IC UPDATE—OPERATIONAL AMPLIFIERS

75¢ ■ MAY 1975

Radio-Electronics®

THE MAGAZINE FOR NEW IDEAS IN ELECTRONICS

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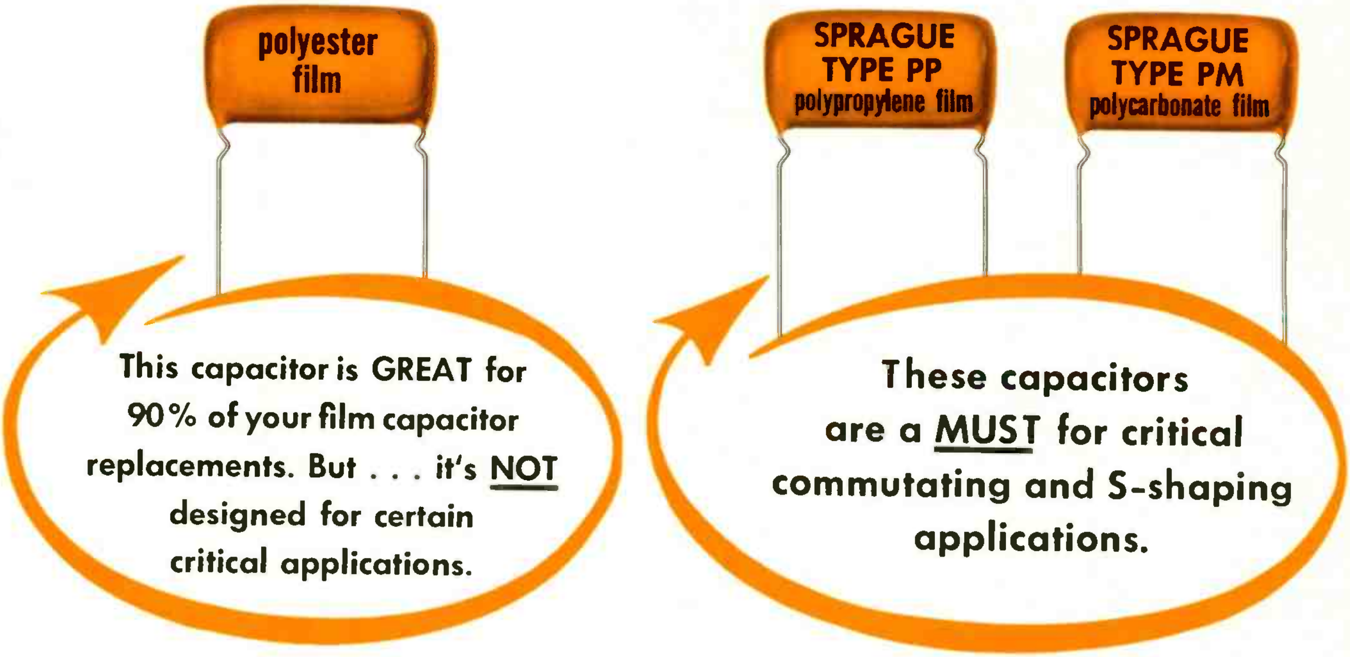
Circle 2 on reader service card

Avoid serious trouble in color TV sets by using the <u>right</u> replacement capacitor!



The next time you replace a dipped tubular in one of the newer color TV sets, don't automatically assume you're replacing an ordinary every-day film or paper capacitor. If it happens to be a deflection capacitor used for commutating or S-shaping, you need a polypropylene or polycarbonate film replacement with (1) high a-c current-carrying capability; (2) close capacitance tolerance; (3) good capacitance stability. The standard replacement capacitors used in the industry, even our superior Type PS dipped tubulars, just won't do the job . . . and they could cause the set to become inoperative again.

Play it safe . . . dipped tubulars may look alike on the surface, but there can be a big difference in the film dielectric. Keep a supply of Sprague Type PP and PM capacitors on hand for those critical situations where ordinary replacements won't work.

SPRAGUE TYPE PP POLYPROPYLENE FILM TYPE PM POLYCARBONATE FILM CAPACITORS

μF @ WVDC	Cap. Tol.	D. x L.	Cat. No.
1.75 @ 100	±5%	.900 x 1.000	PM1-M1.75
1.5 @ 150	±5%	.800 x .937	PM15-M1.5
.01 @ 400	±5%	.400 x .750	PP4-S10
.015 @ 400	±5%	.450 x .750	PP4-S15
.033 @ 400	±5%	.500 x .750	PP4-S33S
.06 @ 400	±5%	.800 x 1.250	PP4-S60S
.081 @ 400	±2%	.600 x 1.300	PP4-S81S
.2 @ 400	±5%	.700 x 1.700	PP4-P20
.0018 @ 600	±5%	.400 x .750	PP6-D18S
.0022 @ 600	±5%	.400 x .750	PP6-D22S

μF @ WVDC	Cap. Tol.	D. x L.	Cat. No.
.0039 @ 600	±5%	.400 x .800	PP6-D39S
.01 @ 600	±5%	.500 x 1.250	PP6-S10S
.066 @ 600	±5%	.800 x 1.250	PP6-S66S
.075 @ 600	±5%	.750 x 1.250	PPS-S75S
.022 @ 800	±3%	.600 x 1.300	PP8-S22S
.047 @ 800	±5%	.700 x 1.250	PP8-S47S
.051 @ 800	±5%	.800 x 1.250	PP8-S51S
.0018 @ 1600	±5%	.500 x 1.300	PP16-D18
.002 @ 1600	±5%	.500 x 1.300	PP16-D20
.0033 @ 1600	±5%	.550 x 1.300	PP16-D33
.0039 @ 1600	±5%	.600 x 1.300	PP16-D39

For cross-reference information on close-tolerance polypropylene and polycarbonate film capacitors, showing original part numbers with correct Sprague replacements, ask your Sprague distributor for Cross-Reference Guide C-873, or write to: Sprague Products Company, 81 Marshall Street, North Adams, Mass. 01247.

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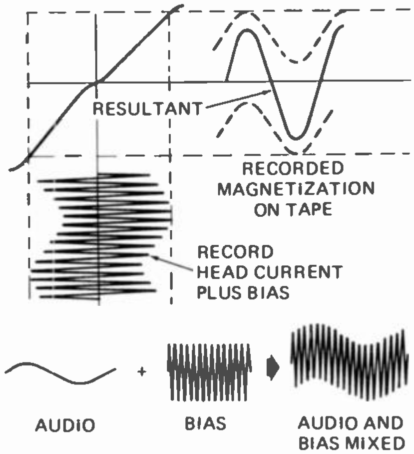

TAPE BIAS is combined with audio signal. **For full details see page 70.**

Cover photo courtesy Heath Company
Cover design by Louis G. Rubsamen

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looking ahead

New watch readout

Digital wristwatches may well be the wave of the future, but many watchmakers feel that readouts leave something to be desired. Of the two types currently used, the LED is easier to read, but requires the use of two hands, because the free hand must be used to push the button to turn on the display. This makes it difficult to take a surreptitious look at your watch without letting others know about it. Liquid-crystal displays can be read one-handed, but they're often hard to read in low light conditions because of insufficient contrast.

A new type of display is attracting attention now. It is the electrochromic readout, employing metallic chemicals that change to a dark color when a voltage is applied, and keep their color until the voltage is reversed. The numbers are conventional seven-segment figures that stand out clearly against the background and can be designed to show up in any of a large number of colors and shades. The price of the new display is said to be competitive with both LED and LCD devices and the power drain is claimed to be less. American Cyanamid, who holds several electrochromic patents, is understood to be the leader in the field. An experimental watch program is under way in Switzerland using the displays now. But don't expect to see them in calculators—their response time is too slow, at least for the time being.

Back to 90 days

As expected—and forecast here two months ago—Zenith has decided to go along with the trend to reduce labor warranties on solid-state color TV sets from one year to 90 days, starting with the 1976 models, to be introduced in May and June. RCA and Sylvania had already announced their intentions to reduce warranties. The cutbacks represent an attempt to reduce costs and, the manufacturers say, avoid the necessity for large price increases—although there are expected to be some price hikes in the new sets, anyway. The financial reports of TV manufacturers indicate that most of them lost money on the production of television sets last year.

G-E quits audio

Another mass-market manufacturer is curtailing its product lines. General Electric, believed to be the largest marketer of phonographs in the United States with sales of more than a million units annually, has decided to discontinue manufacturing and eventually the marketing of phonographs, including compact stereo systems. G-E will continue to sell radios, tape recorders and players, and, of course, television. Last year, RCA discontinued all audio products, including radio.

