously senior sales engineer for ITT Cannon Electric in Northern Illinois. He has also held marketing and engineering management positions with Winchester Electronics and Amp Inc.

The Electronic Industries Association has announced the appointment of **Mark V. Rosenker** as staff vice president of public affairs. Rosenker joined EIA in 1977 as director of public relations for the Association's Communications Division. In December 1979 he was named EIA's director of public relations.

Before joining EIA, Rosenker served as deputy press secretary for President Ford's campaign organization. Most recently, he was a consultant to the Reagan/Bush transition office, and has served in both the Ford and Nixon administrations in various capacities. Rosenker's professional experience also includes commercial public relations activities and the broadcast industry, at both the local and network levels.

Dan Harp, general manager of Consumer Products Distributing Inc. (CPD), has named **Larry Ervin** as parts manager for the company.

CPD, headquartered at 3330 Pagosa Court, Indianapolis, IN 46226, is the authorized distributor for Sony and other major consumer brands for central and northern Indiana. The company was founded in 1969 and now ranks among the top 20 distributors of electronic products in the United States.

Robert Loranger, president of Loranger Manufacturing Entertainment Division, has announced the appointment of **Dennis Hedlund** as national sales manager. Hedlund will report to **Gary Schwartz,** director of marketing and sales.

Before his new position, Hedlund gained extensive experience marketing both audio and video software. His most recent position was with Magnetic Video, where he was national accounts manager.

David A. Golden, O.C., LL.B., LL.D., chairman of the board of Telesat Canada, will deliver the 7th Tanner Lecture at the International Electrical, Electronics Conference and Exposition on October 6, 1981, in Toronto.

Golden has had a distinguished international career in the aeronautics and telecommunication industries spanning 30 years. A former deputy minister of defense production, he has also served as president of the Air Industries Association of Canada, deputy minister of industry and president and chief executive officer of Telesat Canada. In recognition of his service, he was awarded the C.D. Howe Award of the Canadian Aeronautic and Space Institute in 1970.

Golden is chairman of the boards of CCM Inc. and Computel Systems Ltd., in addition to his duties at Telesat.

Thomas C. Carlson has been named director of operations for ITT Schadow Inc., Eden Prairie, MN.

Robert G. Inglis, general manager, said Carlson will have responsibility for manufacturing, fabrication, production engineering and materials.

Carlson previously worked as superintendent of switch products, quality control manager, and process engineering supervisor for Honeywell Micro Switch, Freeport, IL.

Leonard Lacaze Jr. has been promoted to manager of engineering, industrial products for ITT Cannon Electric, Santa Ana, CA.

Robert C. Enright, general manager, rectangular and industrial products for this division of International Telephone and Telegraph Corporation, said Lacaze will supervise design engineering of connectors for the industrial and automotive markets.

A U.S. Navy veteran, Lacaze joined ITT Cannon in 1976 as product design specialist. He was promoted to supervisor of engineering in 1978.

Before joining ITT Cannon, Lacaze worked for Westinghouse Air Brakes, Peoria, IL, and Ford Motor Company.

Micro Automation has named **O.T. Ewe,** 37, its sales and service manager for the Asia Pacific area. He reports to **John Spangberg,** the firm's vice president, sales.

Ewe has 18 years' experience in the semiconductor and electronics industries. Most recently, he was manufacturing engineering manager in National Semiconductor's Bandung, Indonesia, facility. There his duties included engineering and maintenance supervision of assembly and end-of-line facilities, with responsibility for a total work force of more than 400.

In his new position, Ewe will handle all sales and customer service responsibilities for Micro Automation's product line in the Asia Pacific Area, from the area office in Singapore.

Understanding synchronous demodulation

By Jim Smith, CET, Sencore National Accounts Manager
and Greg Carey, Sencore Chief Field Engineer

Although possible for decades, synchronous demodulation for video signals was not used in color TV receivers until integrated circuits reduced the manufacturing costs. Theory and practical adjustment of synchronous detectors are covered in this adaptation from a **Sencore** *technical bulletin.*

Germanium diodes have been used for years as video detectors in TV receivers, even though better demodulators were known. Diode demodulators are uncomplicated while other systems then were costly. Modern integrated circuits have changed this by allowing superior performance from synchronous demodulators at an affordable cost.

The following review covers the operation and shortcomings of diode-type video detectors.

Diode detection

A video diode detector rectifies radio frequencies exactly as a power-supply diode rectifies 60Hz power. The halfwave recitification has IF sinewaves at the diode input and half cycles at the output (Figure 1). Resistance and capacitance filters fill in the spaces between these half cycles, thus providing a video signal of approximately the same waveshape as the original modulation.

Diode detectors have four basic shortcomings: (1) the input signal must exceed a certain level before diode conduction can begin; (2) diodes have a nonlinear knee; (3) beat-frequency distortion is caused by the nonlinearity; (4) and a diode detector accepts any signal that is applied to it, including adjacent-channel sound signals or adjacent-channel video.

Two of the shortcomings, the beat interference and the ability to detect whatever is applied to its input, can be reduced to an acceptable level by the addition of traps in the IF stages to reduce the adjacent-channel sound and adjacent-channel video signals. The traps reduce these two interfering signals to such a small level that they do not usually reach the diode to be detected or create interference beats.

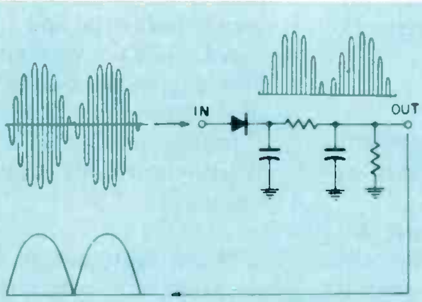

Figure 1 A diode-type video detector operates by rectification of the incoming IF-signal sine waves. Output of the diode consists of dc pulses that are smoothed by the resistance/capacitance filter to form the original modulation.

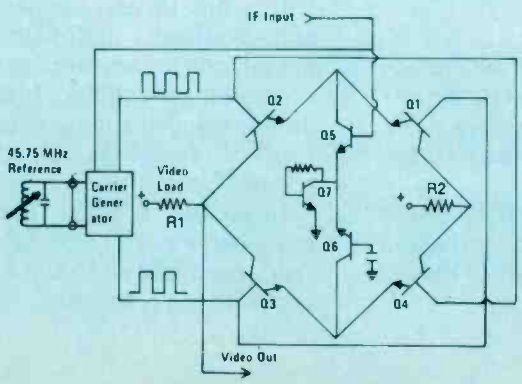

Figure 2 This is a simplified schematic of a typical synchronous detector. Transistors Q5, Q6 and Q7 form a differential amplifier. Q7 is called a *constant current source,* and maintains the total Q5 and Q6 current at a fixed level.

The 920KHz beat interference created by the mixing of the 42.17MHz color carrier and the 41.25MHz sound carrier is more difficult to reduce in the detected video, because this frequency is in the middle of the video spectrum. This 920KHz beat is reduced by trapping the sound signal to an extremely low level and removing the signal before it reaches the video detector. The sound then must be detected with another diode to change it from 41.25MHz to the 4.5MHz IF signal that is amplified in the sound IF circuits.

The effects of the diode on linearity of the detected signal can be reduced by increasing the applied signal level. The non-linear portion, which includes the threshold voltage and knee of the diode, will then be a small part of the overall signal. This will reduce the effect, but not eliminate it completely. This means that the IF stages will have to provide more gain. Yet high-gain stages in the IF often add more distortion and noise to the detected signal.

Technically, the simple diode is not the best choice for a video detector, but until recently, it was the only economical answer for the design engineer.

The synchronous detector required about 50 additional parts, including closely matched transistors and resistors. IC technology has made the synchronous detector economically feasible for the design engineer to use in TV receivers. It is, for example, easy to make the matched transistors that are required for the synchronous detector on an IC chip.

Operation of synchronous demodulators

Attempting to understand the operation of the synchronous detector all at one time is complicated by


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air cooled
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service manual
SMALL AC
GENERATOR
service manual
Outboard motor
Chain Saw
service manual
board motor

Demodulation

the three distinct circuits that perform completely different functions. These circuits are: (1) The carrier generator; (2) the bridge made up of the four "carrier switching" transistors; and (3) the differential amplifier.

In Figure 2, transistors Q5, Q6 and Q7 form a differential amplifier. Q7 is called a **constant-current** source; the heart of a differential amplifier. Its only job is to provide a regulated amount of current through both Q5 and Q6.

A differential amplifier schematic drawn without the switching bridge

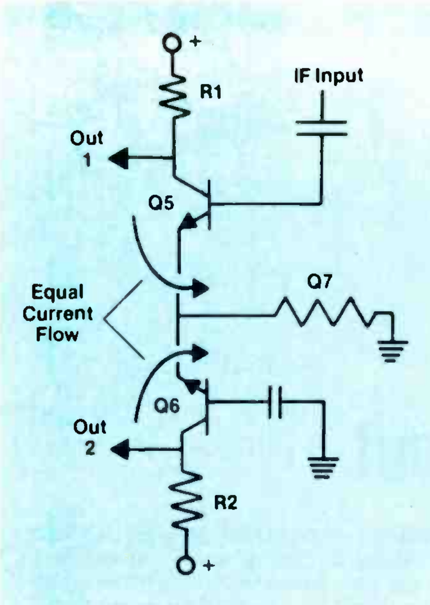


Figure 3 These are the current paths when the differential amplifier has zero signal at its input.

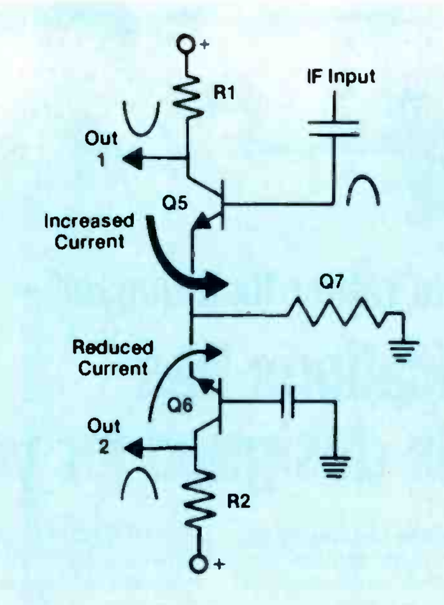


Figure 4 A positive-going signal at the IF input increases the Q5 current and equally decreases the Q6 current. The Q7 current remains fixed.

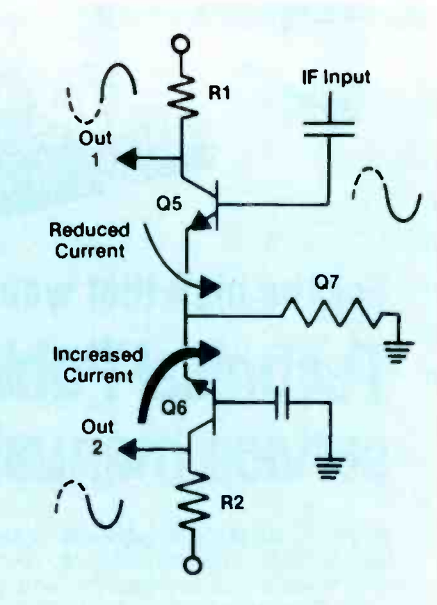


Figure 5 A negative-going signal reverses the current pattern, with decreased Q5 current and increased Q6 current. Again, the Q7 (total Q5 and Q6) current remains unchanged.

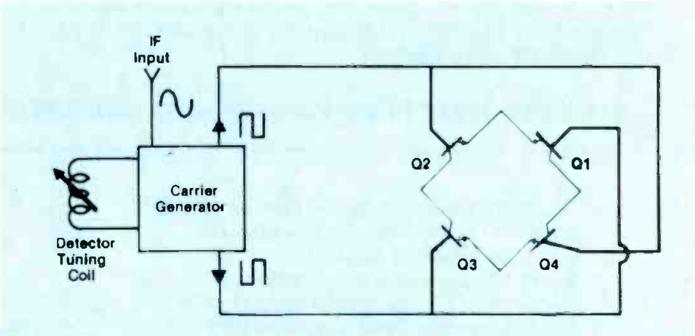


Figure 6 This simplified schematic shows only the carrier generator and the four switching transistors.

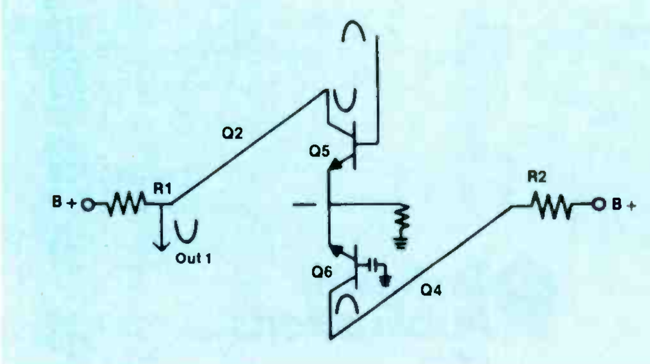


Figure 7 The four switching transistors operated essentially as on/off switches. Therefore, with the conducting transistors shown as a wire and the nonconducting transistors omitted, this is the bridge action during a positive half-cycle of the IF signal.

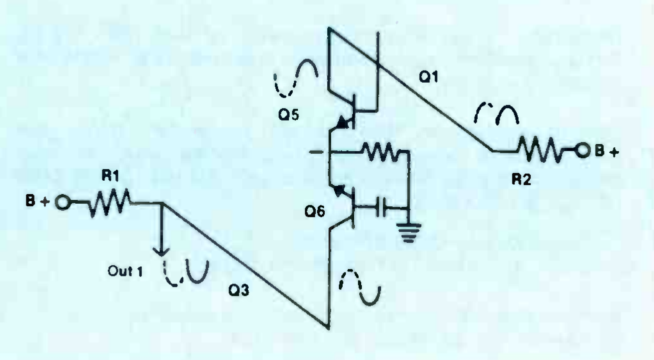


Figure 8 During the negative half-cycle of IF signal, the switching transistors and differential amplifier have these output signal polarities.

steps (Figures 9 and 10) with minimum overshoot on the steps.

5. Adjust the balance of the IF stages in the normal manner, starting with the sensitivity adjustment of the tuner and first IF input, then the second IF for proper balance.

NOTE: Do not adjust any of the synchronous detector adjustments for IF response. The signal shaping occurs in the IF stages and not in the synchronous detector.

Aligning a Zenith with limiter coil

Used this method for Zeniths with limiter coils:

1. Adjust the *detector-level-control* for +8.5V at test point C1.

2. Connect the VA-48 RF/IF cable to the input of the third IF stage and adjust the RF/IF switch to the third-IF position. Use the special bandpass-output point on the IF circuit board. Adjust the RF/IF-level control for a stable output signal. Do not be surprised that the pattern is stable at only one setting of the level control, because the injection follows the AGC-controlled stages.

3. Adjust the limiter coil for the least amount of overshoot on the low frequency bars and stairsteps. Be sure not to compress the sync pulse.

4. Adjust the 45.75MHz oscillator coil through its entire range and note the two points that the oscillator drops out or goes out of sync and produces noise. Set the slug of the 45.75MHz oscillator coin halfway between these two points for best operation and aging of the circuit components.

5. Move the VA48 RF-IF cable to the UHF input on the VHF tuner and adjust the IF stages for the proper response of the bar-sweep pattern at the video-detector output, with the VA48 RF-IF selector set to the tuner-sub position.

NOTE: It is recommended that the amplitude of the last two bars (3.02 and 3.56MHz) be kept to about 70% in amplitude when compared to the 0.188KHz reference bar. This will provide the best high-frequency detail and more closely match the bandpass of the video amplifier circuits in the receiver.

Correct reference and limiter adjustments are shown by the Figure 11 waveforms, while incorrect adjustments are shown by Figure 12 and Figure 13. □

Zenith vertical-sweep system

By Carl Babcoke, CET, Electronic Consultants

The vertical count-down and deflection system in a Zenith System-3 color TV receiver has few components, and it appears to be simple. However, the simplicity is possible only because of a sophisticated-design integrated circuit. Explanations of circuit operation are followed by troubleshooting tips and methods.

Excellent vertical linearity (Figure 1) is provided by the vertical-sweep circuit in each 1981 Zenith System-3 color receiver. This is coupled with an outstanding stability achieved without any critical components or adjustments.

All transistors of previous designs (except the power outputs) have been replaced with one integrated circuit (IC2126). The vertical components are on the lower half of module M2 (Figure 2). Replacement of module M2 should solve all vertical malfunctions, except those from yoke or power-supply defects.

Although the troubleshooting of vertical-circuit failures appears to be unnecessary because module exchange is so easy, there are two important reasons for understanding the stage-by-stage vertical deflection. First, the circuits are unique and radically different from previous designs. Therefore, they should be interesting to all technicians who want to understand these newer solid-state designs. Also, after the manufacturer's warranty has expired, repairs at the component level will be profitable for technicians who know troubleshooting methods and understand the circuit operation.

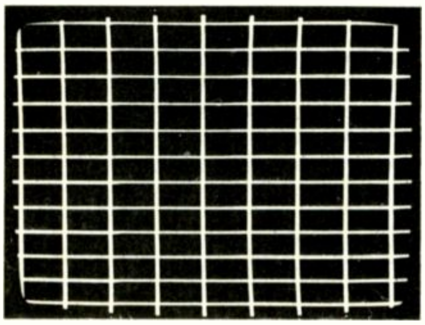


Figure 1 A crosshatch pattern shows that the System-3 Zenith vertical linearity is good. Only one vertical control is supplied: the height adjustment. The circuit automatically corrects for minor linearity changes, even during extreme height adjustments. No locking control is needed because of the countdown operation.

Countdown and driver operation

The Figure 3 schematic shows the complete vertical-sweep system of module M2 plus the yoke. Also included are important waveforms, along with dc and peak-to-peak ac voltages.

Both vertical and horizontal drive signals begin with the 503kHz oscillator on M1 module (M1 also has tuners and IFs). This 503kHz signal is sent to IC2126 pin 9 on the M2 module (Figure 3). Frequency dividers in IC2126 produce 15734.4Hz for horizontal drive (pin 11 signal sent to M10) and 59.94Hz for vertical deflection (pin 6 signal for Q126 base).

Notice that malfunctions of vertical and horizontal sweep can occur in M1, M2 or M10 modules.

IC2126 also selects standard or non-standard operation of the vertical-drive signal coming from pin 6.

Almost none of the countdown or mode-selection operation in IC2126 can be tested. Therefore, the following explanation is based on the Zenith TP24 Technical-Training Program.

Zenith lists three improvements for the System-3 vertical countdown system. (1) Vertical pull-in is virtually instantaneous following channel changes. (2) Vertical stability is better with non-standard video signals, such as video games, CATV signals and videocassette recorders (especially in the speed-search mode). (3) Horizontal and vertical start-up is more dependable at low line voltages.

The vertical-count-down (VCD) frequency range during non-standard operation has been increased from 46-64Hz to 46-86Hz. The internal phasing circuit identifies whether the video signal has the standard 525 lines per frame, and a noise detector has been added to help identification of video.

One of two countdown modes is chosen automatically by the IC. Standard operation is selected when the signal conforms to broadcast specifications. The non-standard mode is used for other types of video signals, particularly those not having a phase-locked 262.5-to-one ratio between horizontal and vertical sync.

Standard-mode operation—The standard mode is selected by IC2126

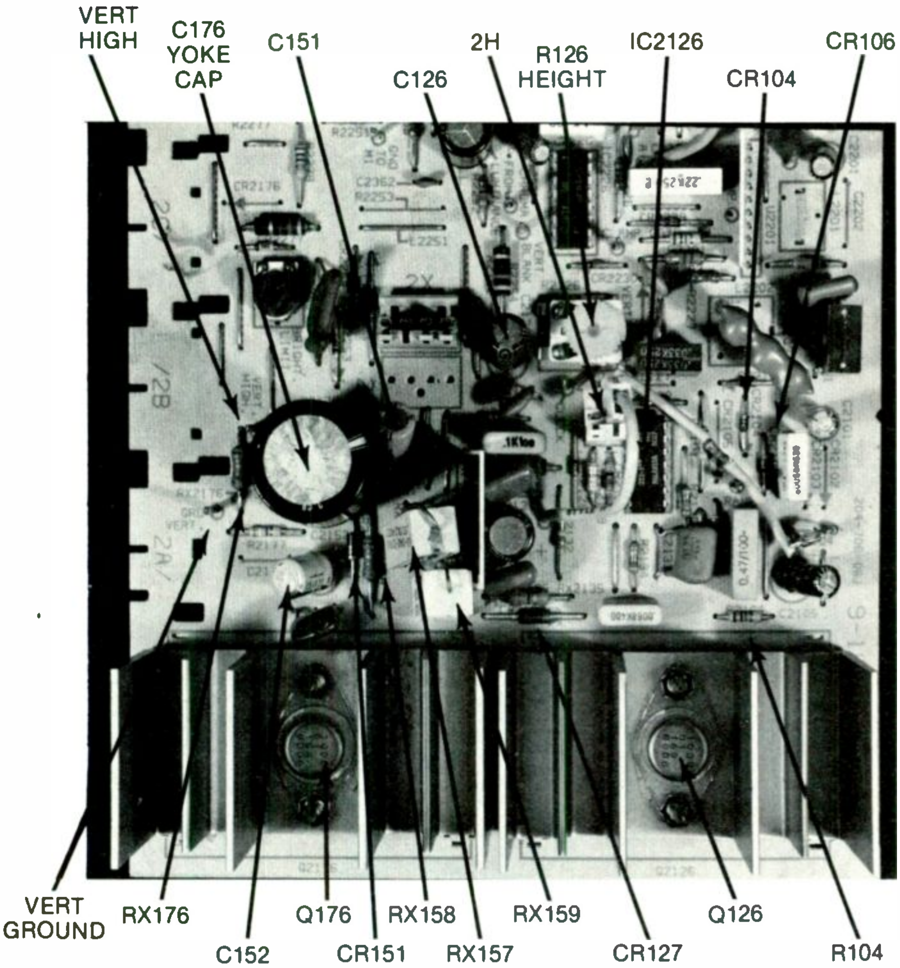


Figure 2 Arrows point out locations of important vertical-deflection components on the M2 module.

when it finds equalizing pulses in the composite sync plus a coincidence between the internal divider 525-count and the vertical sync at IC2126 pin 12. The correct phase-locked vertical-drive signal at IC2126 pin 6 is obtained by internal dividers from the horizontal-drive signal at pin 11.

Phasing between the sync pulse and the vertical-drive signal is compared, but not during all fields. Therefore, noise cannot cause instability. Seven consecutive samples of in-phase signals cause non-standard operation to be switched to standard operation, and eight consecutive samples of out-of-phase sync and sweep will cause a change to non-standard operation.

Noise is made up of many narrow pulses that can simulate erratic vertical-sync pulses. Therefore, noise pulses in standard broadcast video might be interpreted as non-standard sync, thus producing an unwanted change from standard operation. To prevent this, a noise detector has been added. When the detector shows that noise is present, the circuit searches for equalizing pulses. If equalizing pulses are found, the switch to standard operation is made. Otherwise, non-standard operation is selected.

Non-standard-mode operation—The countdown system counts the number of equalizing pulses during the vertical-drive period. Nine or more equalizing pulses counted by the mode-recognition circuit are usually sufficient to identify a signal as standard.

A non-broadcast signal, however, might have the correct number of equalizing pulses but not have 525 lines of video per frame. Standard operation is not desired for such signals. An improved phasing circuit identifies this situation and forces the countdown system to operate in the non-standard mode.

IC2126 voltages and signals

General functions of IC2126 and some of the signals have been discussed. Practical troubleshooting

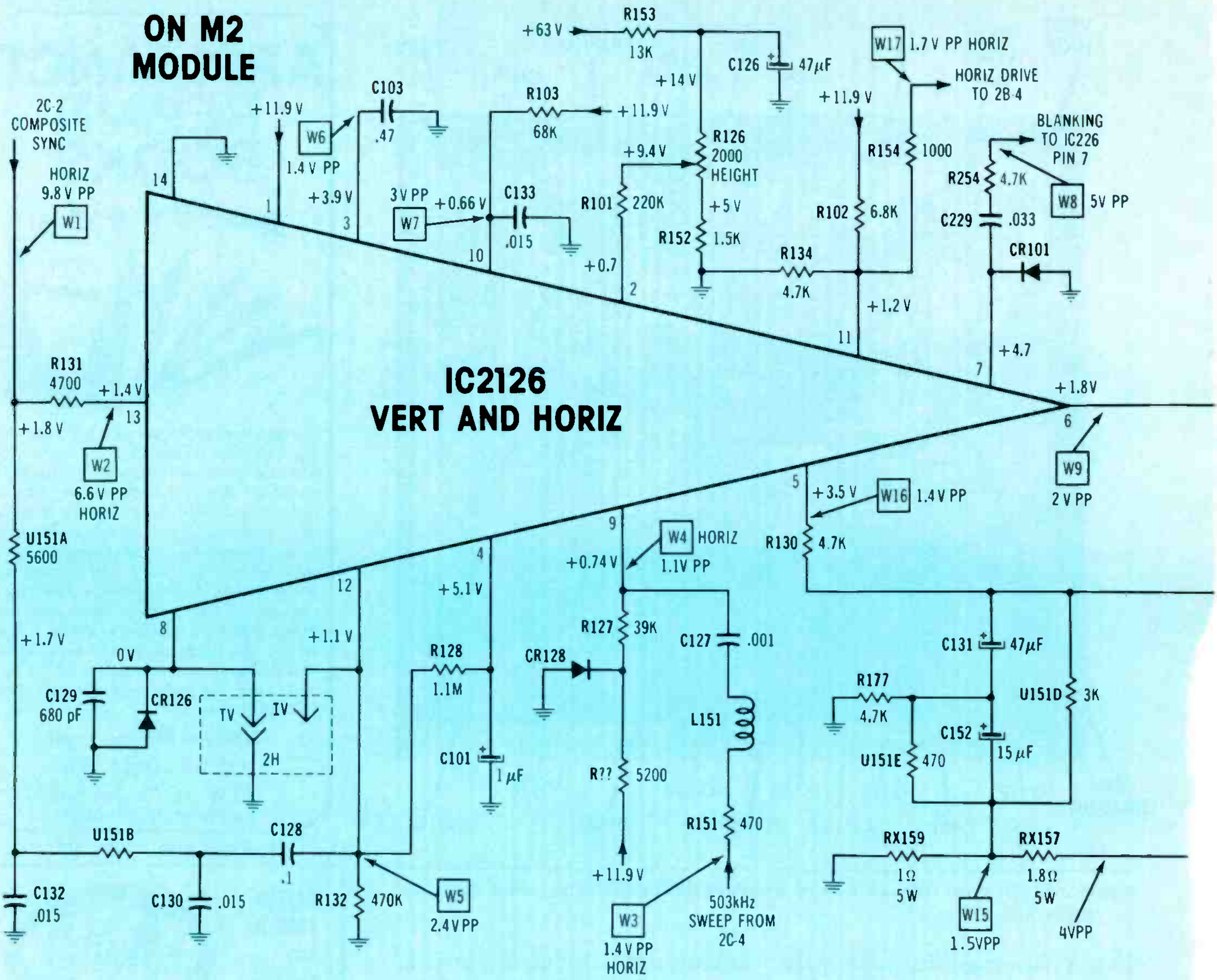


Figure 3 This schematic of the complete Zenith System-3 vertical-sweep system includes dc voltages and waveforms measured in the sample receiver. All waveforms were photographed at the vertical-sweep rate except W1, W2, W3, W4 and W17.

Vertical sweep

demands more. No IC can operate without supply voltage, for example. Pin 1 should have about +12V, while pin 14 is the IC ground return. These should be tested first.

Unfiltered composite sync enters IC2126 at pin 13. This is the source of equalizing pulses needed for identification of standard video. After filtering by U151A/C132 and U151B/C130, the resulting vertical sync reaches pin 12. It is used for comparison with the divided vertical signal. The function of pin 4 is obscure; perhaps it is merely the source of positive voltage for pin 12.

IC2126 pin 9 accepts the 503kHz sinewaves from M1 module. Incidentally, the pin-9 wiring of Figure 3 is different from the Zenith schematic because it conforms to the actual M2 wiring. A later modification probably accounts for the discrepancy.

Pin 5 has a waveform (taken from the low end of the yoke winding) that corrects for vertical nonlinearity.

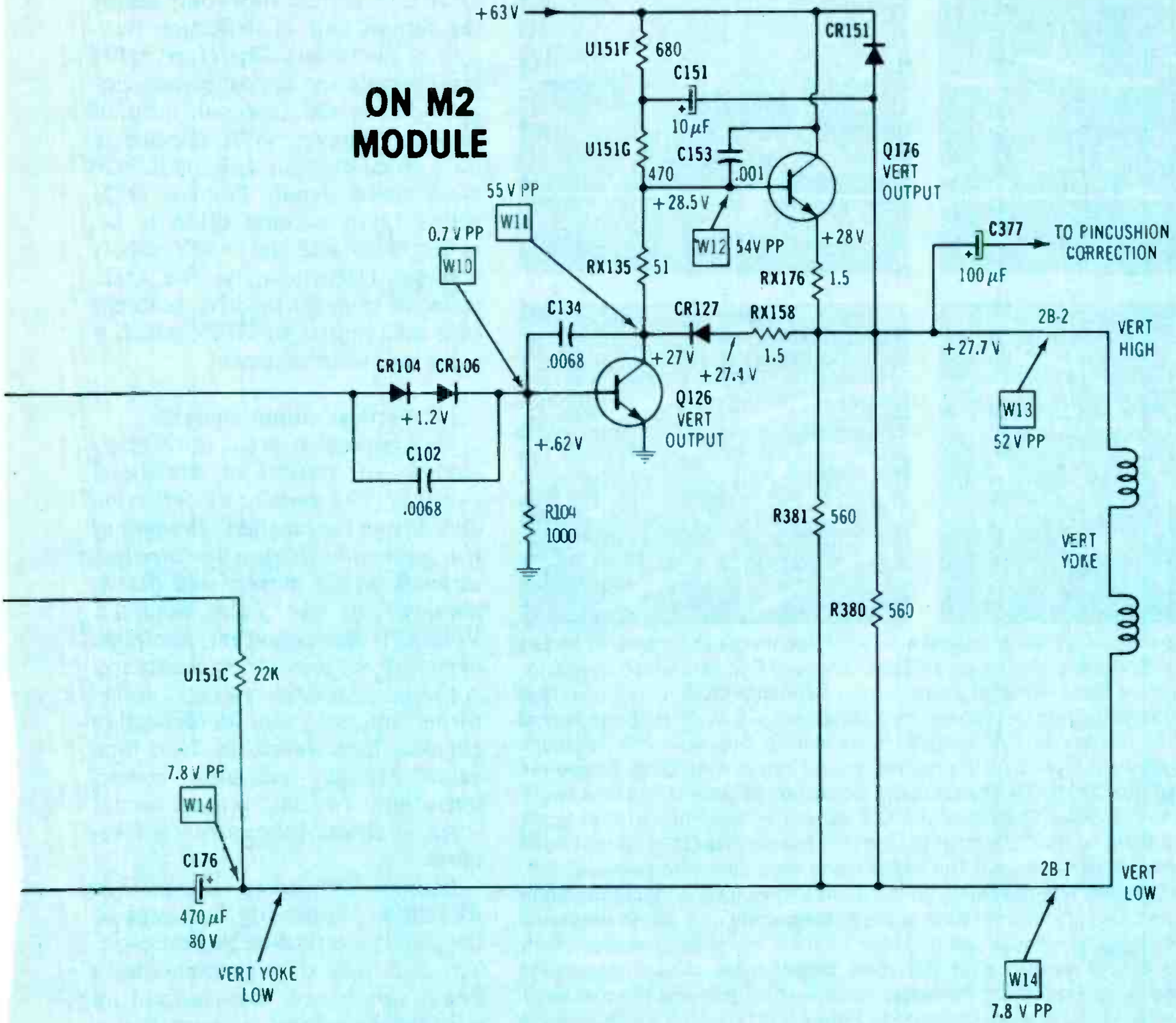
Waveform W6 at pin 3 is a sawtooth for comparison with the yoke's sawtooth of current. Differences between the two sawteeth produce linearity correction.

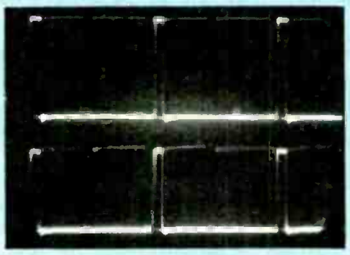
Pin 10 has narrow positive-going pulses (W7) without any clear function. Probably the bypassed Vdc is essential while the waveform is incidental.

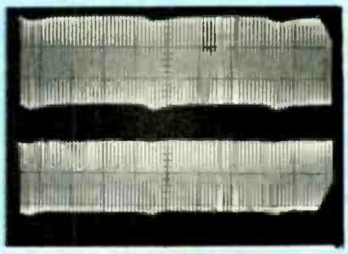
Variations of pin 2 dc voltage (by the height control) produce the desired picture height. The small waveform found there apparently has no function.