The big British record-changer manufacturer BSR, meanwhile, has reached an agreement to buy the second biggest mass-market changer maker, Glenburn. Both firms were formed by Danial McDonald, whose name is used on BSR's audiophile turntable.

TV saves energy

Television probably is the only product which has already met its government-established energy conservation goal for 1980. The Commerce Department is assigning each major product a target for energy saving by 1980. The TV industry was charged with reducing the average power consumption of its products by 25% between January 1972 and December 1980. The EIA estimates that the average set made in 1974 consumed 147 watts as compared with 225 watts for 1973 sets—a decrease of about 35%. Most of the decrease is the result of the increasing proportion of solid-state sets in television's mix, but the rise in the number of small-screen sets and the increasing use of slot-mask picture tubes has probably been another factor. There will be further energy savings as the industry shifts completely to solid-state. (In 1974, 72.6% of the color sets produced or imported into the U.S. were solid-state, up from 51.1% in 1973. All-solid-state circuitry was featured in 39.1% of monochrome sets last year, up from 20.3% in 1973.) The government isn't asking for an energy reduction for audio products.

Troubled calculators

The turbulent calculator industry has incurred a major casualty. Bowmar Instruments, one of the pioneer manufacturers and still one of the top four producers, has filed a petition for voluntary bankruptcy because of inability to pay its debts. The company is being reorganized. Earlier, Bowmar had filed a $240-million patent and anti-trust suit against its major chip supplier Texas Instruments.

The fierce competition in the calculator field has driven prices steadily downward. It's estimated that some 15 million were produced last year. And already this year, hand-held four-function calculators—which sold for $100 and up as recently as 1972—have been sold as low as $9.95.

'Emergency radio'

Those low-cost radios capable of tuning to the rapidly increasing number of government weather radio channels are going to become more indispensible as the result of a new ruling by the President's Office of Telecommunications Policy. After years of experimenting with various emergency warning systems, the government has decided that the weather channels will constitute the sole federally operated radio system for communicating attack or disaster warnings directly to the public. The system will incorporate a tone-alert signal designed to activate special home radios automatically. The OTP said consumer use of the system will be completely voluntary and there's no intent to "legislate a warning receiver into the private home."

Tubeless TV camera

The first television camera to provide a standard 525-line video signal without a pickup tube is being placed on the market by RCA in sample developmental quantities. The pickup element is a postage-stamp sized charge-coupled device, with 512 elements horizontally by 320 vertically. Other CCD cameras are currently on the market, but none of them approach the high-resolution capabilities of the RCA unit or are capable of being used with an unmodified standard TV set as monitor.

The CCD chips are still highly expensive — RCA is selling them at $1500 and $2300, depending on quality—but an RCA official forecast they'd be selling for about $30 in the early 1980's or possibly sooner. The CCD principle is seen as most likely to make possible the low-cost home color cameras required by upcoming generations of consumer color videotape recorders.

by DAVID LACHENBRUCH
CONTRIBUTING EDITOR

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Circle 4 on reader service card

new & timely

Cinemascope-like color TV is now possible with new system

A new projection-TV system, recently demonstrated in New York by General Electric, transmits wide-screen pictures with standard equipment. It may make network wide-screen theater television practical.

The color TV camera is equipped with a cinemascope-type (anamorphic) lens to compress an 8 × 3 view into the standard 4 × 3 television format, which is then handled as an ordinary TV signal. At the receiving end, another anamorphic lens broadens the picture out again into the wide-screen 8 × 3 aspect. The process of compression and re-expansion is optical rather than electronic. Pictures can be up to 20 feet wide.

SPECIAL ULTRA-WIDE-SCREEN LENS being adjusted by Dr. William Good, manager of G-E's Video Display Operation in Syracuse, NY, makes a Cinemascope-like screen display available to projection television theaters.

To get the light necessary for large-screen projection, G-E's single-gun light valve system is used. Illumination from a 650-watt sealed-beam xenon tube is modulated by passing it through a deformable membrane composed of an oily substance. The membrance is scanned by three electron beams that pass through three diffraction gratings, each of which transmits one of the color television signals. Deformation of the membrane in accordance with the electrical signal causes it to transmit more or less of the light from the xenon tube. The optical image thus produced is focused on the projection lens, which spreads it out to the large-screen aspect.

The single-gun light valve is already being used in a number of industrial aplications. Its single gun needs no convergence adjustments, and it is free of the problems of adjusting the image for picture and color registration that is practically insurmountable in the wide-screen format for any system using three optical paths. These advantages may hasten the day of the wide-screen "teevie" house.

Veteran Wireless Operators celebrate golden anniversary

Fifty years ago, a new radio organization was introduced dramatically by Radio WRNY, the broadcast station owned jointly by Hugo and Sydney Gernsback, and situated in the Hotel Roosevelt in New York City.

"This is Radio News Station, WRNY. You are about to hear one of the most extraordinary broadcasts in the history of wireless communication. We are broadcasting the first official meeting of a group of wireless men who are about to form a society or an organization."

Thus, in 1925, the Veteran Wireless Operators Association was founded. Dedicated to fostering a fraternal spirit among wireless operators and to recognize meritorious services by them, it conducts an annual memorial service at the Wireless Operators Monument, erected in New York City's Battery Park in memory of operators who lost their lives in performance of their duty. It adds bronze plaques as other names are added to the list of radio officers who have gone down with their ships.

The Association also presents awards to deserving figures in the communications field at annual awards banquets held each February. Marconi, de Forest, Sarnoff, Barry Goldwater (K7UGA-K3UIG) and Zworykin have been among those so honored. The Golden Anniversary Banquet was held February 22, 1975.

The address of the Association is: Box 35, Church Street Station, New York, NY 10008.

Optoelectronic system frees headphones from cords

A cord-free headphone system just developed by Siemens uses modulated infrared light as a medium, with a photodiode as the receiver and a number of luminescent diodes in parallel as the transmitter. Infrared is particularly suitable for transmitting purposes. The radiation cannot be absorbed nor distorted by dark or rough areas, and protruding edges of furniture have no effect on the quality of reproduction. The signal-carrying "light" is evenly diffused throughout the room, and the headphones do not have to be trained in any particular direction.

The new silicon optodiode receiver element (Siemens BPW 34) was developed with special attention to achieving the smallest possible capacitance, despite its rather large area of 9 mm^2. It is covered with a filter to prevent other than infrared light from producing signals in the diode. The transmitter elements are Siemens LD 241 luminescent diodes. An array of smaller diodes rather than one large one makes impedance matching easier. Four such diodes produce a peak output of 60 mW, which is adequate for a

SIEMENS BPW 34's on a musical background.

medium-size room. Four diodes, doubling the power, will cover a small hall.

The system was originally intended for home entertainment devices designed for headphone reception, but would be suitable for studio use where it would not create nor be affected by electromagnetic interference. It could also be used for multichannel remote control systems.

Yankee technician maintains Tonga communications network

William P. Bowden, former RCA technician from Sherman Oaks, CA, is fast becoming an important figure in South

(continued on page 12)