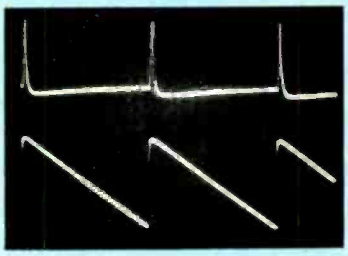
W8 at pin 7 becomes vertical blanking when it is applied to pin 7 of luminance IC2226.

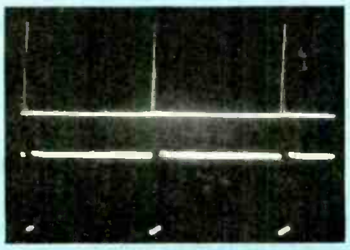
Vertical-drive waveform W9 at pin 6 appears to consist only of negative-going pulses with a small sawtooth on the right. Waveform W13 at the sweep output has positive-going pulses and a smaller sawtooth. It appears logical that the output transistors (Q176 and Q126) merely invert and amplify the W9 drive waveform, while any minor discrepancies between input and

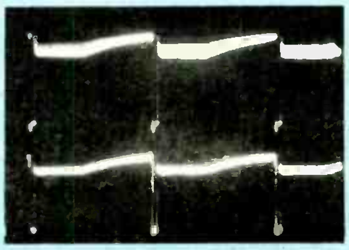


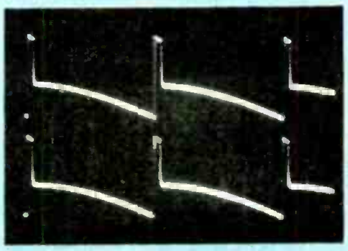

W1H
W2H

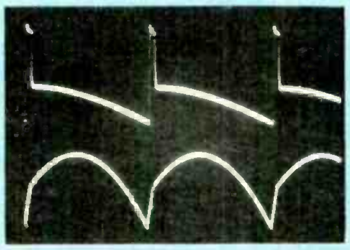

W3H
W4H

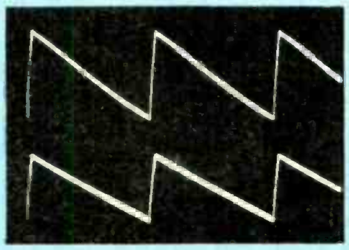

W5V
W6V

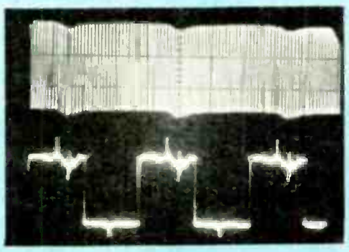

W7V
W8V


W9V
W10V


W11V
W12V


W13V
W14V


W15V
W16V


W3H
W17H

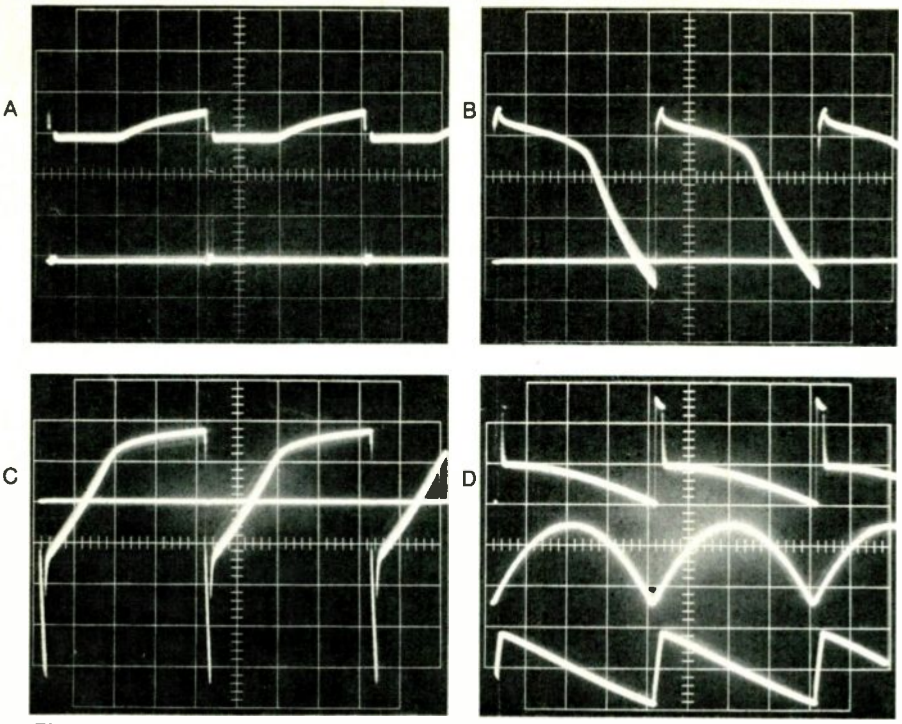


Figure 4 Three of these waveforms have the zero-voltage line to show where conduction should occur. Some waveforms are similar to those in Figure 6, which have additional information. (A) Base signal of power-output transistor Q126 has zero volts at the tips of negative-going pulses, followed by a plateau at +0.6V (that allows almost zero C/E current). Increasing C/E current flows during the sawtooth segment. Therefore, Q126 draws current only during the *second* half of deflection. Scope vertical was adjusted for 0.2V/div. (B) The Q176 B/E signal has about +0.7V at the beginning of the sweep (0.2V/div). Therefore, the C/E current is maximum at that point, followed by decreasing current to zero at the center of sweep. No Q176 current flows during the second half of sweep. (C) The scope leads were connected across diode CR127 to locate the zero line (0.5V/div.). Since diodes have little conduction below 0.6V of forward bias, CR127 does not pass appreciable current until about the center of deflection. (D) These waveforms are included to show the phase between them. Top trace is the output waveform to the yoke, center trace shows the voltage waveforms across C176 (notice the minimum voltage at retrace and the maximum voltage at the center of trace; also, compare to Figure 3 W14, which was scoped to ground), while the sawtooth at bottom is the current waveform through C176 and the yoke.

Vertical sweep

output waveforms are caused by the automatic linearity correction. *Although that conclusion is logical, it is incorrect.*

The Figure 4 waveforms offer first proof that the previous theory has no merit. When the zero-voltage line is added to the Figure-3 W10 Q126-base waveform producing Figure 4A, it is clear that Q126 has zero bias during the vertical-retrace time, followed by insufficient bias for half the sweep time. Therefore, linear amplification is impossible.

Technicians who have followed previous articles of the new color TV series will remember that silicon power transistors cannot develop any appreciable collector/emitter current unless the base/emitter forward bias exceeds about +0.6V. That condition applies here, also.

Because of this, Q126 should have no collector/emitter current until the sawtooth begins to increase the base voltage above +0.6V (at the center of the scope cycle and the center of vertical deflection, also). Figure 6A waveforms show base voltage and emitter current, thus proving that no Q126 B/E current flows until the start of the base sawtooth.

Therefore, the positive pulse in the Q126 collector and the sweep-output waveform cannot come from amplification and inversion of the negative-going base pulses. Evidently, the Q126 base pulses are needed only to turn off the C/E current completely and rapidly at the end of each cycle, which initiates the sweep retrace. Otherwise, Q126 ignores the negative-going base pulses.

Another important conclusion: Q126 C/E current flows only during the second half of deflection (bottom of the raster). Therefore, Q176 must supply the opposite yoke current during the first half (top of raster). However, Q176 appears to have no connection with the IC2126 pin-6 drive signal. Perhaps Q126 drives Q176 because Q176 is between Q126 and the +63V supply voltage. Unfortunately, the Q126 collector *appears* to drive both the base and emitter of Q176, which is not a logical arrangement.

Vertical output analysis

One important point during any analysis of vertical or horizontal sweep is: *The amount of deflection depends on the magnetic strength of the yoke, and in turn the strength depends on the current and the inductance of the yoke windings.* Voltage is not important, except to overcome the losses from resistance. Although specific voltage waveforms are generated in deflection circuits, these waveforms have little value beyond indicating correct operation. In this vertical-output stage, analysis of the *current* is foremost.

Figure 5 shows simplified schematics illustrating five steps of the Zenith vertical-deflection cycle. The multitude of such points have been combined by indicating whether the current is increasing or decreasing, or if the yoke capacitor is being charged or drained. The arrows indicating current flow are placed for the obsolete idea that current begins at the positive source and ends at the negative. Electron-flow purists can imagine all arrows in the opposite direction.

Analysis of continuing operations must assume a starting point. For this analysis, the starting point is the end of the retrace cycle where maximum Q176 current is charging the C176 yoke-coupling capacitor.

Sweep at top—In Figure 5A at the end of retrace and the beginning of trace at the top of the raster, Q126 is drawing zero C/E current because its base voltage is zero (tip of Figure 4A negative-going pulse). Switching diode CR127 also is open, because the cathode is more positive than its anode (Figure 4C).

While Q126 and CR127 are open, the Q176 base receives a large forward bias (Figure 4B) through the combined 1150 Ω resistance of

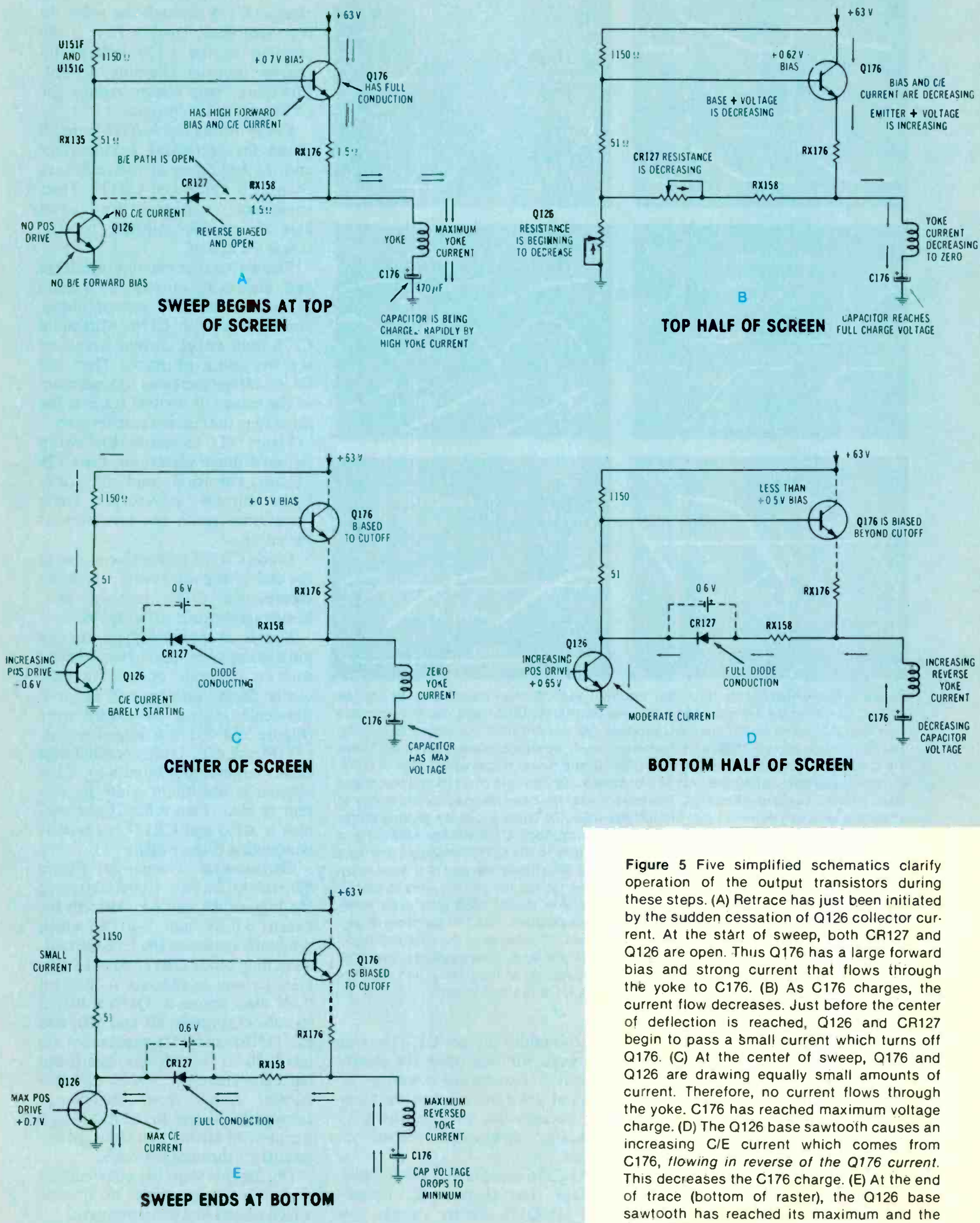


Figure 5 Five simplified schematics clarify operation of the output transistors during these steps. (A) Retrace has just been initiated by the sudden cessation of Q126 collector current. At the start of sweep, both CR127 and Q126 are open. Thus Q176 has a large forward bias and strong current that flows through the yoke to C176. (B) As C176 charges, the current flow decreases. Just before the center of deflection is reached, Q126 and CR127 begin to pass a small current which turns off Q176. (C) At the center of sweep, Q176 and Q126 are drawing equally small amounts of current. Therefore, no current flows through the yoke. C176 has reached maximum voltage charge. (D) The Q126 base sawtooth causes an increasing C/E current which comes from C176, *flowing in reverse of the Q176 current.* This decreases the C176 charge. (E) At the end of trace (bottom of raster), the Q126 base sawtooth has reached its maximum and the Q126 C/E current is maximum. Retrace reverses these steps.

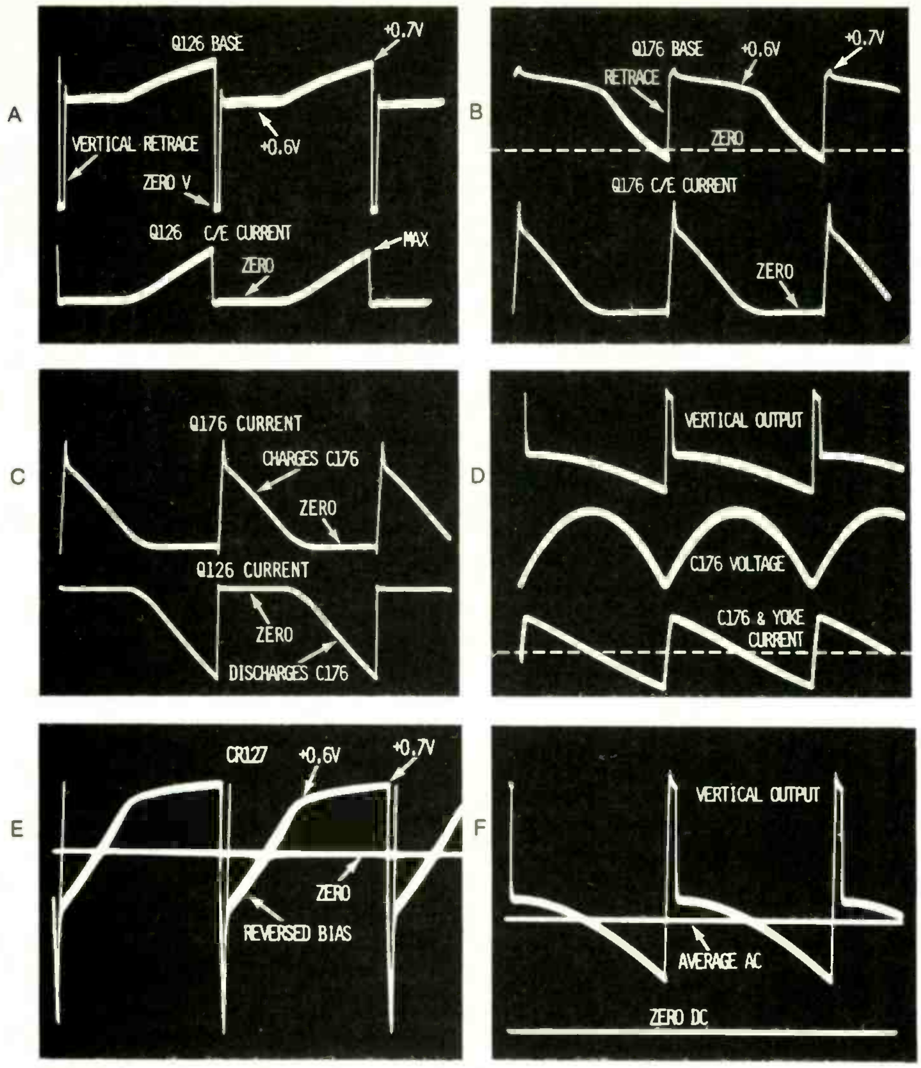


Figure 6 These waveforms have had the faint vertical lines touched up to provide clarity, and voltages are marked on the waveforms. (A) Dual-trace waveforms prove that the Q126 base signal does not produce C/E current until the sawtooth begins. The top trace is base voltage and the lower trace is emitter current of Q126. (B) These are the base-voltage (top trace) and emitter-current (lower trace) waveforms of Q176. Current flows only during the first half of sweep. (C) Currents of Q176 (top trace) and Q126 (lower trace) are compared. The lower trace has been inverted by the scope to show the reversed current flow through the yoke. (D) Triple exposure gives a phase comparison between the vertical-output waveform (top), C176 voltage (center) and the C176 and yoke current (bottom). (E) In addition to the CR127 voltages and zero line, an extra vertical line has been strengthened. This line at the end of retrace has a very short rise time and normally cannot be seen unless the retrace area is greatly expanded by the triggered scope (a B&K Precision model 1535 was used here). Remember that CR127 forward bias (anode more positive than the cathode) is produced largely by Q126 current, and the curve levels off because of the inherent diode-type voltage regulation. (F) An average-voltage line and a zero-voltage line were added by scope to the vertical-output voltage waveform. At the yoke's high side, the voltage never dips below about +3V. Neither is C176 drained to zero.

Vertical sweep

U151F plus U151G (Figure 3 has complete schematic) because the lower legs (RX135 through Q126 to ground, and RX135 through CR127 and RX157 to RX176 at the Q176 emitter) of the base voltage divider are open.

The huge Q176 forward bias produces maximum Q176 C/E current, which rapidly charges C176 through the yoke winding (note the double arrows). Downward-pointing arrows of yoke current represent proper polarity for moving the CRT scanning downward across the screen.

As C176 accepts the charge, its dc voltage rises (Figure 4D, center), and the Q176 emitter voltage rises faster than the base voltage. This reduces the forward bias and decreases the emitter current that charges C176 through the yoke. At the same time, current flow is decreasing as the C176 voltage increases (normal charging action). Therefore, two effects reduce the C176 (and yoke) current.

Sweep during top half—Figure 5B shows the decreasing yoke current and the beginning of the resistance changes in Q126 and CR127. Their equivalent resistances are shown here as variable controls, because that is the action.

Remember that maximum voltage and maximum current in a pure capacitance are 90° out of phase, and so it is with C176. Maximum C176 (and yoke) current occurs at the beginning of trace. Then the C176 voltage increases to maximum at the center of vertical trace at the same time the current reaches zero.

Figure 4D compares the sweep output-voltage waveform, the C176 voltage waveform, and the yoke/C176 current waveform. These waveforms verify the previous explanation.

Diode CR127 begins to conduct at the end of the top sweep, which decreases the Q176 forward bias, hastening the turn-off of Q176.

Sweep at center—Yoke current must completely cease twice during each vertical cycle: once at the raster center during retrace, and again at the center during downward trace (Figure 5C). Q176 is biased to cut-off (Figure 6B), Q126 conduction is barely beginning (Figure 6A), C176 voltage is maximum while its current is zero (Figure 6D), yoke current is zero, and CR127 is partially conducting (Figure 6E).

Bottom-half sweep—In Figure 5D, the Q126 base signal is tracing the Figures 4A and 6A sawteeth between +0.6V and +0.7V, which gradually increases the C/E current. Switching diode CR127 passes sufficient current to produce a constant 0.6V drop across it. Q176 is biased to cut-off (Figures 4B and 6B), and the 1150Ω and 51Ω resistances are too high to furnish any significant current. Therefore, *Q126 collector current comes from the charge previously placed in C176.* Notice the upward arrows that show *reversed* current through the yoke.

During this step, the yoke current gradually increases to maximum, which occurs just before retrace.

Sweep at extreme bottom—Reversed or negative yoke current has

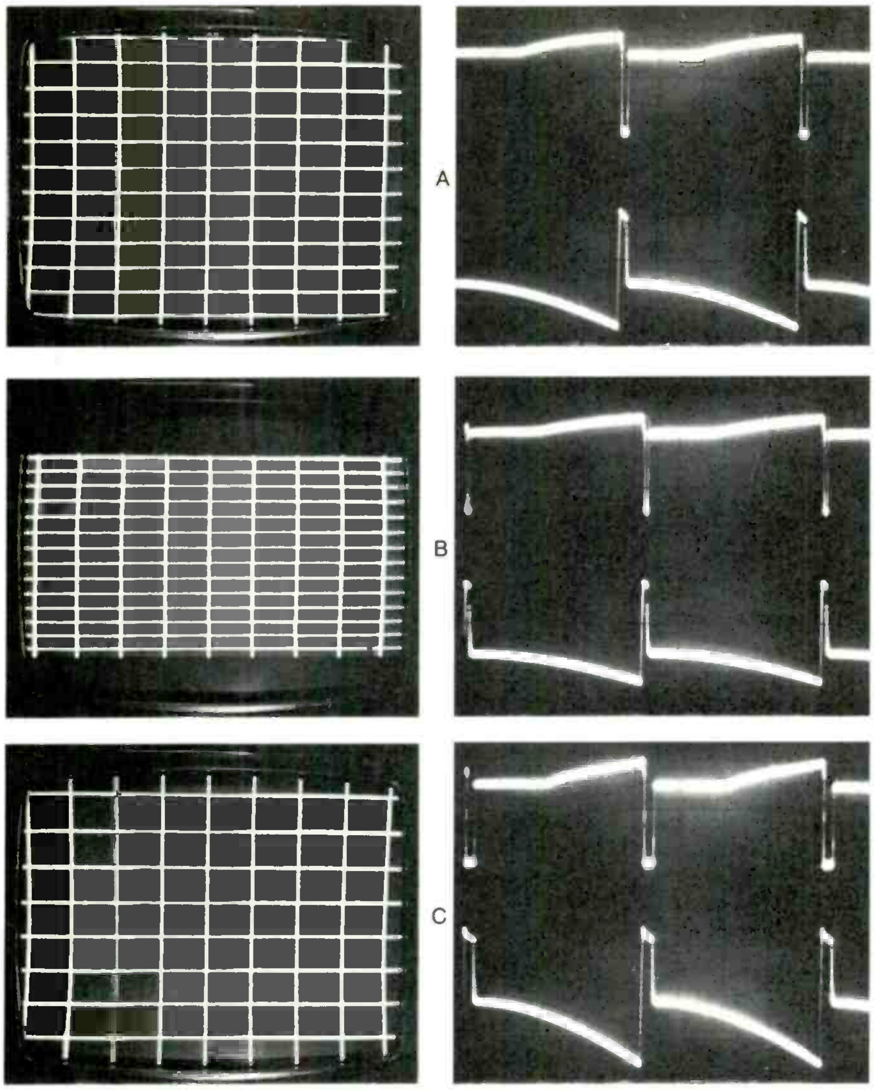


Figure 7 A comparison is made between raster height and sweep waveforms when the height control is adjusted. The television screen shows a crosshatch pattern, while the scope waveforms are the Q126 base (top trace) and the output signal (lower trace). (A) Normal height adjustment produces a full raster with good linearity. (B) Minimum adjustment of R126 reduced the picture height and narrowed the retrace spikes in both waveforms. (C) Maximum height adjustment overscanned the screen and broadened the retrace spikes in the waveforms.

reached maximum (Figure 5E) as the Q126 base sawtooth reaches +0.7V. Q176 remains cut off.

The voltage across C176 measured +31V at maximum (center of sweep) and +23V at minimum (retrace). Thus the capacitor is never completely discharged. Maximum voltage at the sweep output (vert high) is about 32V, and minimum is 13V at the low point of the waveform. These figures neglect the large retrace positive-going spike formed by the collapsing yoke field at the beginning of retrace. This spike is clipped by CR151 (Figure 3) when the amplitude exceeds the +63V supply.

Retrace—The next negative-going pulse (Figure 4A) at the Q126 base initiates retrace by cutting off Q126 collector-to-emitter current. Loss of Q126 C/E current stops the yoke current, thus rapidly bringing the sweep back to the center of the screen. Cessation of Q126 current also removes the forward bias from CR127; this produces a huge forward bias at the Q176 base. The strong forward bias forces Q176 to draw a large current that snaps the sweep back to the extreme top of the screen. This is the point where the description started. This completes one cycle of trace and retrace.

Automatic linearity

Minor nonlinearity is corrected by a sample of the sawtooth yoke current that is taken from the negative end of C176, the yoke-coupling capacitor (see Figure 3).

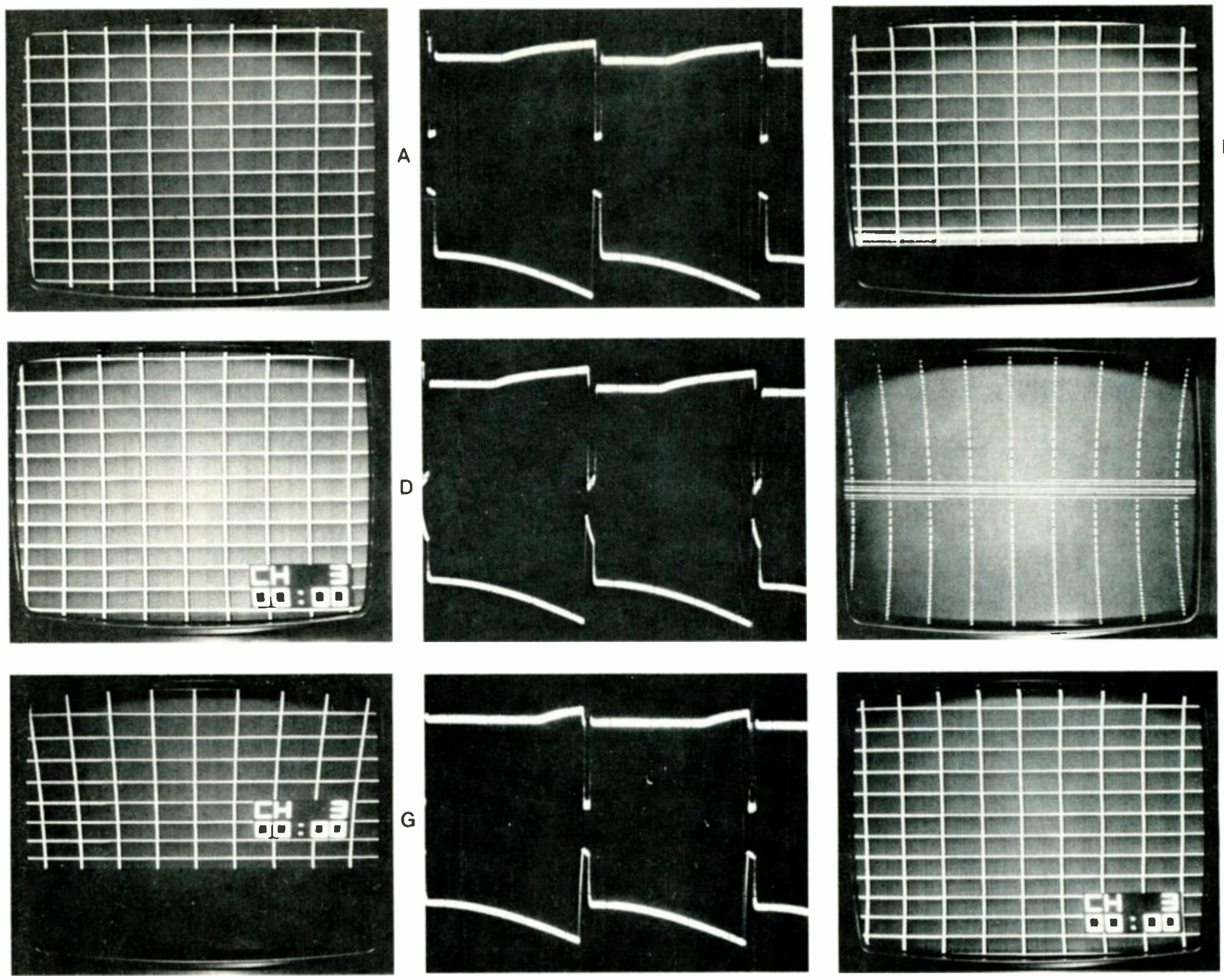


Figure 8 Nine vertical-sweep defects were simulated, the television crosshatch pattern was photographed, and the Q126-base and the sweep output waveforms were recorded. (A) These are normal conditions for comparison. (B) A 5Ω resistance was added in series with the Q126 emitter. This simulates a bad joint to ground. Notice the foldover at the bottom, where Q126 current should be maximum. (C) A 470Ω leakage between the collector and emitter of Q126 produced a loss of top deflection. (D) An open C151 made a slight linearity change. Also, the waveform tips became tilted. (E) A short across RX159 (in the yoke return) removed most of the linearity correction and gave excessive drive to Q126. The non-linear sweep gave tremendous height that obscured the crosshatch. Notice the pincushioning of vertical lines. (F) A 10Ω short across CR127 gave top foldover. A 2Ω short increased the foldover. (G) Reduced height at the bottom, but no foldover, resulted from a 47Ω leakage across C176. Notice that the Q126 conduction occured too late. (H) A 47Ω leakage across the collector and emitter of Q176 made little change in the crosshatch, but Q126 evidently was forced to conduct over about 80% of each cycle. It is likely Q126 would operate too warm and eventually fail from this defect. (I) Leakage of 2700Ω across C131 (in the linearity-correction signal to IC2126 pin 5) produced top retrace foldover and highly distorted scope waveforms.

Vertical sweep

A waveform of yoke *current* can be obtained by adding a low-value resistance in series with the yoke coil. The current causes a voltage drop across the resistance, producing a *voltage* waveform identical to the current waveform.

In a System-3 Zenith, the current waveform is obtained across RX159, a 1Ω, 5W power resistor. This waveform (W15V) is modified slightly by C152 that is paralleled by 470Ω U151E, then is passed through C131 and R130 to pin 5 of IC2126. Resistors U151D and U151C also play a minor part.

Inside IC2126, the W16V yoke-current waveform is compared to W6V. Only the retrace edges have appreciable differences. From the comparison comes an error-correction signal that affects the driving waveform at pin 6 (W9V).

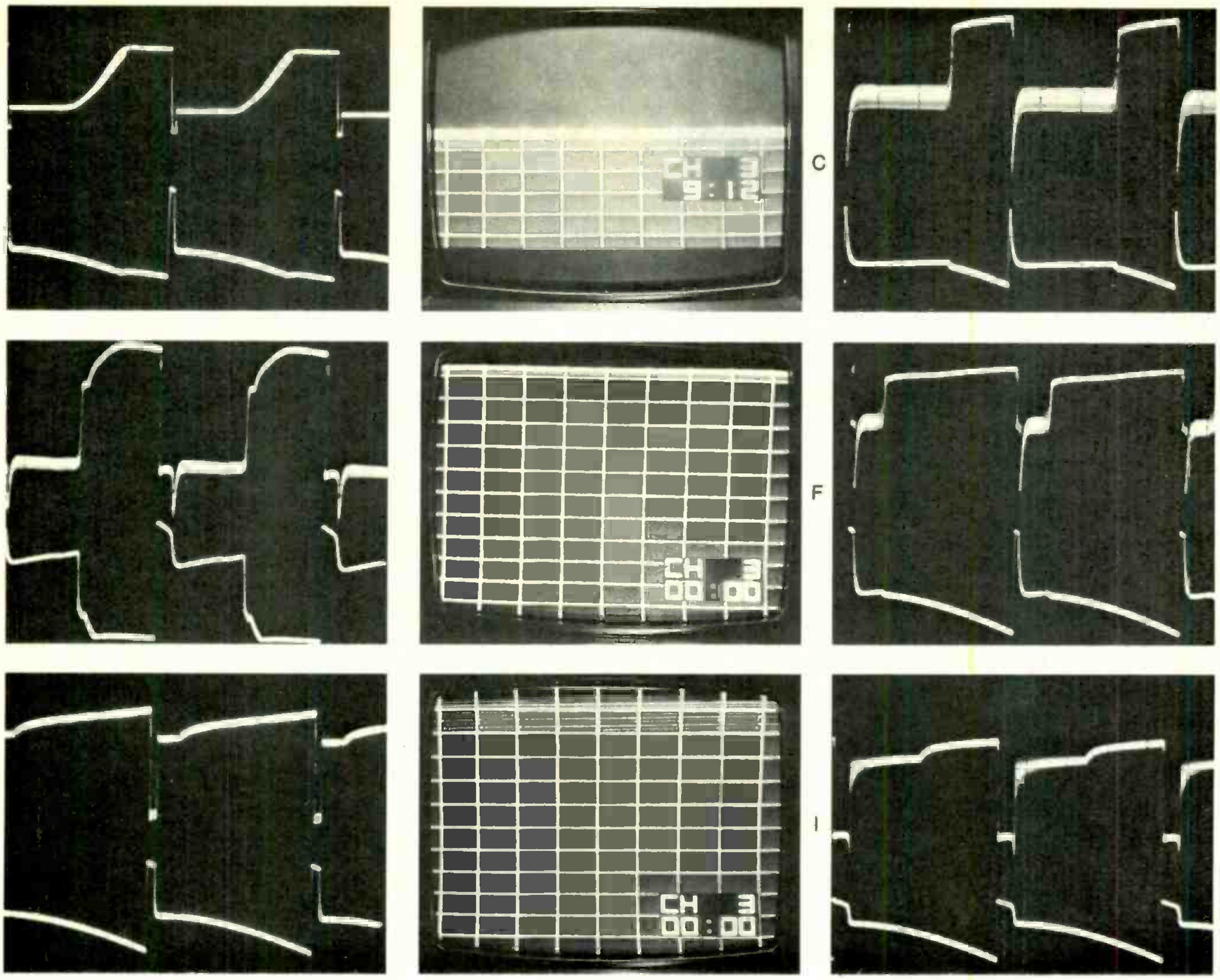
Effects of height adjustments

A crosshatch pattern is best for identifying vertical non-linearity. In Figure 7, a crosshatch pattern reveals the excellent vertical linearity obtained at normal, minimum and maximum adjustments of the height control. There is no linearity control or other adjustment.