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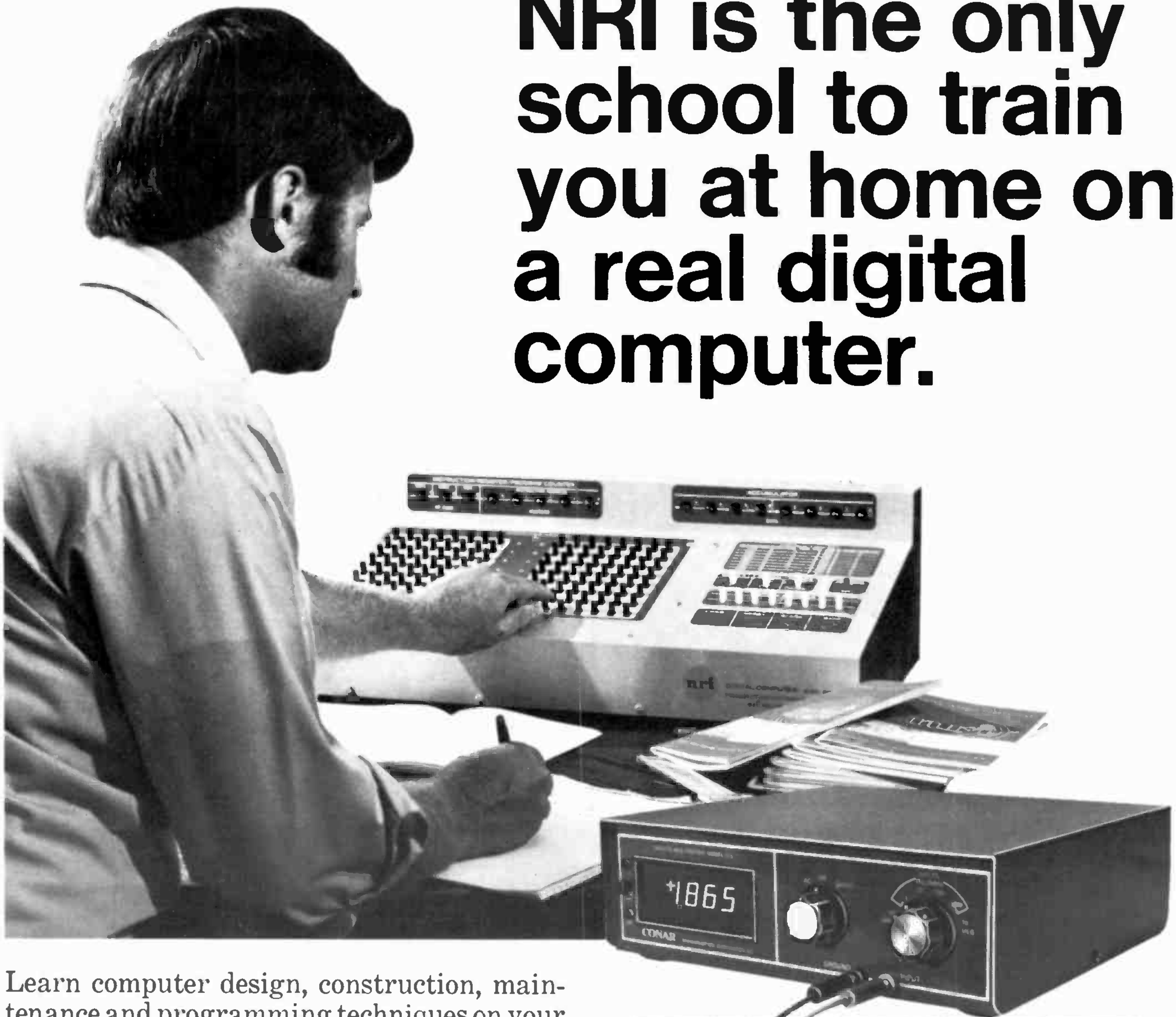

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new & timely

(continued from page 6)

Pacific communications. A Peace Corps volunteer, he is working as a radio repair technician in the Telephone and Telegraph department of the kingdom of Tonga (once known as the Friendly Islands), a country of 150 islands and 96,000 people east of Fiji.

His work, Bowden says, is not

PEACE CORPS VOLUNTEER TECHNICIAN William Bowden checks a signal generator in the Tonga Telephone & Telegraph Dept. workshop.

monotonous. The department handles overseas communications, radio and telegraph between the islands, the non-automated telephone exchange, airport communications, ships radars, ship-to-shore and even mobile police radios.

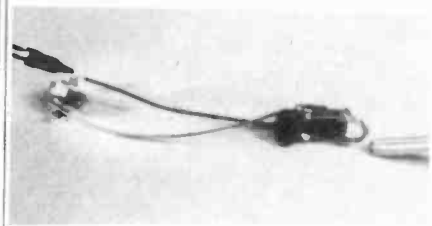
Bowden is also training young Tongans in electronics, working with three radio repair apprentices and supplying lesson materials to the instructors in charge of the department's electronic training course.

Fish signal their passage through dangerous waters

Radio-Electronics readers are familiar with the use of miniature radio transmitters to check the movements and habits of small wild animals. Now fish have adopted the technique and signal to Fish and Game researchers how well they are able to overcome hazards while ascending rivers to spawn.

The Division of Fishery Services in Laconia, NH, is "tagging" sea run salmon and shad with tiny radio transmitters to determine how well they can get through a pump storage reservoir, and how many don't make it.

The transmitter—about the size of a peanut—is placed inside the fish, since externally attached tags have been found to hamper their swimming ability and would reduce its chances of getting through difficult places. The fish is anesthetized and the transmitter inserted through the throat into the stomach. A small protrusion on the



transmitter prevents it from leaving the stomach and being expelled by the fish. After a time, stomach juices dissolve the protrusion and the fish is able to eliminate the transmitter.

By that time, the biologists have the information they need and know whether the fish does, in fact, pass into and out of a pump storage unit, and if so, what are the effects and the percentage of mortality.

SWITCHBOARD-IN-THE-SKY, completed with the sixth Intelsat IV satellite, launched over the Pacific, 22,000 miles high and one degree from the International date line. It surrounds the earth with a ring of communication stations. The new satellite, built by Hughes Aircraft Co., backs up and adds capacity to the original Pacific satellite, launched in January 1972. They serve the 1.3 billion people of the Pacific basin through 19 earth stations scattered from the USA to Singapore. There are six satellites altogether, three over the Atlantic and one over the Indian Ocean. R-E

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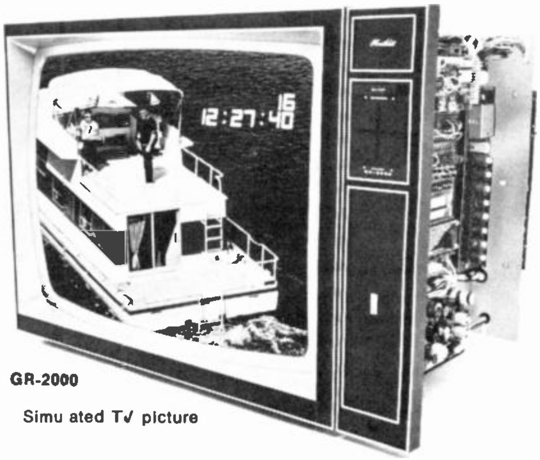

GR-2000

Simu ated T√ picture

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200 watts, minimum RMS, per channel into 8 ohms with less than 0.1% total harmonic distortion from 20-20,000 Hz.

AA-1640 $439.95, less meters

Specifications don't say it all, but they do indicate the quality of this exceptional amplifier. Take the power statement above, for example; if you are familiar with Heath's conservative stance in specifications, you will know that there's no question that this amplifier will do *at least* that well. The same holds true for the exceptionally low distortion figures. Other impressive figures are: hum and noise 100 dB below full output; damping factor greater than 50; channel separation 50 dB minimum.

The features behind the specifications. The super power comes from the super power supply ... a 25 lb. transformer that will maintain full output under the most demanding program material. Two 6 lb. die-cast heatsinks cool the 16 output transistors ... no noisy fans are needed. Even when used as a PA amplifier, it needs only normal ventilation. Automatic circuitry helps protect your speakers; a 10-second delay protects your speakers from turn-on "thumps" and disconnects them instantly when power is turned off. The delay circuit also disconnects the speakers if it detects DC or extremely low-frequency AC at the outputs. Automatic thermal shut-down helps prevent damage from overheating. And speaker fuses are located within the primary feedback loop ... an exclusive Heath design which maintains a high damping factor for high-definition bass response.

Optional peak-responding meters continuously monitor the output. The back-lighted meters have linear calibrations from −30 to +3 dB and can also be read directly in watts from 0.2 to 200 watts into 8 ohms. So fast they even respond to record "clicks", they are useful as overload indicators. And if you buy the meters at the same time as the amp., you save $20.

Front panel controls include pushbutton on/off, left and right channel gain controls, and LED power and high temperature indicators.

To hear music as you've never heard it before ... build the AA-1640. For sheer power and exceptionally low distortion, we believe it is one of the finest amplifiers ever made. Super-amp ... super-sound.

Kit AA-1640, less meters, 69 lbs., Exp/Frt **439.95**
Kit AAA-1640-1, meters only, 4 lbs., mailable **69.95**
Kit AA-1640 & Kit AAA-1640-1, 73 lbs., Exp/Frt **489.95**

NEW Heathkit Stereo Microphone Mixer ...129.95

For fine home recording facilities and elaborate PA and sound reinforcement systems. Wide response (40-20,000 Hz, +1 dB) and low distortion (0.5%) with unusual versatility. Each of the two outputs has its own master control and meter and switchable for stereo or mono modes. Six inputs: two high-level for disc or tape, four low-level for microphones (switchable to high impedance, unbalanced, or low impedance, balanced). The fourth mic. input has a "pan" control to adjust its apparent location anywhere from left to right. All inputs can be individually switched to left, off, or right channel. Mixing bus access permits paralleling added mixers for extra inputs and outputs. Two lighted dual-range meters plus adjustable LED peak indicators. Slider controls and switches.