Notice that waveforms of the Q126-base signal (top) and the vertical-output signal (bottom) exhibit no significant changes during height adjustments except for variations in the width of pulses that occur during vertical retrace.

Q176 drive

The operating principle of this output stage is completely different from previous complementary push-pull stages. Q126 is driven by the in-



tegrated circuit in conventional fashion. But *the IC does not drive Q176.* In Figure 3, it appears that the collector of Q126 drives either the base or emitter of Q176 (it is connected through components to both). Even that is an illusion.

Actually, Q126 and CR127 together operate to heavily bias the Q176 base at the center of retrace. This step is precisely triggered. However, the turn-on of Q176 requires the turn-off of Q126. Q126 and Q176 operate alternately. Consequently, it is not possible for one to supply the other with a drive signal. After Q176 is triggered into full current by Q126 and CR127, it has a gradually decreasing current without interference from Q126 or CR127 until shortly before the zero-current center of sweep. At that point, Q126 and CR127 operate to make a proper transition from Q176 current to Q126 current through the yoke. The circuit cannot operate properly without a nondefective CR127 diode.

Troubleshooting vertical sweep

For the first step, always verify the +12V and +63V supply voltages (Figure 3). Second, measure all dc voltages at the IC2126 pins, comparing them with Figure 3 and the Photofact for this model.

Check waveforms W4H (pin 9), W17H (pin 11), W6V sawtooth (pin 3), W16V (pin 5) and W9V (pin 6). Remember that a serious failure in the Q176/Q126 output stage will distort the W16V and W9V waveforms, even when IC2126 is normal.

Any major overload or short in the Q176/Q126 stage probably will burn open either RX158 or RX176, or both. These should be checked first. Next, an in-circuit transistor or junction tester should be used on Q176 and Q126. Although they are bolted to the module board as though in a socket, the base and emitter pins are soldered to the board. This virtually eliminates any possibility of poor contacts at base and emitter, but the transistors are more difficult to remove. If the transistors remain suspect following the in-circuit tests, remove them for more accurate external tests.

Symptoms of defects

Although it was not possible to verify the symptoms of all parts defects, the accompanying pictures and waveforms showing the symptoms of simulated malfunctions should help guide technicians during troubleshooting of the M2 module.

Figure 8 shows the effects of each defect by the crosshatch pattern on the television raster. In addition, the W10V Q126-base waveform (top trace) and the vertical-output waveform at vert-high pin (bottom trace) are given for each parts defect. □

Multimeter Roundup

This year's roundup features information on digital multimeters as supplied by the manufacturer. For more information, please circle the corresponding number on the Reply Card.

Ballantine Laboratories

Ballentine has available the 3½-digit multimeter, model 3028B. It provides measuring capabilities such as 20mV full scale sensitivity, and is

available with 10μV resolution and measurements down to 10mΩ.

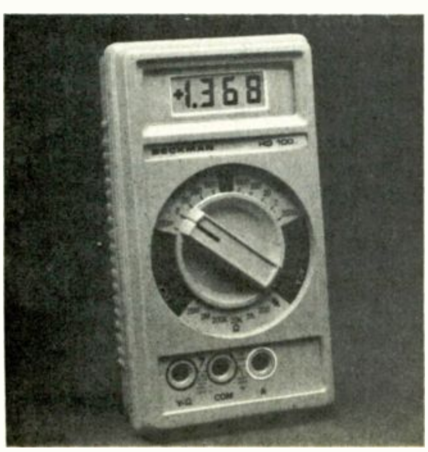
Seven functions and 35 ranges are contained in the portable, RMS responding DMM, which has a 0.43-inch LED display. The multimeter has full EMI shielding and overload protection (without fuses) on all ranges and modes, with overload signaled by a flashing display.

Also available is the model 3036A, 4½-digit DMM, and the model 3030A, 'universal' 3½ digital portable DMM.

Circle (64) on Reply Card

Beckman Instruments Inc.

The rugged HD-100 DMM is designed with a double thick case, and



is shockproof, waterproof and drop-proof. The electronics inside, including LCD and battery, are shock-mounted and have voltage ranges that can withstand 1500Vdc and 1000Vrms, and is protected from 6kV transient for 10 microseconds.

Other features include 2000 hours of battery life, 0.25% Vdc accuracy and single rotary switch operation.

Circle (65) on Reply Card

B&K Precision

The model 2831 is well suited for all types of lab or bench operation. The bright, 0.43-inch-high LED display is visible under all types of lighting conditions and allows for fast, easy reading.

The model, from B&K Precision, a Dynascan Corporation, has a 10 Ω range, capable of 0.01Ω resolution. This range offers the user accurate resistance measurement of switch and point contacts, motor and coil windings, and wire lengths. The 10Ω range provides a means of locating a shorted winding in a transformer, motor or coil.

Circle (66) on Reply Card

Model 2845

B&K Precision, a Dynascan Corporation, has available the model 2845 autoranging, hand-held digital multimeter.

The minicomputer-controlled

DMM has an autoranging feature, dc accuracy of 0.1%, and a 3½-digit LCD display. Uncomplicated, the model requires no range switch; a single pair of test jacks is used for all measurements. Additional features include: RF shielded; overload protected; safety leads and design; 'LO BATT' indicator; operates from one 9V battery or ac; and auto-zero/auto polarity.

Circle (67) on Reply Card

Data Precision Corporation

The model 945 4½-digit, hand-held multimeter measures both ac and dc voltages with a resolution of 10μV up to 1000Vdc and up to 700Vac in five ranges. Both plus and minus are displayed in dc measurements, eliminating any possible ambiguity. Resistance is measured from 200Ω at 10mΩ resolution to 20MΩ in six ranges.

There are five ranges of dc and ac current measuring from 10nA to 2A. Basic accuracy is ±0.05%. Powered by a 9V battery, the unit features a 0.43-inch high liquid crystal display of the high contrast

type. The battery is designed to last 100 hours before requiring replacement. A low-battery light indicates the end of battery life.

Circle (68) on Reply Card

Data Tech

The model 30LC, bench-top portable DMM has six functions and five ranges, and features 3½-digit LCD readout, auto-zero and polarity plus enclosed rotary switch wafers.

Extremely low power consumption allows up to 2400 hours of continuous operation on four D size disposable batteries. The 30LC has

a basic accuracy of 0.1% and features an optional 10A current range.

Circle (69) on Reply Card

DeForest Electronics

The model MM300 is a 3½-digit multimeter with true rms, 0.5-inch LED display and overload indication. The internal 6V, 2.5 AH battery provides seven hours of typical

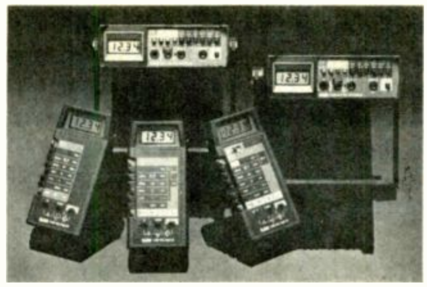
operation. A built-in charger recharges battery to 100% of capacity in 16 hours. Simultaneous operation and battery charge at reduced rate are provided by the ac line adaptor.

Circle (70) on Reply Card

Fluke Manufacturing

John Fluke Manufacturing Company has available a series of hand-held and bench multimeters. The series D multimeters have been designed to meet the test and measurement needs of the service technician, home hobbyist, student or working engineer.

The series is also designed to make it possible for the users of multimeters in these markets to move from a high quality analog



multimeter to a high quality digital multimeter with improved accuracy and ease of use.

In addition to measuring ac and dc current and resistance, various instruments deliver such features as true RMS ac measurements, conductance, diode test and temperature functions, logic level and continuity testing, and peak hold measurements.

Circle (71) on Reply Card

GC Electronics

A 21-range digital multitester (Cat. No. 20-200) is one of several pieces of versatile electronic and electrical test equipment added to the GC line. The tester, housed in an impact-resistant thermoplastic case, has a 19-position range selector switch.

With a 0.5% accuracy mark, GC's digital multitester features zero needle adjustment, automatic overrange, overload protected meter movement and automatic polarity indication. Readout is 7-segment, 4-digit (0.5-inch) LED display.

The 43-range multitester (Cat. No. 20-210) has a range doubler switch for increased current-voltage capability, single-knob range selector and a 4½-inch, 2-color mirrored

scale to prevent parallax errors. It also features protection against accidental meter overload and ±1% temperature stabilized resistors.

Circle (72) on Reply Card

Heath Company

The IM-2215 hand-held portable digital multimeter is designed for use in the field. The unit features high-to-low resistance test voltage for measuring semiconductors and in-circuit resistance, built-in references for in-the-field calibration and a 3½-digit liquid crystal display.

Five ranges allow ac voltage measurement to 75V rms and dc

voltage measurement to 1000V, while the 6-range resistance function spans impedance measurement up to 20MΩ. Ac and dc current is measurable to 2000mA. Push-button switches allow 1-hand operation, leaving the other hand free for probe replacement.

A 9V alkaline battery can provide up to 200 hours of operation while the battery condition is continuously monitored.

Circle (73) on Reply Card

Hickok

The MX series of digital multimeters, designated the MX 331 and MX 333, both provide 0.1% basic accuracy, 10M Ω input impedance and overload protection.

The MX 333 contains two unique features: VARI-PITCH and LOGI-TRAK. VARI-PITCH is a built-in audible signal that changes frequency proportionate to digital readings,

Roundup

and LOGI-TRAK is a self-contained logic testing capability that combines the features of a high performance logic probe and voltmeter in one convenient function.

Circle (74) on Reply Card

Hickok

The LX 304 features an easy-to-read, ½-inch high, 3½-digit LCD display; automatic polarity, zero and overrange indication; 6-month battery life for typical use; simplified 1-hand operation; and rugged construction with excellent overload characteristics for long term reliability.

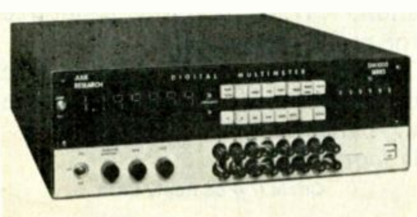
Other features include an automatic decimal point, a built-in low battery indicator, diode and transistor testing capability and 0.5% accuracy on Vdc ranges.

The LX series multimeters are self-contained, with test leads that store in the removable, protective thermoplastic cover. They will withstand a 4-foot drop without loss of accuracy.

Circle (75) on Reply Card

Julie Research

The JRL DM-1000 series digital multimeter measures an unknown



quantity with a linearity and accuracy of ±0.0001% (1ppm) of full scale, and with a measurement time of approximately 1.5 seconds at rated accuracy.

The DM-1000 series digital display consists of seven digits; six significant digits plus a seventh digit which permits 20% overranging. It has BCD output logic levels (T^2L) available for use in conjunction with data loggers, output data terminals or computers.

The DM-1000 series is available as either a bench or panel mounted unit approximately 19"x10½"x8⅜". Weight of the unit is 40 pounds.

A low cost zero to 12V digital voltmeter add-on and a combination of voltmeter and a 1mΩ to 1.2MΩ digital ohmmeter add-on is available. The following range extenders are also available: medium voltage to 1200V; high voltage to 120kV; low voltage to 10nV; current ranges to 1200A.

Circle (76) on Reply Card

Keithley

The model 128 hand-held beeper DMM was recently introduced by

Keithley Instruments as part of an aggresive program of product introductions for 1981. The model 128 is a versatile and low priced beeper DMM, which offers capabilities not found in more expensive models.

The 128 was developed for the industrial and consumer service and repair markets. It offers a 0.5% basic accuracy, 3½-digit resolution (1mV, 0.1Ω), 10A capability, resistance measurements to 20MΩ and five functions.

The 128's beeper feature will operate on all ranges and functions. Moreover, the model 128 will display a reading plus a direction arrow and activate the beeper simultaneously.

The beeper indicates levels above the threshold when set on volts or amps; while on ohms, it indicates levels below the threshold. In all cases, the display remains active so that a precise measurement can be made. A side-mounted switch allows the user to disable the beeper if desired.

Circle (77) on Reply Card

Model 176

Keithley engineers began the model 176 project by determining which capabilities of a bench 4½-digit DMM were really useful, and which just added to the price. The resulting clean design offers the following essential features:

4½-digit LCD display with full range and function accunciators; 0.05% basic accuracy; fully protected from overload; 20kHz frequency response; 100μV to 1000Vac and Vdc; 1μA to 2Aac and Adc; 0.1Ω to 20MΩ; 1000-hour battery life with standard alkaline cells; optional battery eliminator; and externally accessible current protection fuse.

Measurements below 20V are usually more critical than those at higher voltages, so the model 176 has a 0.05% dc accuracy and ac frequency response to 20kHz on the lower ranges. The 176's 20V and 1000Vdc measures are specified at better than 0.1%, while the 200V and 1000Vac are specified to 5kHz and 1kHz, respectively.

Circle (78) on Reply Card

Leader Instruments

The LDM-855 is a 3½-digit multimeter that is suited to both laboratory and field applications.

The unit features an audible tone indication, and fully-automatic ranging and semiautomatic zeroing.

In addition to an automatic polarity indicator and a low battery warning built into the unit, ac and dc current measuring functions are included. A LO Ω function provides a reduced test voltage to lower the risk of damaging components being tested.

The LDM-855 operates for 1000 hours from two internal "C" cells (supplied). An instruction manual and set of test leads is included with each instrument. The carrying handle also serves as a tilt-up stand.

The instrument uses a ⅜-inch,

7-segment liquid crystal display with a maximum of 1999. Reversed polarity is indicated, and over-ranging is indicated by a flashing "1" in the most significant digit position.

All push-button controls are located on front panel, as are the test lead receptacles.

Ranges include dc voltage from 0.1mV to 1000V, ac voltages from 1mV to 1000V, dc current from 10μA to 200mA, ac current from 10μA to 200mA, resistance from 0.1Ω to 2000kΩ.

The LDM-855 measures 6⅛x2¼x4⅞ inches. It weighs 1.1 pounds.

Circle (79) on Reply Card

Model LDM-854

The model LDM-854 true RMS digital multimeter features a wide

range of measurement capabilities, including true RMS ac measurements to 20kHz.

Push-button controls permit the selection of five ac and dc voltage ranges, six resistance ranges and five ac and dc current ranges. Resolutions of 100μV for ac and dc voltage, 100nA for ac and dc current and 0.1Ω for resistance measurements allow use of the LDM-854 where small changes must be observed.

Features of the LDM-854 include true RMS ac voltage and current measurements with automatic zeroing and an automatic polarity indicator. The 0.5-inch LCD display provides a clear, readable display incorporating a "LO BAT" warning indicator. Accessories include the LPS-854 ac adapter, the LP-6 high voltage probe and the CC-854 carrying case.

Dc voltage ranges are 200mV, 2, 20, 200 and 1000V. Accuracy is ±0.2% of reading, ±1 digit. Input impedance is 10MΩ, 100pF. Maximum input is 1000Vdc. Ac voltage (all measurements are true RMS) at 200mV, 2, 20, 200 and 750Vrms. Accuracy at 20Hz to 40Hz is ±1% of reading, ±3 digits.

Resistance ranges offered are 200Ω, 2, 20, 2000kΩ, and 20MΩ. Accuracy is ±0.25% of reading, ±2 digits except 0.75% of reading, ±2 digits on 20MΩ range. Maximum input voltate is 250Vrms or 250Vdc.

The LDM-854 operates from an internal 9V cell, or from 117Vac, 50-60Hz with the optional adapter.

The LDM-854 measures 6⅛x2¼x4⅞. It weighs 1.1 pounds (0.5kg).

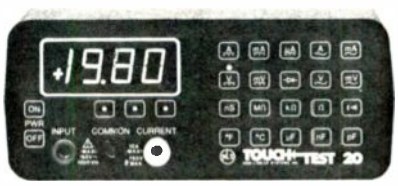
Circle (80) on Reply Card

Non-Linear Systems

A portable/bench-type meter that tests and measures 10 electrical parameters, 20 functions and 44 ranges is available from Non-Linear Systems Inc.

The Touch/Test 20 multimeter measures ac and dc voltage; ac and dc current; resistance; temperature in Celsius and Fahrenheit; conductance; capacitance; and performs diode/transistor and continuity tests.

The model features selection and control of functions, ranges and power; large, 0.55-inch high LED readout; and automatic polarity and overload indication.



Also available is the Touch/Test 21, with a large 3½-digit, 0.6-inch LED readout.

Circle (81) on Reply Card

Optoelectronics

Model TRMS has a 4½-digit LED-readout DMM, giving a basic Vdc accuracy of 0.04% of reading ±1 digit, true RMS Vac and Aac

ranges, a precision C/F thermometer and a choice of ac-line or battery operation.

Circle (82) on Reply Card

Sencore

The DVM56 Microranger from Sencore is an automatic 4½-digit DVM with many features. The

features include automatic range changing from zero to 2kV at 0.075% dc accuracy by switching to dc volts. There is less than a two second wait for even the highest range. Internally protected 2kV automatic measurements can be extended to 10kV with a 10kV probe, included; the decimal automatically shifts. Measurements may be extended to 50kV with the HP200 high voltage probe.

Also available from Sencore is the DVM37 3½-digit, 0.1% portable digital multimeter. The multimeter comes with an unbreakable Cycolac case with aluminum panel and tilt stand carrying handle. The model is fully protected inside by 8kV transient and 2kVdc protection on every function and range, including ohms.

Circle (83) on Reply Card

Simpson Electric Company

The model 465-2 autoranging DMM is a 3½-digit 0.1% DMM that reads out on 0.43-inch LEDs

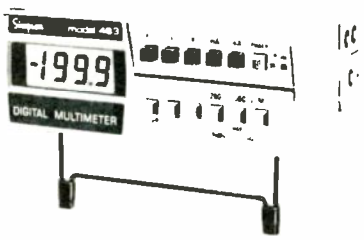
with properly positioned decimal point, auto polarity and zero blanking.

A special hold function allows the user to lock the range in use for faster repeated measurements. All modes are overload protected. The unit is ac operating or battery charging: 120Vac, 220V and 240Vac ± 10%, 50-400Hz, 6VA nominal.

Circle (84) on Reply Card

Simpson Electric Company

The model 463 compact digital multimeter has ½-inch, 7-segment,



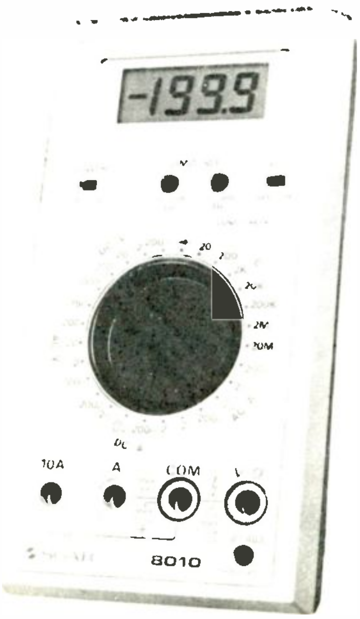
3½-digit LCD for easy viewing in daylight or roomlight. It features up to 200 hours continuous battery operation on a 9V alkaline transistor battery.

The unit features 0.1% accuracy on dc voltage ranges, convenient push-button range and function selection, automatic polarity and zeroing.

Circle (85) on Reply Card

North American Soar Corporation

The model 8010 is a 3½-digit LCD multimeter with basic dc accuracy of 0.1%, which includes high-low limit setting capabilities. The 8010's limit set function can be set by two (one high, one low) front panel adjustable controls. Also, the



unit has a separate diode test position, continuity buzzer, extremely wide resistance measuring range of from 0.01Ω to 20MΩ, plus ac/dc current to 10A.

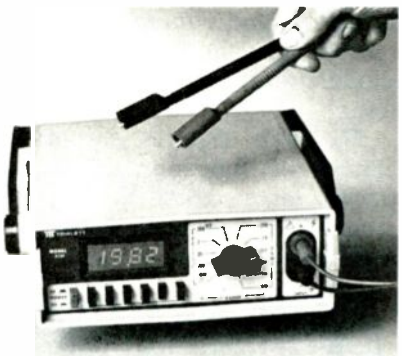
The 8010 is housed in a RFI/EMI shielded ABS plastic case with a single-knob function, range selector switch. A shatterproof transparent window protects the LCD readout from being scratched or accidentally damaged. The unit is supplied with test leads, battery, spare fuse and the company's 1-year warranty.

The model 8025 is similar to the 8010, however the basic dc accuracy is 0.25%. It also has the limit set function on all ranges and functions except resistance.

Circle (86) on Reply Card

Triplett Corporation

The model 4200 digital multimeter features true RMS conversion for improved measurement



of complex ac signals. Unlike typical average-detecting multimeters, the model 4200 computes the true root-mean-square level of a complex ac signal and gives an equivalent dc output level for highly accurate measurements.

Like other 4000 series multimeters, this unit features fuse overload protection to 1000V on all ranges, an easy-view 3½-digit, 0.43-inch LED display, typical accuracy of ±0.2%, 32 ranges, push-button function selectors, single range selection switch with only two input jacks, auto-zero and auto-polarity in the voltage and current modes, plus RF shielding.

Included are safety test leads, a combination carrying handle/bench stand, line cord and instruction manual. It also includes high voltage probes, miniature clip leads for high density circuits, 30Adc current shunt, clamp-on ac ammeter and a man-made leather carrying case.

Circle (87) on Reply Card

Triplett Corporation

The model 3450 is a 24-range battery-operated DMM that has a

special ohms range with audible continuity tone. The unit displays immediate resistance reading with no range change needed, plus has a 0.15% basic dc accuracy.

The special range indicates continuity with a ½ second 80dB musical note, and provides actual resistance measurement if the circuit under test is less than 1000Ω.

The 3½-digit DMM with ½-inch LCD display also features Hi and Lo power ohms; overload protection up to 1000V with special 2A/250V fuse arrangement; no nuisance fuse blows in volt and ohm ranges; and a long battery life of 500 hours with the 9V battery. The display has a low battery indication with 8 hours battery life remaining.

Its single color-coded range selector switch, which permits the model 3450 to be operated with only one hand, selects: 0 to 1000Vdc or Vac in five ranges, 0 to 20MΩ resistance in six ranges and 0 to 200mAac or dc current in 4 ranges.

The unit includes safety designed 36-inch long test leads with screw-on insulated alligator clips, 9V alkaline battery, wire tilt stand, instruction manual and a full one-year warranty. Optional accessories include: carrying cases, clamp-on ammeter with shunt and line separator, and miniature hook test leads.

Circle (88) on Reply Card

VIZ Manufacturing

The WD-762 is a general purpose, bench/portable digital multimeter designed with advanced LSI circuitry. The large LCD display clearly indicates both the numerical value and unit of measurement.

The WD-762 can measure up to 10A of ac or dc current. The full range of high or low power ohms is push-button selectable, thus permitting accurate in or out of circuit resistance measurements to be easily made.

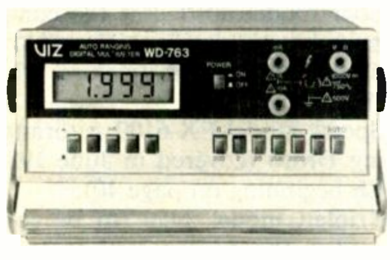
The WD-762 is housed in a fully shielded case so that precise and stable measurements result when used in a high R.F. ambient. The unit is supplied with an ac adapter as standard equipment. An easy access battery compartment and holder for four "C" size cells is located in the rear panel.

Circle (89) on Reply Card

VIZ Manufacturing

The WD-763 is an autoranging general purpose, bench/portable digital multimeter that features an AUTO-RANGE mode. This mode is especially useful when functions of unknown level are to be measured.

The ac and dc current ranges are available in manual range only. The



manual range selection buttons when depressed can act as a "range hold" switch, or the unit can function like an ordinary manual range digital multimeter.

The WD-763 can measure up to 10A of ac or dc current. Full range high or low power ohms is push-button selectable, thus permitting accurate in or out of circuit resistance measurements to be easily made. The WD-763 is housed in a fully shielded metal case so that precise and stable measurements result when used in a high RF ambient.

Circle (90) on Reply Card

Weston Instruments

The model 6504 microcomputer-based portable digital multimeter is a 4½-digit, LCD-display instrument that offers a full complement of measurement and computation facilities in a compact, bench-top unit.

The unit offers five-range measurement of dc and ac voltage and current, with true RMS ac sensing, and six-range measurement of resistance. Its basic accuracy of ±0.03% ±2 digits and its wideband ac frequency response (to 20kHz) place it in the forefront of its class.

As a new class of 'intelligent' instrument, the model 6504 not only provides a high level of valuable computing power for field, shop and laboratory operations, but does so in a simple format that is easy to use and understand. Its programmed-in automatic self-checking routines make the operating procedures accurate and foolproof. And the few push-button keys required for computation control are incorporated in the instrument's range and function controls, and in its large LCD readout display, on a panel only 8½ inches wide by 3 inches high.

The unit is available with two standard options: a rechargeable battery that enables complete instrument operation for up to eight hours without ac power, and an IEEE-488 interface bus that permits the instrument to be used with automatic test and data acquisition systems.

Circle (91) on Reply Card

DeForest Electronics

The model MM200 features 3½-digit full overrange, automatic polarity, five functions, 1mV resolution, and fused inputs for protection. The unit has an 8-hour rechargeable battery or can be ac line operated.

Circle (92) on Reply Card

Mura Corporation

The model 80-M is suitable for use where measurements must not appreciably disturb the circuit being tested.

This unit features high 50,000Ω/Vdc and 12,500Ω/Vac sensitivities on most ranges. Special circuitry has been included to protect the meter movement against accidental overload.

Dc voltage can be measured on any one of seven ranges, while dB and ac voltage measurements can be made on six practical ranges. Also included are four dc current ranges and four resistance ranges.

In conjunction with a power supply, the 80-M can be used to measure capacitance and inductance. A mirror scale has been provided to help eliminate parallax errors from readings.

A convenient carrying handle built onto the case can also be used to position the meter for easy readings. Built in a high-impact case, the multimeter is available with an optional pouch, model H-8P.

Circle (93) on Reply Card

Workman

Model B70-036 is a pocket-sized VOM with a leatherette case for tester and leads. Sensitivity is 20K/V for dc and 10K/V for ac measurements. Functions are Vdc, Vac, Adc and resistance.

See your local electronics distributor for more information.

Audio indications in digital multimeters

An audio tone that indicates circuit continuity is helpful during resistance tests to show erratic conditions not properly identified by the slow but accurate digital readout. Other valuable features are also discussed. Photographs shown here were supplied by the manufacturers, and are included to spotlight unique features that solve many measurement problems.

By Carl Babcoke, *CET*

Years ago when the first digital multimeters were offered to the electronic servicing industry, a typical instrument was large, heavy, ac-operated, moderately accurate and susceptible to drift (requiring controls for correction). Also, the units had only 2 or 2½ digits, probably in a Nixie tube. At that time, there were few advantages over the vacuum-tube-voltmeters (VTVMs) that were supreme before solid-state.

Evolution since then has brought LED readouts, which are excellent except for current drain and limited visibility in bright lighting, and 3½ digits for better resolution. Also, almost all modern digital multimeters (DMMs) have automatic zeroing, automatic overrange indication and automatic placement of decimals. These items are superior to their VTVM counterparts. Stability in the presence of stray signals from TV horizontal-sweep circuits or extreme noise levels has been increased. This was a problem with some early DMMs.

Liquid-crystal displays (LCDs) and MOS or CMOS large-scale-integration ICs have reduced the power requirements until a single 9V battery can operate a DMM for 200 to 2000 hours, depending on the model.

A refinement era

The basic functions of DMMs have been improved so efficiently that no additional revolutionary developments appear likely. Instead, these instruments are being improved by the addition of minor (but very important to the technician) features. Originally, VTVMs had several advantages over DMMs, such as: peak-to-peak ac measurements; wide-bandwidth ac readings; better forward-conduction tests of diodes using resistance ranges; the possibility of noticing transient trends by swinging of the analog-meter pointer; and last, shorter settling times before a stable reading was obtained.

Some of these DMM shortcomings have not been alleviated. Only one service-type DMM has peak-to-peak ac readings and decibels, although several laboratory models have these features. Few models have shielded test leads and jacks that are helpful for reducing pickup of extraneous signals. There is no standardization of ac frequency response. Many models specify accuracy only up to about 500Hz. And some DMMs have auxiliary indicators or analog meters to rapidly indicate relative readings, or show peaks and nulls.

Much progress has been made with other items, however. Most DMMs now have both low-voltage and high-voltage ohmmeter ranges that permit conduction tests of solid-state junctions, or apply such a low voltage that the junctions are almost open so the circuit resistances can be measured.

Dual-voltage resistance ranges are a great improvement over high-voltage or low-voltage operation. There is a better combination, however: a diode test of the voltage drop occurring when a constant current flows through the diode, plus a full complement of low-power resistance ranges from 200Ω full scale to at least 20MΩ full scale. Higher ranges are needed also.

This combination of tests gives the best of both worlds. Voltage-drop diode tests operate well in-circuit, including power supplies and output transistors where ohmmeter tests are of little value. Then the ohmmeter operation can be held to extremely low voltages that will not allow even germanium diodes to conduct.

Another area showing progress involves supplying fast indications that supplement the slow but accurate digital readings. It is not unusual for DMMs to require one or two seconds (some range up to 8 seconds) to produce a stable readout. One solution is an audio tone to indicate continuity or other condition.

Audio-tone DMMS

According to manufacturer's specifications and results published in "Reports from the Test Lab" feature, these digital multimeters have some type of audio indication of continuity:

- B&K-Precision model 2845 autoranging DMM (covered in January 1981 **Electronic Servicing** starting on page 21);
- Data Precision model 936 portable DMM (covered in June 1981 **ES** beginning on page 12);
- Fluke model D-804 (picture with this article);
- Hickok model MX-333 DMM covered in February 1981 **ES** starting on page 18;
- Keithley model 135 DMM (to be covered in August 1981 **ES**);
- Keithley model 128 Beeper DMM;
- Non-Linear Systems model Touch-Test-21 (picture with this article);
- Simpson model 467 has visual indication and an analog bar graph (picture with this article) in addition to the audible continuity;
- Soar model 8010 uses the continuity buzzer also for high and low limits of readings (picture with this article);
- Sperry model EX-6100 autoranging DMM (covered in June 1981 **ES** beginning on page 40);
- Triplett model 3450 (to be covered in the August 1981 issue of **ES**);
- and the Weston Roadrunner (it says "beep-beep").

Honorable mention is earned for the Beckman 300 series, which has a visual ohms symbol as an instantaneous continuity indicator, in addition to an excellent diode voltage-drop test.

The gold medal for the most complete and most effective audio-tone indication goes to Hickok for its model MX-333, covered in the

Figure 2 Fluke model D-804 DMM features audio-tone indication of continuity, temperature measurements (with external probe), and a peak-hold mode.

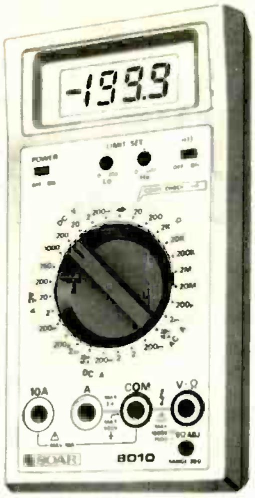


Figure 3 Soar model 8010 has a continuity buzzer, a separate diode test, a shielded case, and basic Vdc accuracy of 0.1%. The distinctive function, however, is testing for high and low limits of reading. Two controls, one for high and one for low, can be adjusted for the allowable limits. If the reading exceeds that range, the buzzer sounds. This is in addition to the usual LCD readout.

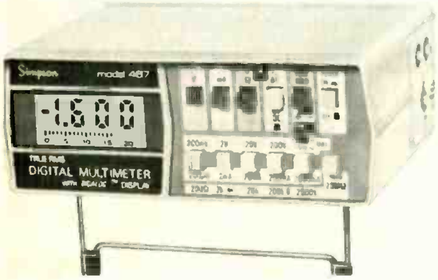


Figure 1 Simpson model 467 has several unique features, including visual and audible indications of continuity, arrows to show a change of signal polarity, true RMS ac readings, pulse identification, and an LCD bar graph to show nulls, peaks and trends.