Kit TM-1626, 12 lbs., mailable **129.95**

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Proof that good sound can cost less. The preassembled AM/FM tuner section has 5 µv sensitivity for distant station reception. Ceramic filters offer 60 dB selectivity to remove alternate channel interference. AFC. Integrated circuit FM IF. Phase-locked loop integrated circuit multiplex. Direct-coupled amplifier design with an honest 4.5 watts, min. RMS, per channel into 8 ohms from 50-15,000 Hz with less than 1% total harmonic distortion. Slider vol. and balance controls; ganged rotary bass and treble controls. Inputs for ceramic cart. changer and tape. Handsome walnut-grained vinyl-clad plastic and metal enclosure included. It's one of Heath's new Valu-Component line; see them all in the Heathkit catalog.

Kit AC-1118, receiver, 15 lbs., mailable **139.95**
Kit AS-1140, pair of speakers, 15 lbs. **34.95**
Order with speakers and save 5%.

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Circle 100 on reader service card

letters

ME, OH MY. ME AND MY SINEWAVES!

In the Service Clinic for November 1974, I showed the results I got from playing with a function generator and an R-C network. (I wasn't kidding; I really was *playing!*) I wrote it up mostly as a sort of "Well, well! Look what happens here!" thing. Didn't expect it to be printed.

I have received a surprising amount of mail from readers on this. Most of them, quite correctly, took me to task for saying that a sinewave wasn't changed by passing through the integrating and differentiating networks. (One of my books did give me an explanation something like that. Needless to say, I can't find it now!)

Here is the correct explanation: what looks like a sine wave is really a cosine wave; practically the same as the original sinewave but shifted *in phase* by 90 degrees! Since I was using a single-trace scope, this was not apparent; a dual-trace will show it.

For one more, the "change a triangular wave to a sine wave" is not precisely correct, either. This is actually a parabolic waveform. To the Uncalibrated Eyeball, it does look like a sine wave. In fact (and here I was right for a change!) quite a few function generators actually make a very good sine wave from a triangle. However, they do it with a good sized network of diodes and resistors, etc. Thanks very much to the many readers who took the time to write about it, especially Ken Holet of G-E Applications Engineering. He spotted the parabolic wave!

JACK DARR
Service Editor

UART TO TVT

In the article "Add This UART To Your TV Typewriter" **(Radio Electronics,** Feb. 1975), a diagram was omitted from step 3 of the "Changes To TV Typewriter." This diagram (Fig. 1) shows connections to IC6 and IC1. Connect IC1 pins 8, 9 and 10 as shown. Also, the correct equation should be $CR = A6 \cdot \overline{A7} \cdot A3$

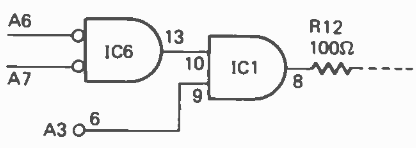

Fig. 1

Several readers have asked about my statement in the article that mentions adding a 74123 and relay for automatic

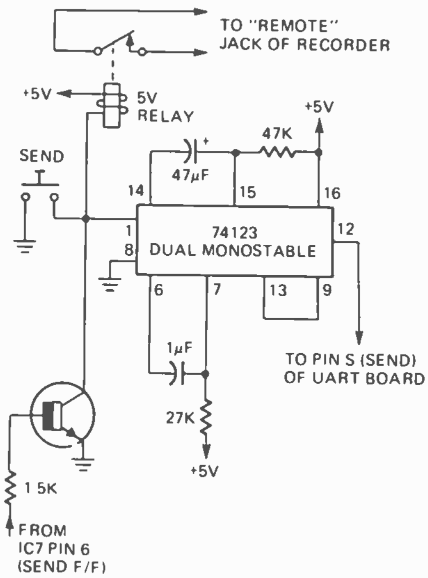

Fig. 2

START and STOP of the tape recorder. The accompanying diagram (Fig. 2) should explain how. The idea is to delay the SEND signal to the UART for a second or so until the recorder reaches speed. Depress SEND pushbutton and hold until characters start to be transmitted.

ROGER SMITH
Phoenix, AZ

OOOPS!

I read your "New & Timely" article (page 12) in the November **Radio-Electronics** with great interest. Unfortunately, the statement that the color TV camera is manufactured by Motorola is *incorrect.* It is actually designed and manufactured by Magnavox.

The camera used at Mount Sinai is the Magnavox Chromavue 400 and we have been shipping it for the last 1½ years.

We also offer a battery-powered version called the Chromavue 440. Suggested price for this unit is $2750. And . . . it is designed to match up with the new color battery-powered video tape recorders.

I would appreciate it if you print a correction in your next issue. The camera is, in fact, a **Magnavox Chromavue 400.** And . . . Magnavox is, in fact, the *first* manufacturer to offer a *color* TV camera at such a low price. Plus . . . it is built in Magnavox plants in the U.S.A.

JOHN C. COPE
Magnavox Video Systems
Ft. Wayne, IN

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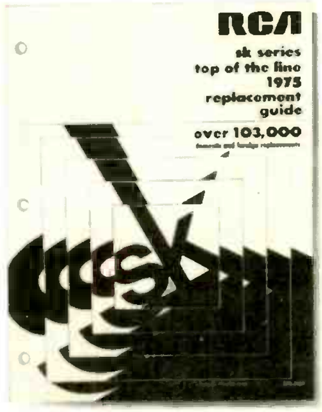

Circle 9 on reader service card

equipment reports

Tri-Star Tiger Capacitive-Discharge Ignition Simpli-Kit

Circle 101 on reader service card

AS THE COSTS OF DRIVING AND MAINTAINing a car continue to rise, many people are turning to the field of automotive electronics for help. One area of recent interest in this slightly ignored field is the electronic ignition system. Until this year, there have been only two ways to obtain the benefits of better performance offered by the electronic system. You could either buy a car with the electronic ignition system installed by the factory or find an automotive center that would install the system in your present car. Both of these alternatives presented a cost that was more than most motorists cared to pay. Now, with the advent of kits for electronic ignitions, there is a third and less expensive alternative.

Recently, I was considering installing such a system in my car. Faced with the costs of the three alternatives and my "college-student" budget, I chose to assemble and install the system myself. I chose a kit that is called the Tiger Capacitive Discharge Ignition Simpli-Kit. It is distributed by the Tri-Star Corporation of Grand Junction, Colorado. The kit consisted of all parts, equipment and instructions necessary to assemble and install the system. The only equipment that is needed is a soldering iron, a pair of wire cutters and a pair of screwdrivers. It is essential that you have some knowledge of soldering, but very little knowledge of electronics is necessary. Still, you will learn in the course of assembly a little about the difference between a diode and a transistor. The parts are pictured in the instruction book and the parts are color-coded so that people with a lack of electronics knowledge (like me) can not only tell a resistor from the solder but also a 270-ohm resistor from a 33-ohm resistor. The time for the assembly totalled about three hours. In other words, you could assemble the kit on a Sunday afternoon, I had very little trouble assembling the system due to the fact that the instructions and the kit were as the manufacturer said—simple.

As for installation in the car, it took about an hour to completely put the system to work. Although the kit includes hardware, a drill or punch is needed to install the ignition housing. There are easy-to-follow diagrams to help with the placing and wiring of the system in the car. In addition, there are instructions for trouble shooting and adjustments for cars with tachometers. When I finished the installation of the system, I was afraid to start the car for fear that my car would blow up or burn just like my cooking projects have done in the past. To my amazement, it did not burn but started better than ever. I decided to keep track of my gas mileage over a period of two weeks. I found that at the end of the period, my mileage increased by 3-4 miles per gallon. Although it was not a very scientific mileage report, it is a fact that the system delivered more miles per gallon of gasoline in my particular car.

As for the kit, its type is recognized as the most desirable for today's cars; a capacitive-discharge ignition system or CDI. It is favored because of its low current drain, constant output over various speed ranges and it allows the engine to remain in tune longer due to reduction of contact breaker wear. The kit also has a switch on the housing which allows the driver to change from CDI to the standard ignition in case of failure of the CDI. As said before, the kit includes all circuit boards, diodes, transformers and housing. The extra tools can be found in most homes or borrowed from a neighbor. Perhaps one of the best things about the kit is the fact that there is a guarantee for components to be free from defects in workmanship and material for ninety days. The guarantee does not cover mistakes in assembly methods and techniques.

I can honestly say that working with the kit helped me learn a little about electronics and my car. If you have an electronics amateur or professional in the house as I did, there are many things that can be learned in the course of assembling the kit about electronics such as the use of a voltmeter and the purpose of a transistor. I would recommend this kit for anyone that owns a car without a CDI. **R-E**

(continued on page 20)

Power-play-mates

TU-7700 and AU-7700

SANSUI's power playmates – the TU-7700 tuner and the AU-7700 amplifier are made for each other – by design.