Figure 4 Non-Linear Systems model Touch-Test-21 has 20 functions and 44 ranges selected by internal autoranging and finger touches to the function symbols on the panel. LEDs indicate the function in use. Additional test functions include: an audible continuity indication; a diode test; temperature readings (with probe); conductance readings; and capacitance values.

Figure 5 Model 945 from Data Precision does not have an audible tone, but has a basic Vdc accuracy of 0.05% and shows a positive or a negative polarity symbol for decreased ambiguity. Perhaps the most unusual feature is that five of the six ohmmeter ranges can be used to test diodes at decaded currents. Open probe voltage is 3.5V. A specified constant current is applied for each range from 0.1μA on the 20MΩ range to 1mA on the 2KΩ range, while the readout shows actual voltage drop across the diode. A list of these five voltages can be made into a 5-point current-versus-voltage curve.

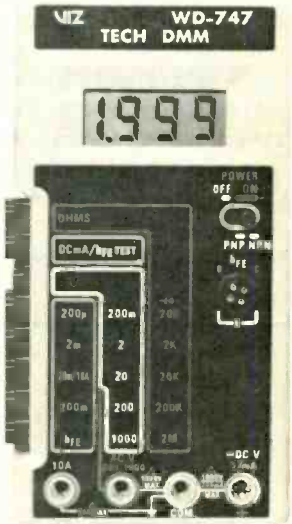


Figure 6 VIZ model WD-747 is a 4-function DMM with tests for PNP- and NPN-transistor hFE gain. A 4-pin socket is provided on the panel for these transistor tests.

February 1981 Test Lab Report beginning on page 18).

Model MX-333 DMM is the only one uncovered by this investigation that varies pitch (Hickok calls the feature **Vari-Pitch**) according to the numerical value of the readout, and that operates on all functions, including identification of pulses in digital signals. The volume of the audio tone is the highest of those tested to date. A good voltage-drop diode test is also supplied.

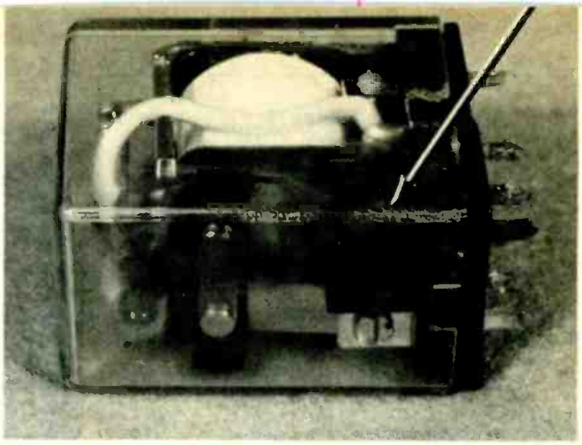
Comments

An effective audio-tone indicator is judged to be a valuable addition to any digital multimeter. Not only does it give a faster indication of continuity, but it allows some tests to be made without requiring the operator to look at the instrument. This is an important point in many practical cases, such as tests made around integrated circuits where an instantaneous short between pins (if a probe slips) can ruin the IC.

An advantage is in checking for intermittent continuity, where the digital readout changes much too slowly. Maximum benefit for these tests can be obtained only with an audio tone that begins instantly and continues until the continuity is finished. Alternately, the tone should begin instantly, and, if it endures for only a short time, should be instantly reset so it can produce separate tone beeps for erratic opens.

Several other important features are illustrated by the pictures and captions. These include: pulse identification (Figure 1); temperature and peak-hold measurements (Figure 2); adjustable high and low limits with buzzer sounding for readings outside those limits (Figure 3); functions selected by touch pads, along with autoranging, plus diode, conductance and capacitance tests (Figure 4); a unique diode test over five ranges (Figure 5); and transistor gain checks (Figure 6). □

Maintenance of relays and solenoids



A **smoked corner** of this relay cover gave evidence of overheated and ruined contacts inside.

Selection of replacement relays and solenoids begins with knowledge of their construction, typical failures and the reasons for early failure.

By Carl Babcoke, *CET, Electronic Consultants Co.*

Relays and solenoids are employed by the millions in industrial, home appliance and home-entertainment electronic equipment. Both relays and solenoids produce physical movement from electrical power, but otherwise there are only superficial resemblances between them.

Solenoids (Figure 1) usually activate a valve or move a lever. The advantage over mechanical methods is that the valve or lever can be moved by an electrical signal from a distance. This allows a more convenient layout of equipment or permits sophisticated control by electric power from a timer, a sequencer, a panel switch or an industrial computer. One uncomplicated example is shutting off water flow by a solenoid-controlled valve when a full tank activates a sensor.

On the other hand, relays use electric power to activate electrical contacts that in turn perform the required switching. A small switch or sensor can control a tiny relay that turns on and off large amounts of power.

Electric contacts fail more often than all other relay parts. Solenoids normally have no contacts;

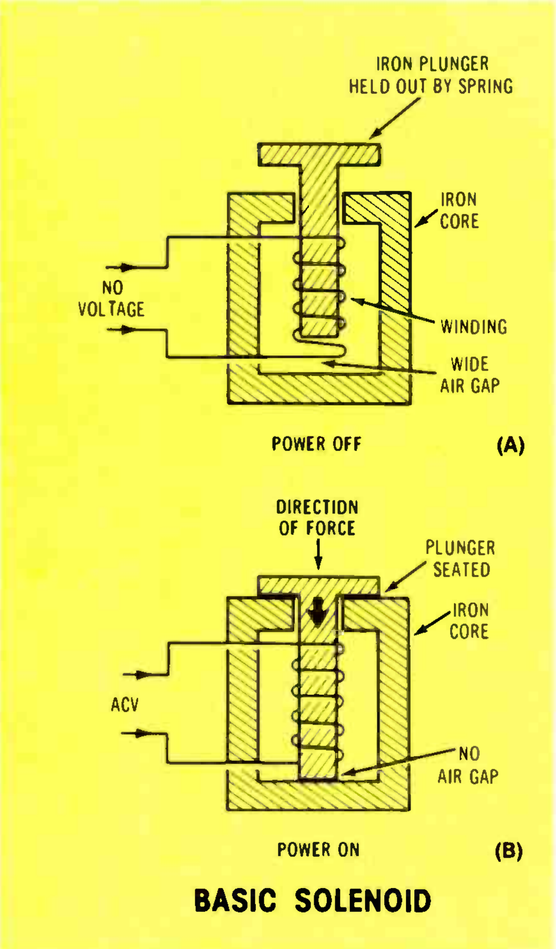


Figure 1 One type of solenoid for continuous-duty operation is arranged in almost power-transformer fashion, but with the center leg of the core made movable. (A) Before power is applied, a spring or a linkage holds the plunger out of the core, leaving an air gap at each end. (B) When Vac power is applied, the magnetic pull between plunger and core pulls the plunger into a tight fit with minimum air gap at the ends.

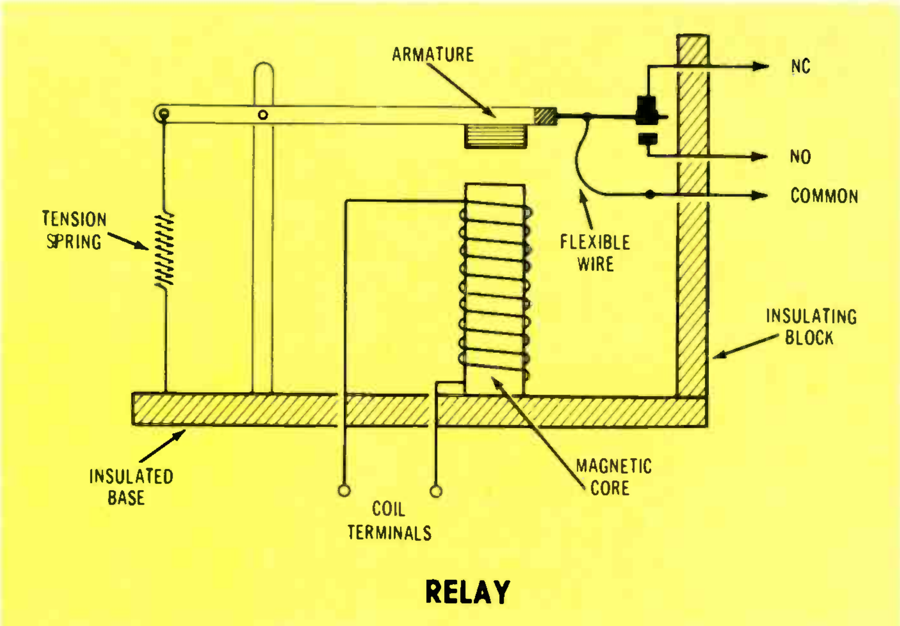


Figure 2 A relay for Vdc operation of the coil is shown. Ac types are slightly different. A magnetic path travels from one end of the core to the other through the metal bracket and the armature to its air gap. When dc power is applied to the coil, the magnetic field across the gap between armature and core pulls down the armature, against the force of the tension spring. Movement of the armature also opens and closes the contacts. The most common defects are burned contacts.

therefore, solenoids require far less maintenance or replacement than relays do.

Relay information

Figure 2 shows a drawing of a typical relay and its basic components. Clearly, the concept is simple, consisting of a pivoting armature that moves one or more insulated switch contacts. When no power is applied to the electromagnetic coil, a spring holds the armature away from the magnetic core. This unpowered condition switches on the normally closed (NC) contacts and opens the normally open (NO) contacts. Application of power to the coil moves the armature nearer the pole piece of the core and reverses the switches; the NC contacts open and the NO contacts close.

The design of relays for dependable and efficient operation over millions of cycles is difficult, however, because it involves many considerations and workable compromises. This dependability must be obtained in hostile industrial environments, yet each relay must be as small as possible and the price must be reasonable.

Many of the design considerations are important, also, in choosing a replacement relay. Therefore, the following general information is for the guidance of electronic technicians.

Contact considerations

Clean metal contacts should provide a milliohm or less of resistance when properly activated. There must be a limit on the current, however, if this low resistance is to be maintained. Excessive current density through the contacts creates heat that can be intense because of the small area. Enough heat can soften the surfaces and create a metallic bridge that becomes a weld under some conditions. A weld causes a short across the contacts, preventing the contact from opening.

These welds seldom form except when a load defect causes excessive contact current. Check the current before replacing any relay that has contacts that are welded together. A good test is to pry the contacts apart, breaking the weld, and then trying the operation. The relay should be replaced, but often it will function well enough to check the load current or other possible causes of failure.

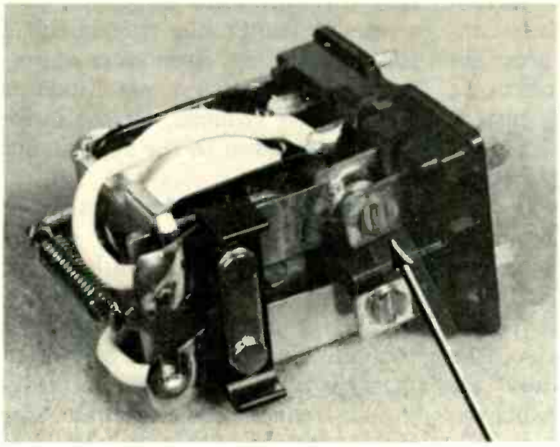


Figure 3 An arrow points to contacts burned by an overload of current. The relay was previously used to protect speakers from shorts in a powerful stereo amplifier.

Particles of solid material can become embedded in the contact surfaces, thus increasing the resistance and the heat. Excessive arcing can pit the surfaces also (Figure 3).

Some solid materials on the contact surfaces can be condensed vapors of Teflon, soldering rosin or metals from brazing, solder, adhesives or salt from finger greases. Excessive amounts can cause contact failure.

Other causes of high contact resistances are surface films from greases, lubricants, plasticisers, hydrocarbons, oxygen or water vapor.

The solid materials directly affect the performance, while the films usually do not interfere until carbonized by arcing contacts. One possible film defect is called *tunneling,* an effect similar to perforation of thin insulation material because of excessive voltage.

These contact defects can occur without arcing or excessive current at the contacts. Almost all contact damage, however, is produced by arcing transients that are present at contact opening or closing. It is imperative for all electronic technicians to understand contact arc suppression.

Arc suppression

Methods for reducing contact arcing to a minimum vary according to the type of load supplied by the contacts and whether the power is ac or dc.

Large starting current

Inrush loads are those that draw a much higher current at the instant of contact closing, followed by normal current. Examples include: on/off switching of a transformer primary; ac solenoids; capacitor-input power supplies; large capacitors used for arc suppression without limiting resistances; tungsten lamps; and some types of ac motor.

Heavy-current-inrush transients cause contact damage by producing some melting at the first point of continuity. This transfers some metal from one contact to the other and roughens the surfaces. Any surface roughness tends to cause abnormal heating and early failures. Extreme cases of inrush transients can weld the contacts together.

Fine silver contacts are recommended for longest contact life. Silver-cadmium oxide can be used to minimize contact sticking.

Also, an appropriate relay should apply strong force to the contacts for both closing and opening modes and must have a minimum of contact bounce.

Inductive loads on Vdc

Inductive loads often cause frequent and serious failures of relay contacts, especially when the power is dc. Start-up is no problem, because inductance current rises slowly. Large arcs, however, are formed each time the contacts open.

Most explanations of these contact arcs are incomplete or incorrect. One theory is that current through an inductance tends to continue flowing, and the arcs are formed by the inductance's desperate effort to keep the current flowing. There is a small truth and a larger misconception contained in that belief.

If a perfect inductance could be constructed (having zero-dc wire resistance and zero distributed capacitances), opening the power switch would instantly reduce the current to zero. Capacitors are almost a mirror image of inductors, and if the discharging current of a charged capacitor is interrupted by a switch, the current stops immediately without any arcing.

Origin of the arcing across relay contacts (or power-switch contacts) from switching off inductive loads is *tuned ringing produced by power from the collapsing inductive field that charges the coil's stray capacitance.* In other words, energy from the inductance charges the capacitance. Next, the capacitance charge energizes the inductance. This action continues, with one element alternately powering the other, until the circuit losses reduce the ringing damped-wavetrain sinewaves to insignificant.

Scope waveforms of these ringing transients prove the accuracy of the previous statements. Unfortunately, operation of a service scope for this task does not provide enough stability of trace to permit sharp photographs. Therefore, the proper photographs must be postponed for another issue, awaiting the acquisition of a storage scope. In the meantime, these generalities about ringing are summarized:

• The amplitude of ringing transients depends on the energizing power plus the L/C ratio of the inductance and its stray capacitances (or added external capacitances).

• A small capacitance vs. a large efficient inductance (low C/large L) produces an *extremely high voltage* transient. For example, *one relay coil with 10Vdc applied to its field exhibited 350VPP of transient when the coil power was removed by a switch.* In one sense, this is a voltage gain of 35. Ringing from such a low-C tuned circuit occurs at a very high frequency.

• When a larger capacitance is connected to the same large and efficient inductance, the ringing has a lower frequency. Even more important, the maximum amplitude is significantly reduced, almost in inverse proportion to the capacitance change.

From these ground rules, it is clear that arcing can be greatly reduced when the inductance capacitance is increased by adding paralleling capacitors across either the inductive load or the relay contacts (Figure 4), because slower ringing has reduced the amplitude. The ringing persists for a longer time, but this usually poses no problem except in special cases of high-speed operation.

Diode clipping

Virtually all transient amplitude can be clipped by adding a diode of the proper polarity across the inductive load (Figure 5). The diode operates similar to a TV damper diode. Polarity of the diode does not interfere with the normal positive voltage applied to the inductance load. But sudden cessation of current begins to produce a huge negative-going voltage spike, which unchecked would cause a damped wavetrain, and the diode conducts strongly to eliminate all but 0.6V of the transient. When the initial negative-going voltage pulse is removed by diode clipping, there can be no further ringing transients from that pulse. Therefore, the diode prevents all switching transients.

There are some precautions and tradeoffs. The diode must be a fast-recovery type, or it cannot clip all amplitude of high-frequency transients. A color TV solid-state damper diode should make a suitable replacement when the original characteristics are not known. Also, some authorities state that these diode clippers slow the switching of power. Therefore, the diode clipper might not be the most efficient transient-removal system for applications involving rapid on/off repetitive switching.

Capacitor-charging current

When a capacitor is connected in parallel with the relay contacts, as shown in Figure 4, the degree of transient decrease depends on the resistive value of the supply source and all other loads on it. The resonant circuit is series tuned, and a high source resistance is not desirable. On the other hand, a capacitor across the contacts minimizes radiation of radio-type impulse noise compared to a similar capacitor across the load.