The TU-7700AM/FM stereo tuner, a breakthrough in tuner development, has far less distortion and wider stereo sound separation than comparable tuners. Selectivity and sensitivity figures are so good as to be almost unbelievable. And this is a fitting component companion for SANSUI's AU-7700, a star at the top of the line of SANSUI's integrated amplifiers.

55 Watts per channel minimum RMS into 8 Ohm load from 20Hz to 20KHz with no more than 0.1% total harmonic distortion.

Separate or together-power houses both of them. Hear either the TU-7700 and/or the AU-7700 at your nearest SANSUI franchised dealer and be sure to pick up your free copy of "The Sounds of SANSUI" or write directly to us.

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Circle 10 on reader service card

(continued from page 18)

Lectrotech TO-60 Dual-Trace Oscilloscope

THE WIDEBAND, DUAL-TRACE, TRIGGERED sweep oscilloscope is fast becoming THE instrument in the service industry. Lectrotech's new TO-60 is a very good example of this kind of instrument. It's a 5-inch, all solid-state scope, with a bandwidth of DC to 15 MHz on both channels. It has all of the desirable features such as independent triggering of either channel. You can trigger the displays on the channel-A or channel-B input signal. You can also select channel-A trigger

Circle 102 on reader service card

displaying channel-A and channel-B chopped, up to 100 kHz or channel-A and channel-B alternate sweep above 100 kHz. "A and B added," displaying the sum of the two signals, is available too.

Both vertical amplifiers are DC coupled. You can select either AC or DC coupling, or ground the input of the unused channel to prevent interference. In the ground position of the channel-A switch, the sweep becomes free-running so that you can check the operation.

The triggering is solid. You can use automatic trigger on many waveforms. The trigger operates on the highest average point in the pattern. For TV work, switch in the TV Sync selector. This must be used with the amplitude or trig-level control. This gives you triggering on the vertical sync at the lower frequencies, switching automatically to the horizontal sync on the higher ones. A slope selector allows triggering on either positive or negative peaks. To get the best results from this, it must be set to match the polarity of the sync in the TV signal being viewed. The horizontal sweep switch is calibrated from 0.2 second-per-division up to 0.5 microsecond-per-div. The speed can be varied with the center knob, if desired. For calibrated sweep, it's turned full clockwise. Pulling out on this knob gives you a 5-times multiplication of the sweep, equal to a speed of 0.1 microsecond-per-division on the highest frequency.

With the growing use of digital circuitry in entertainment electronics, we'll need scopes with a very fast rise-time, to read the sharp pulses used in frequency-dividers, etc. Here is one place where the

(continued on page 24)

Circle 11 on reader service card

Circle 12 on reader service card

The latest improvement in picture tubes.

Our labels.

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AA	A	
The Same Original Equipment Tube We Make For TV Set Manufacturers	*Every'thing's New Except The Glass!*	*New, Sharp-Focus Electron Gun. Carefully Inspected Used Glass, Components.*

If you can say what you want, you've got it. That's our simple new labeling system.

The labels tell you what's inside, in simple, everyday language.

We've kept our standard color coding: red for all-new; blue for new screen and gun; green for new gun.

And inside, there's the same great tubes you've always had from Sylvania.

Trust Sylvania to make life easier. See your Sylvania distributor.

We're helping you make it.

GTE SYLVANIA

Electronics servicing is no mystery when

The 20 books offered on these two pages are representative of the vast amount of clear and authoritative electronic servicing help available from Sams. They can help you understand and efficiently service almost every electronic application. Look them over—and use the coupon to broaden your skills.

TELEVISION

Here are the first three of an all-new series of specialized service guides by Stan Prentiss.

Developed by the Audel® Division of Howard W. Sams & Co., Inc., they are comprehensive directories of detailed servicing data and information for all 1974-75 models of the leading home-entertainment manufacturers. Each covers troubleshooting, schematics, replacement parts lists, and service tips, and includes specific circuit write-ups and identification of all integrated circuits used.

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COLOR-TV SERVICING GUIDE (2nd Edition)
by Robert G. Middleton

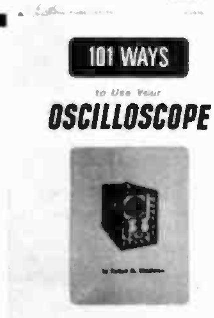
This guide uses color photos to show symptoms of circuit defects as they appear on the picture-tube screen. If the serviceman follows these picture clues and uses proper troubleshooting methods, he can service sets correctly and in less time. Covers both tube and solid-state circuits. 112 pages, softbound.
No. 20990 $5.50

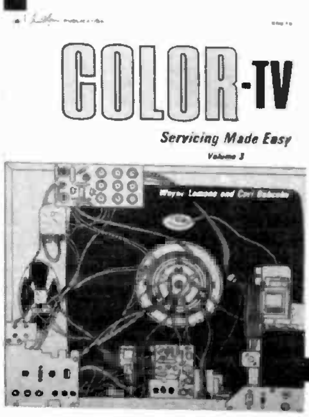
TV SERVICING GUIDE Arranged by Trouble Symptoms
by Leslie D. Deane and Calvin C. Young, Jr.

An invaluable troubleshooting guide that can save much time and frustration. It enables the serviceman to diagnose troubles from picture and sound symptoms. It is organized by sections in the receiver and subdivided according to trouble symptoms encountered and their probable causes. 126 pages, softbound.
No. 20361 $4.50

101 WAYS TO USE YOUR OSCILLOSCOPE
by Robert G. Middleton

This book is an eye-opener to television servicemen and electronics technicians who have gotten in the habit of using an oscilloscope on only a limited number of tasks. It describes potential oscilloscope uses, from basic to involved and complex; includes demonstration photos of waveforms, and discusses likely defects when the waveform is abnormal. 192 pages, softbound.
No. 20416 $4.50





COLOR-TV SERVICING MADE EASY (Volume 3)
by Wayne Lemons and Carl Babcoke

This service guide is designed to help you service all makes and models of color tv. It covers general circuit descriptions; troubleshooting; high voltage regulators, including "fail-safe" circuits; atc circuits; and universal setup procedures; and has separate chapters devoted to specific manufacturers. 288 pages, softbound.
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PHOTOFACT® GUIDE TO TV TROUBLES (2nd Edition)
by the Howard W. Sams Editorial Staff

Shows just what happens to the picture-tube display when any component in the receiver becomes defective. All of the Guide's many pictures are actual photos taken under simulated-defect conditions. By comparing them to the picture produced by a defective set, the components most likely to cause the trouble can be readily determined. 192 pages, softbound.
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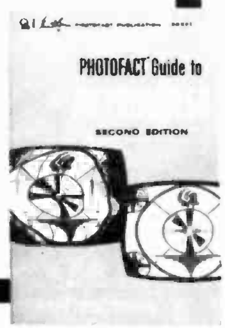

you follow these informative guides.

HI-FI, TAPE & AMPLIFIER

TAPE RECORDER SERVICING GUIDE — by Robert G. Middleton. Brings the technician up to date in servicing a fast-growing field of home and auto tape cartridges, tape cassettes, and stereo tape players. While the basic electronic circuitry may be familiar to the radio and television serviceman, this guide also explains and shows how to service such unique tape recorder features as magnetic circuits and bias oscillators. 96 pages, softbound.
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UNDERSTANDING IC OPERATIONAL AMPLIFIERS — by Roger Melen and Harry Garland. With the advent of semiconductor and microminiature electronics, complete op amps on a single tiny chip of silicon now have many applications. This book covers the IC op amp exclusively, explaining how it works, how it is fabricated, how practical circuits can be designed by using them, and how complete electronic circuits can be formed around op amp circuits. 128 pages, softbound. No. 20855 $3.95

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RTL COOKBOOK — by Donald E. Lancaster. The family of digital-logic integrated circuits called Resistor-Transistor Logic, or RTL, is used in applications ranging from simple switching through digital measuring circuits. This book explains how RTL ICs are used, how they work, and how to adapt them for the complex electronic systems in use today. 240 pages, softbound.
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LINEAR IC PRINCIPLES, EXPERIMENTS, AND PROJECTS—by Edward M. Noll. Introduces the principle of operation of the integrated circuit. Reviews semiconductor theory and practical devices, and discusses common internal circuit arrangements and basic external circuitry. Covers differential and operational amplifiers; multipurpose and digital ICs; and linear IC use in commercial, industrial, home, and test applications. 384 pages, softbound.
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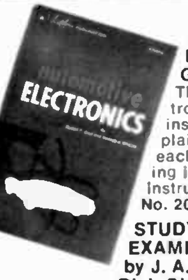
TRANSISTOR-TRANSISTOR LOGIC —by George Flynn. An invaluable aid to understanding the function and circuit construction of logic devices. The book discusses the digital families of which TTL is a part, and covers the basic units —the gate, the various basic circuits, and the voltage and current requirements. Also covered are: flip-flops, decoders, multiplexers, shift registers, counters, TTL math, methods for determining information priority and storage, and how TTL, the dominant form of semiconductor logic, works with other types of circuits and logic families. 176 pages, softbound. No. 20967 $5.50



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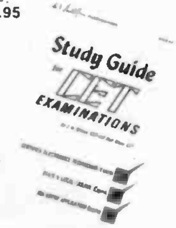

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☐ 20748	☐ 20856
☐ 20918	☐ 20834

Circle 13 on reader service card

EQUIPMENT REPORTS
(continued from page 20)

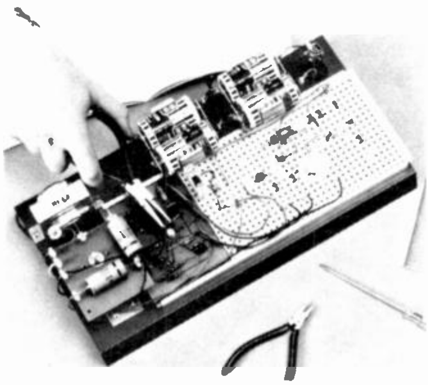
dual-trace scope is essential; the input and output signals can be displayed simultaneously, and the divider action checked with ease. In a divide-by-six stage, for example, you'll see one output pulse and 6 input pulses, and you know it's working properly. The TO-60 vertical amplifiers have a rise-time of only 23 nanoseconds, which is fine.

Two PR-10 probes are used with the TO-60. These are compact, rugged, and have a handy thumb-switch on the case. With this, you can change instantly from direct to low-capacitance without taking the probe off the test point. They're equipped with needle-point tips, to penetrate insulating coatings on PC boards, go through the insulation of wires, etc.

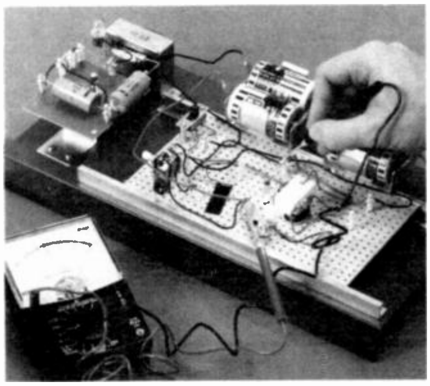
A PR-12 wideband demodulator probe is also available. Since the instrument I got was a pilot model, the final instruction manual wasn't ready yet. So, I don't know the exact spec's on the PR-12. I do know what it can *do*. For one thing, you can pull the IF cable from a tuner and read the demodulated TV signal right off the end of it! This must be at least a voltage-doubler type probe, for I got a reading indicating a level of 4 volts P-P on a horizontal-frequency signal! On the IF output of a Tuner-Subber, I got a display indicating 2 volts P-P. The waveforms were clean as a whistle; fine sharp

(continued on page 30)

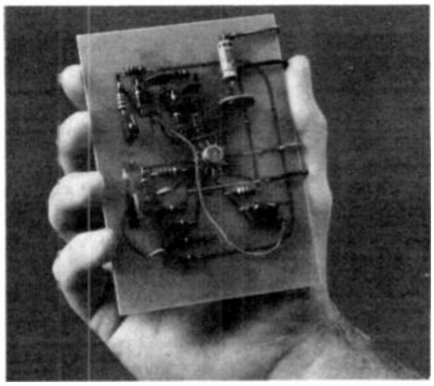
You get your own Experimental Electronics Laboratory... work with components comparable to those used by industry!



With CIE's Experimental Electronics Laboratory, you'll perform actual experiments and become adept at handling components. This valuable "hands on" experience helps you learn the "how" as well as the "why."



Testing and troubleshooting are an important part of your learning experience. Included in your laboratory is a precision "multimeter" to diagnose electrical and electronic troubles quickly and accurately.



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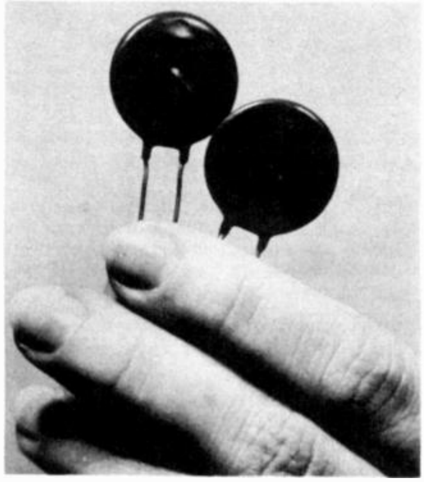
EQUIPMENT REPORTS
(continued from page 24)

horizontal sync, etc. This could be a fast and easy way of checking tuners or for signal-tracing through the IF stages in either tube or solid-state sets.

The TO-60 can also be used for sweep-alignment work. It has an additional horizontal amplifier that is switched on when the time-per-division switch is in the external position. This additional amplifier is necessary for vectorscope applications. It has a sensitivity of 0.5 volt-per-division, and a bandwidth of 0.5-MHz. This can be controlled by the variable control on the time-per-division switch. Vectorscope tests can be made from the front panel, using either channel-A or channel-B and the external input to the horizontal amplifier. Z-axis modulation can also be used from a front panel jack. If external trigger signals are needed, there is a jack for this. Sync can be chosen from internal, external or line frequencies by a 3-position switch. A 1.0 volt P-P square wave test jack is provided, for checking compensation of the low-capacitance probes, or for quick-checking the voltage calibration of the vertical amplifiers. Incidentally, the TV selector can be used with other types of signals, for better triggering; it acts as a low-pass filter to keep out undesired components. The triggering is solid; the TO-60 will lock in on a waveform that is only one division high.

The TO-60 is a solidly-built instrument, in a very compact case. It's only 13 inches deep, so it takes up very little room on the bench. Controls are arranged for easy operation. It should find application in almost any area of electronics work, from entertainment to industrial. It sells for $489.50.

General Electric "GE-MOV" Varistor



TRANSIENTS HAVE NEVER BEEN POPULAR with electronics men. Now, with everything full of solid-state devices, they are even less popular. Transistors and IC's hate voltage transients with a purple pas-
(continued on page 32)

EQUIPMENT REPORTS

(continued from page 30)

sion. It only takes 50 milliseconds or so to damage them badly. So, a fast-acting transient suppressor is a welcome thing.

G-E has come up with a new version. This is a specially compounded varistor, made with metal oxide and a new method, using "grain boundaries" in the polycrystalline material. (A varistor, Clyde, is a special resistor; its resistance *drops* when the voltage increases.) These new devices are called *GE-MOV®* varistors. They're made in many different sizes and voltage ratings, but the most commonly used operates on standard 120 VAC and is readily available from authorized distributors of G-E replacement semiconductors.

GE-MOV varistors are described as symmetrical voltage-dependent resistors which act like back-to-back Zener diodes. They can be used to replace previous types such as Zeners, silicon-carbide varistors, selenium thyrectors, and the old original R-C networks; the first suppressor used.

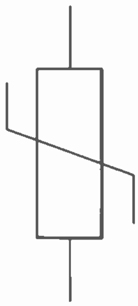


Fig. 1

The basic action of these things is like an open set of relay contacts, connected right across the circuit to be protected. When a transient comes along, they "close" very rapidly. This is a "crowbar" effect that shorts out the transient spike. Then, after the transient passes, the "relay" opens again. This is possible because of the very high resistance of the devices when not conducting. They also have very low capacitance, 300-400 pF. So, you may find them used in the circuitry of amplifier stages, etc., in the same place as bypass capacitors.