Another problem is that the capacitor can hasten failure of the contacts. When the contacts open, the capacitor reduces the transient's amplitude as planned. But during this time, the capacitor becomes charged by the dc voltage across the contacts. When the contacts next close, the capacitor charge is dissipated by flowing through the contacts. All capacitor discharge current is added to the initial load current, and the total might exceed the contact safety limit. The hazard of contact damage is greatest with a large capacitance and a low load current through a light-duty relay, although it can damage other relays when the suppression requires large capacitances up to 1μF.

A resistor can be added in series with the capacitor to limit the discharging current, as shown in Figure 6. Unfortunately, the resistor degrades the transient reduction.

Figure 7 presents an excellent compromise. A diode is placed across the limiting resistor so the capacitor charging current (when the contacts become open) flows through the capacitor and diode without impediment from the resistor. Then when the contacts close the capacitor current is reduced, because the diode is reverse biased and the current must flow through the resistor.

Servicing relays

Most relay failures involve the contacts. These contacts might become self-welded (shorted), open, erratic or have excessive resistance that produces too much heat.

The first step, even before replacement of the relay, is to establish whether this is a premature failure or merely an expected end-of-life failure. Relays that have had a full lifespan should be replaced without further question, if the contact load current is normal.

Premature failure of the contacts, however, justifies an investigation

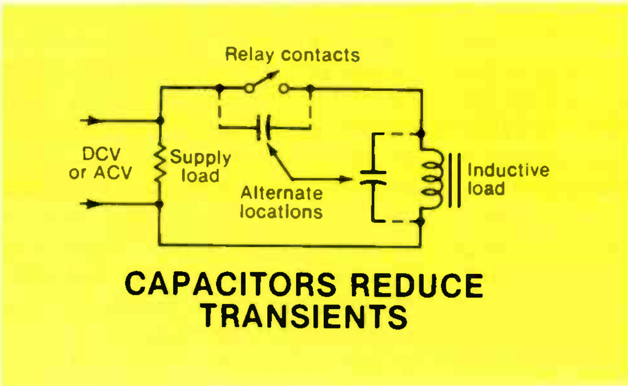


Figure 4 Adding a capacitor across the relay contacts or the inductive load reduces the amplitude and decreases the frequency of ringing transients generated when the relay contacts open and remove power from the load. Placement of the capacitor across the contacts is common, because it minimizes radiation of noise during relay operation. *Optimum capacitance is the value that minimizes the visible contact arcing.* When the contacts close, they short out the capacitor charge. The additional current can cause premature failure of the contacts.

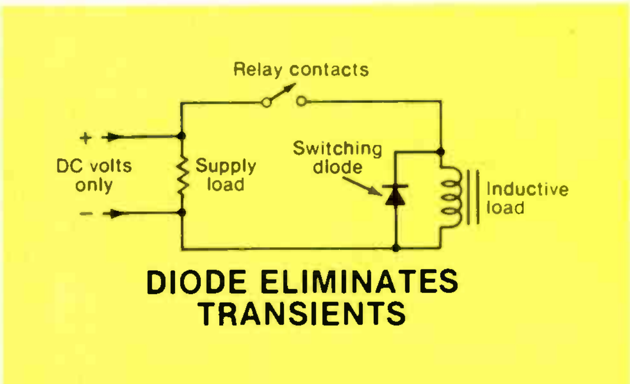


Figure 5 Adding a diode of proper polarity across the relay coil, as shown, eliminates all coil transients when the contacts open. This will not work for ac.

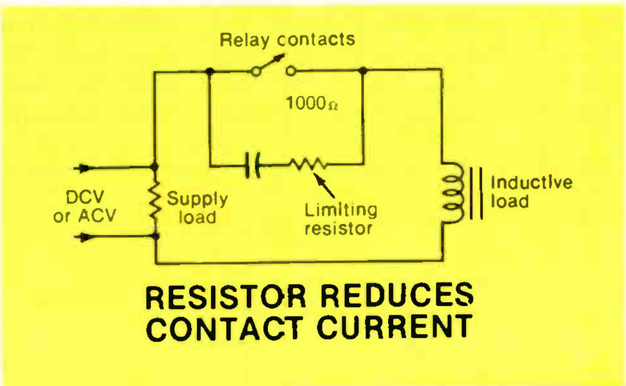


Figure 6 Adding a resistor of approximately 1000Ω in series with the Figure 4 circuit minimizes contact damage from the capacitor-discharge current. The resistor, however, slightly reduces the effectiveness of the transient suppression.

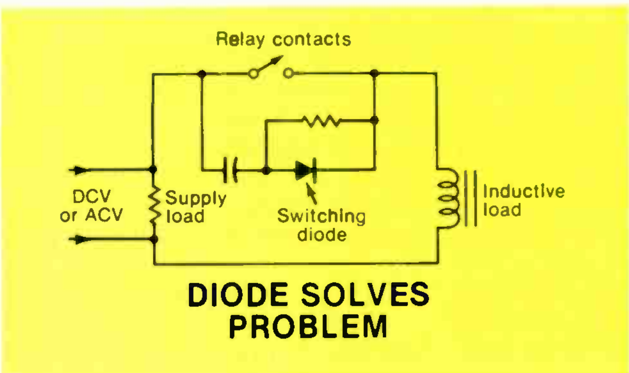


Figure 7 Addition of a properly polarized diode in parallel with the resistor of Figure 6 eliminates the difficulties of these previous circuits. When the relay contact opens, the capacitor charges rapidly through the diode, with the resistor effectively bypassed. When the contact closes, the diode is reverse biased, so the capacitor discharge current must flow through the resistor. Thus, the discharge current is limited. The major transient from the inductive load when the contact opens is a negative-going spike. The spike can pass easily through the diode to the capacitor, where it is tuned to a lower frequency with reduced amplitude.

of the arc-prevention circuitry, plus measurements of load voltage, current or overload conditions. Any abnormal load measurements should be restored to specified tolerances. Also, all defective components in the arc-prevention system should be replaced. Only after all conditions that can cause early contact failures have been corrected should a replacement relay be installed.

A replacement relay should have the same coil resistance and voltage rating. Underpowered coils cause excessive arcing between the contacts, because the contacts cannot be forced together or apart forcefully or rapidly enough.

If a replacement relay does not have a contact maximum-current rating that is identical to the original, select one of slightly higher current rating. Never use one of lower rating.

Relay coils usually fail in one of two ways. The winding can become open from internal corrosion or exposure to high humidity. Shorts between turns can produce different symptoms, depending on regulation of the source voltage and whether the winding power is ac or dc.

For example, shorted turns in an ac-operated relay winding probably would cause an immediate failure. The reduced winding inductance draws excessive ac current, and the resulting heat will burn the coil.

Predicting the symptoms from shorted turns in a dc-operated winding is more difficult. More current will be drawn, in inverse proportion to the change of resistance. A coil power supply without good regulation permits the voltage to drop. The increased current times the reduced voltage might permit near-normal operation, but an overloaded power supply. If the power supply has good regulation, the relay coil will probably operate warmly enough to cause other shorts and an eventual total relay failure.

Repairing contacts

In past years, technicians have repaired minor contact opens in telephone switching relays by using a fine-tooth point file or a piece of kraft paper. Point filing of higher-power relay contacts, however, is *not* recommended. Any extensive filing of contacts is certain to produce an early failure. Some relays are constructed to allow replacement of the contact assembly separate from the relay frame. That is a good solution when possible.

Contact points damaged by arcing usually have a large valley in one point and a large mound on the other, plus numerous irregular areas. It is almost impossible to dress or file these damaged points so the surfaces mate together properly. Anything less than perfect mating causes heat and increases the arcing.

Emergency repairs can be made when absolutely necessary. Welded contact points often can be broken apart by screwdriver pressure, or a single metal knoll on a contact can be filed down to allow better switching. Such temporary repairs can keep the equipment in operation while awaiting replacement parts. Also, a temporary repair allows for testing other allied equipment that might have contributed to the relay failure, without endangering a new relay.

For permanent and dependable repairs, do *not* operate relays having repaired contacts longer than the minimum required to make tests and obtain replacements. The final step of each repair should be the installation of a new relay.

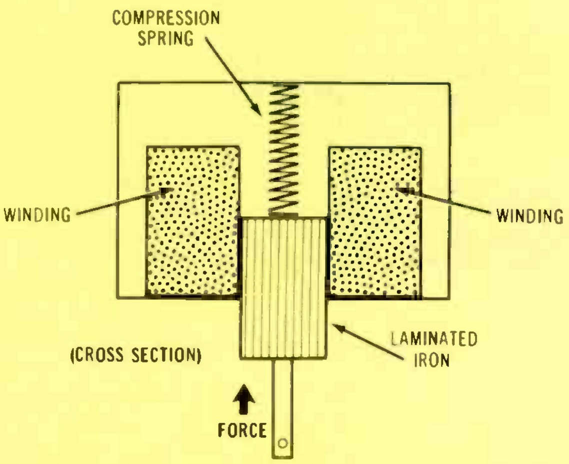


Figure 8 One type of solenoid was illustrated in Figure 1. Another type shown here does not have a core. Applying power to the coil that has no core pulls the plunger to the center of the coil winding, thus supplying lateral movement to anything connected to the plunger. Another type has a solid iron plunger. Solenoids with ac coils draw increased current until the plunger is seated tightly. Thus, a plunger that is prevented from seating can cause burnout of the coil.

Solenoid maintenance and repair

Figure 8 shows a drawing of a typical solenoid. Some have a laminated-iron plunger and a laminated external core. Others, as shown, have a magnetic plunger and a wire coil. Other parts are required to position these components, and a spring to return the core to the open (unpowered) condition. A solenoid develops mechanical power when it attempts to move its core where the magnetic gap is minimized and the magnetic field is at maximum. Through levers or other linkages, this core movement (when power is applied) activates valves or moves another component into a new position.

Either ac or dc power can be used, depending on the purpose and the design of the solenoid.

Ac-powered solenoids have a much higher initial current until the plunger is seated properly, and this higher current provides a strong closing. One prevalent problem with ac solenoids is a mechanical and audible buzz from the movement of the plunger against the core or a bracket.

Some ac solenoids will suffer an overheated and eventually a burned coil if the plunger is prevented from seating correctly. Therefore, one of the few possible preventive-maintenance examinations is to check for bent brackets, worn linkages or any other conditions that change the alignment or stroke of the plunger.

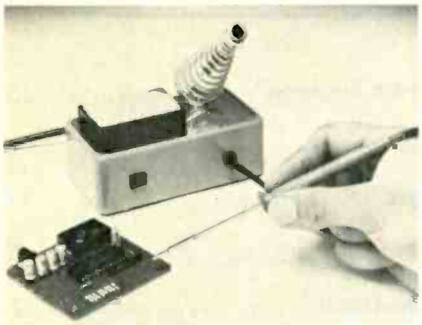
Few repairs are possible for solenoids. Most service consists of replacement of any defective solenoids. Specifications must be checked carefully for coil voltage, torque and core travel to find a suitable replacement when original-type solenoids are not available.

Comments

Maintenance or servicing of equipment containing relays and solenoids can be made easier for technicians if they know:

- the purpose and construction of both;
- how to check for normal operation;
- what conditions cause certain failures and how to correct them;
- how to modify transient-elimination circuits to reduce contact arcing; and
- how to find suitable replacements in catalogs, according to specifications. □

product report



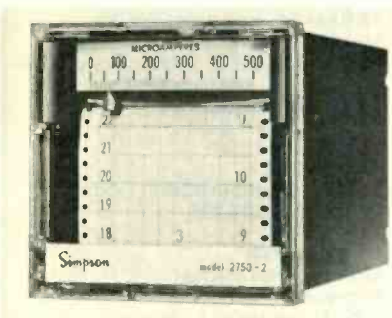
Soldering station

A miniature soldering station from *Wahl Clipper Corporation* operates on 6Wac, allowing precise, safe soldering on miniature circuits and instruments as well as on heat-sensitive components.

The model 7230, the latest addition to Wahl's Iso-Tip line of soldering products, is suited for production line operations, or anywhere fine, close work is required. The ¼-oz, pencil-size iron is easy to control for fast, accurate soldering—even of hair-thin copper leads.

Features of the 7230 station include a double-insulated transformer, a tip-cleaning sponge, sponge well, spring holder, indicator lamp and internal safety fuse. Fourteen tips from 1/25 to 5/32 inches are available, and can be quickly interchanged without special tools. Tips cool down fast from 360°C, and resist seizure.

Circle (50) on Reply Card



Miniature chart recorder

Simpson Electric Company's compact chart recorder uses no inks or pens, and mounts in a standard DIN/IEC 3.62-inch square opening.

The Model 2750-2 features inkless clamping-type operation. The pressure-sensitive chart paper produces a clean, clear trace that will not smudge, fog or blur with age.

A pivot-and-jewel meter movement provides 1.5% recording accuracy with high shock and vibration resistance. Three chart speeds are selected by switching cams. Speeds are 2.36 inches, 0.79 inch and 0.39 inch per hour. Impression rates are 2, 6 and 12 seconds, respectively.

The company is offering the 2750-2 in 10 stock ac/dc voltage and current ranges, with special ranges available to order. 120/240Vac, 60Hz power is standard; 50Hz is available. Front panel size is 3.78"x3.78" overall, and the 2750-2 requires 7.09 inches behind panel.

Circle (57) on Reply Card

Digital disc

The *Sony Corporation* and *North American Philips Corporation* have demonstrated prototypes of the Compact Disc Digital Audio System. Akio Morita, co-founder and chairman of Sony, and Frank Randall, vice chairman of North American Philips, announced that the market introduction of the sound reproduction system will begin in fall 1982.

The marketing plans reflect growing endorsement of the Compact Disc system as the preferred digital audio format by equipment manufacturers and software producers.

Most recently, Polygram Group, a leading international record manufacturer, and CBS/Sony Inc., the largest record company in Japan, announced plans to produce music programs in the CD format. In 1982, CBS/Sony will release more than 100 Compact Disc albums in Japan with the introduction of the CD players.

Philips and Sony jointly submitted the CD format to the Digital Audio Disc Standardization Conference and, in April 1981, the final report was presented. The study recommended the CD format as the standard for audio disc recording and reproduction.

The CD system employs a record that has no grooves, that rotates faster than conventional LP or 45 discs, and that is smaller than either. Only 4.7 inches in diameter, the smooth-surfaced disc carries up to an hour of digitally-encoded stereo music on one side, compared to the LP's maximum of 30 minutes per side. The sound is recaptured by means of a miniature, low-power, solid-state laser pick-up unit within the CD player.

Circle (51) on Reply Card

CB antenna

The 40-channel plus TAK-20, extra low-profile trunk lip mount, 26.5-28MHz mobile CB antenna introduced by *Armstrong Industries,* Division of MCS Inc., features high performance, watertight construction and only 1¾-turn, quick disconnect from the heavy-duty triple chrome-plated mounted bracket.

The TAK-20 is engineered for standard vehicle trunks and hatchback designs. Also featured is the Uni-Axis ball joint that permits a 45° whip tilt in all directions for vertical positioning from all mounting angles. A 17-7PH stainless steel shock spring is also provided.

The antenna's base load with 42-inch-long semi-rigid whip also may be re-mounted onto six other style mounts sold separately by the firm.

The black and chrome base loaded design is shunt fed for quieter operation.

Circle (59) on Reply Card

the marketplace

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For Sale (Cont.)

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FOR SALE: PHOTOFACTS 301 to 390 in Benders, 391 to 1402 in cabinets and 1403 to 1990 in original cartons. Best offer accepted. Jopling's Radio & TV Service, 219 Barrett Place,ZC78225, San Antonio, TX 7-81-1t

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MIRROR IN THE LID, and other PRE-1946 Television sets wanted for substantial cash. Also interested in 12AP4, MW-31-3 Pre-War picture tubes, parts, literature on Pre-War Television, Arnold Chase, 9 Rushleigh Road, West Hartford, Conn. 06117 (203) 521-5280 2-81-7t

DESPERATELY NEED: Information on "Telicon" projection TVs from 1947, RCA "Test Lamp" for 1940's projection TVs. Arnold Chase, 9 Rushleigh Road, West Hartford, Conn. 06117 (203) 521-5280. 2-81-7t

WANTED: Lampkin 109 CB/AMATEUR service monitor, Cushman CE-15 spectrum monitor, SENCORE DVM56, and SENCORE FC-45; Robert W. Biddle, American Consulate, APO New York, NY 09224.

WANTED: An operating manual for a Model 49 Jackson tube tester. Harry M. Efter, P.O. Box 493, Deland, Florida 32720 7-81-1t

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