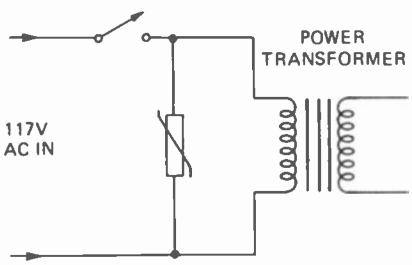
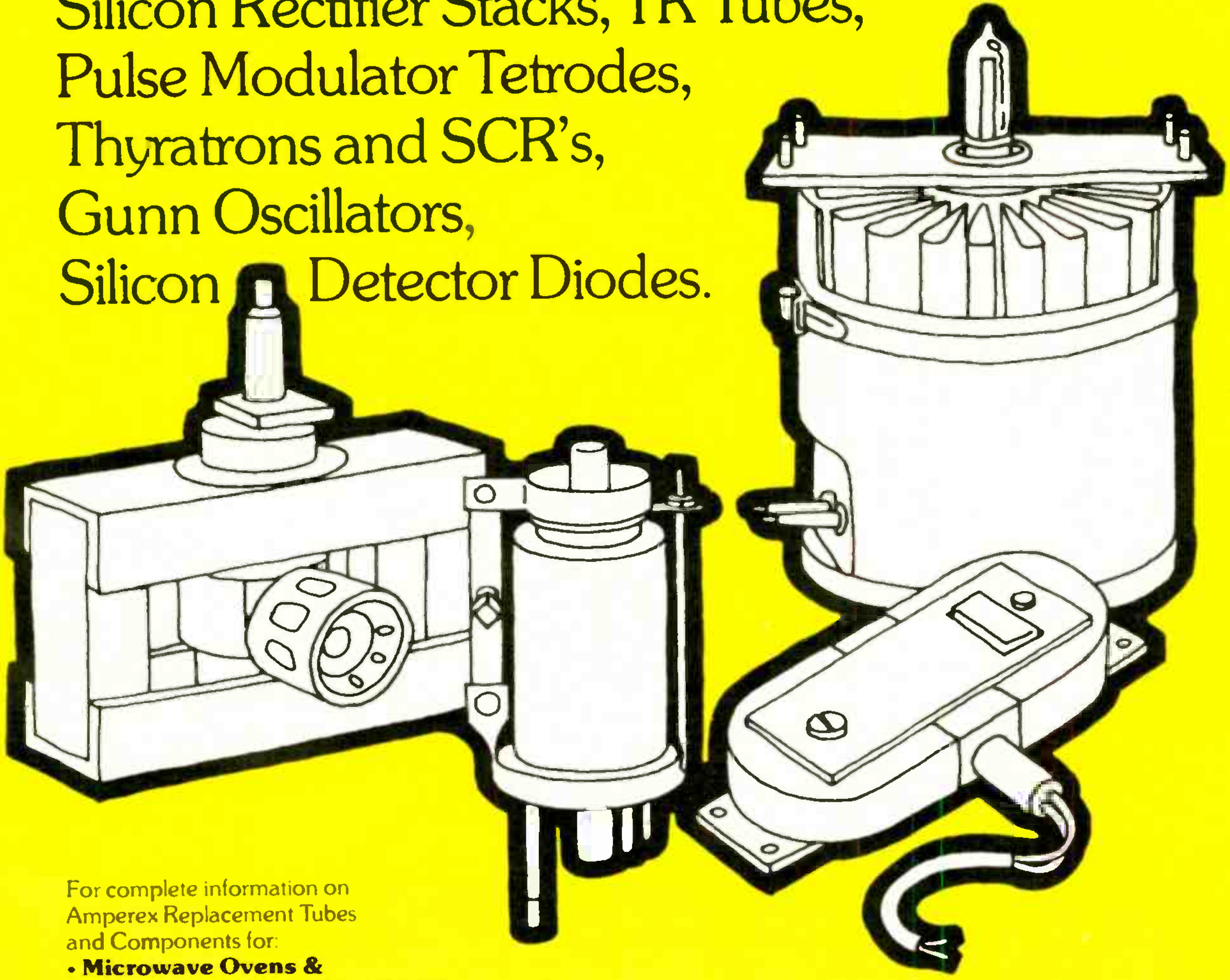


Fig. 2

Figure 1 shows the symbol adopted for the MOV. Figure 2 shows a common use for it; right across the AC line input, to a TV, stereo, etc. Here, it will absorb sharp line transients, from lightning or

(continued on page 34)



EQUIPMENT REPORTS

(continued from page 32)

sudden switching on or off of heavy loads. If a direct hit from lightning gets it, that's it. Nothing will stop that. The type used for this purpose is listed as GE 750. G-E makes a wide variety of MOV varistors in addition to the type 750. These range from 26 to 1,000 volts. Their numbering system is different. Take the V130LA 10A. The "130" in the type number stands for the operating voltage; it can be connected directly across an AC line at not more than 130 volts rms. The "10" farther along means that it can absorb 10 joules of energy without damage.

For other uses, they might be connected to the bottom of the load on a transistor amplifier stage, as in Fig. 3.

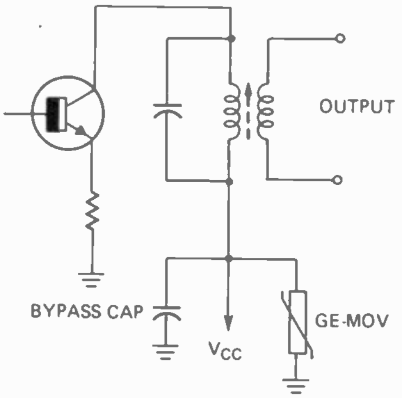


Fig. 3

If the collector voltage used was 30 volts, a Type V33ZA5 would do. This goes into conduction at 33 volts DC, and will handle a 5-joule transient. These low-voltage types have a very fast reaction, less than one *nanosecond!* There will be quite a few other, similar places where the protective characteristics would be very handy indeed.

In industrial electronics and control work, one of these will do wonders in suppressing arcs across relay contacts, as in Fig. 4. A copy of an actual oscillogram of unprotected and protected relay contact arcing is seen in Fig. 5. The arcing (shaded area to the left) looks like about 2-3 kV peak! In the second picture, you can see that there is no arcing at all! All you have to know for this is the energy absorbed per pulse, and the maximum supply voltage. This can be calculated from the formula $E = \frac{1}{2} \times L \times I^2$ Where L is the coil inductance and I is the peak coil current. This will give you the voltage rating and the energy in joules for the last significant figure in the type number. These are available in many voltages from the 33-volt series up to 1,000 volts at 160 joules.

For the present these are sold only to original equipment manufacturers and industrial users in bulk quantities.

Application and installation data is packaged with the GE-750 device. This is the one intended for use by service technicians in the home entertainment

(continued on page 61)

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8 NEW KITS
LAB POWER SUPPLIES

A new family of laboratory power supplies from the Heath Company. They offer a variety of voltage ranges, automatic output monitoring and adjustment of output. There's one for every bench

by LARRY STECKLER
EDITOR

FOR MANY YEARS BENCH POWER SUPPLIES WERE NOT VERY important to the technicians, experimenters and hobbyists that used them. Just about anything that would deliver 6 or 12 volts DC with enough amperage to power a car radio would meet most needs. But today it's a very different world. The modern power supply must provide precise voltages, be well regulated, offer constant currents and provide accurate monitoring and metering of the voltages and currents that it delivers.

The reason for this "revolution" is the semiconductor—the transistor, integrated circuit, or other solid-state device that is not very tolerant of extreme voltage and current changes. As we well know, even a small change in a DC supply voltage can play havoc with a solid-state circuit.

To fill the needs of the modern electronics bench, the Heath Company has introduced eight great new power supply kits. There are four pairs of fraternal twins, and are shown in the photo at the top of this page and on this month's front cover.

When we at Radio-Electronics previewed these kits, just a few months ago, we learned that they included several rather special features. They provide either constant current or constant voltage. A remote-sensing connection permits precise compensation for voltage drop at the load when the power supplies are used with long leads. The digital readout units have a two-decade auto-ranging to provide high resolution for low voltage and current settings. And the units are fully protected against shorted outputs or even the chance of open remote sensing leads.

A bit further on we'll take a closer look at each of these features, but for now, lets stop for just a moment and scan the specifications listed in Tables I, II and III.

Now that we've taken a moment to look at the specifications of this family of power supplies, let's take a quick run-down on how they work. All eight power supplies are pretty much alike, except for their output ratings. So we can talk about one unit and, in effect, be describing all of them at the same time.

The Heathkit Laboratory Power Supplies all consist of six basic circuits—a power source (the power transformer block in Fig. 1), the output amplifier current source (Q101 in Fig. 2), the output amplifier (Q1, Q2, Q3, Q4 in Fig. 1), the voltage regulator, and the display circuit (a block diagram of the digital display circuit is shown in Fig. 2).

Because of its size and complexity we are unable to present the full schematic of the power supply here, so for the purposes of this discussion we will use the block diagrams of Fig. 1 and Fig. 2.

TABLE I — SPECIFICATIONS
(TYPICAL FOR MODEL IP2731)

LOAD REGULATION	
Voltage	±0.05% + 1mV
Current	±0.10% + 1mA
LINE REGULATION	
Voltage	±0.05% + 1mV
Current	±0.10% + 1mA
RIPPLE & NOISE	
Voltage — 1mV RMS, 0.03% of rated output, peak-to-peak.	
READOUT ACCURACY	
Voltage: Analog — ±3% of rated output.	
Digital — ±0.5% of reading ±1 count using lab standard. ±1% of reading ±1 count using built-in calibrator.	
Current: Analog — ±3% of rated output.	
Digital — ±1% of reading +4 counts using lab standard. ±1.5% of reading +4 counts using built-in calibrator.	
STABILITY AT OUTPUT	
Voltage	±(0.01% + 1mV/hr
Current	±(0.05% + 1mA)/hr
LOAD TRANSIENT RECOVERY	
Output voltage within 0.05% + 1mV within 50 μs for rated output current change or 5A, whichever is less.	
OUTPUT VOLTAGE OVERSHOOT	
None, using power switch only.	
OPERATING MODES	
Constant voltage, constant current, auto-series, auto-parallel.	
PROGRAMMING MODE	
Voltage — A—Zero to rated output with 0 to 5.0V applied; B-Zero to rated output with 0 to 5000-ohm external resistor.	
Current—Zero to rated output with applied voltage to 1.0 volt/amp.	
Frequency response — DC to 100 Hz, 2 dB.	
Transient response — 0.1 ms for low current to high current change. 1.0 ms for high current to low current change.	

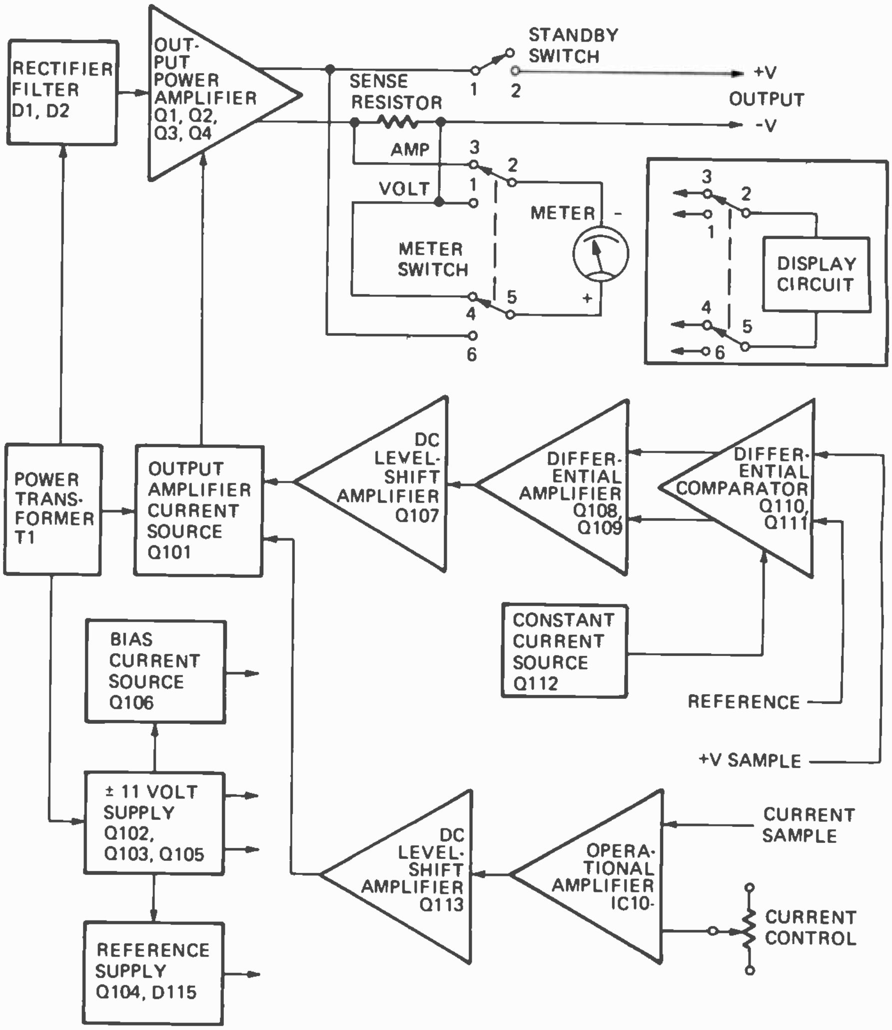


FIG. 1—BLOCK DIAGRAM OF THE COMPLETE power supply. When shown in this way it doesn't appear as elaborate as it really is.

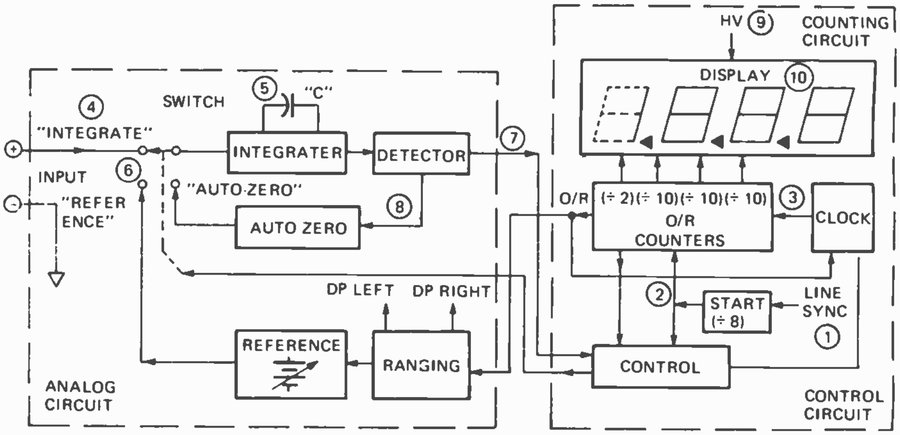


FIG. 2—BLOCK DIAGRAM OF THE DIGITAL READOUT CIRCUIT. Follow this diagram along with Fig. 3 when looking at how it works.

The power source

The power transformer (T1) has a dual primary that can be switch selected to permit 120 VAC or 240 VAC, 50/60 Hz operation. The secondaries, of course, supply the AC voltages to power the various circuits in the unit.

One secondary is connected to the output amplifier current source. In addition, it supplies voltage to the meter lamps. Another secondary feeds a rectifier filter network to produce a 75 VAC output (for the 60-volt supply). Still another secondary is used to produce +20 and −20 VDC sources for the +11 VDC and −11 VDC supplies. This voltage is fed through a

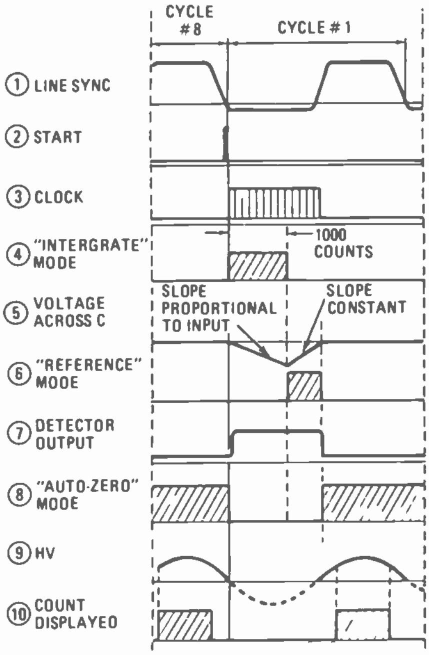


FIG. 3—WAVEFORMS IN THE digital readout circuit. Use along with Fig. 2.

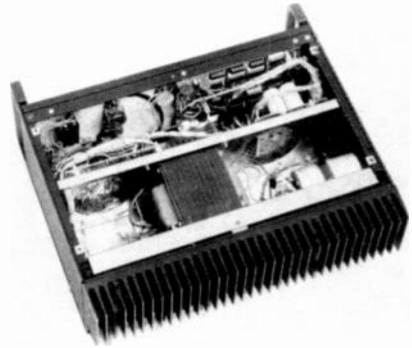
constant-current network so the regulated 11 volts is available for use in the current and voltage regulators.

Output amplifier current source

This circuit supplies drive current to the output amplifier. Its constant-current output is controlled by the current and voltage regulators to maintain the desired power supply output level.

Output amplifier

The output amplifier supplies the output power. The power transistors in this circuit are connected in parallel. Power from the output amplifier current source is amplified and coupled to the base of the power transistors. This current determines the voltage as well as the maximum current passed by the power transistors.



WITH ITS COVER REMOVED you can take a look inside the power supply.

The output amplifier current source operates at a higher DC voltage level than the output amplifier. This insures that up to six power supplies can operate in parallel with complete voltage and current control.

Voltage regulator

The voltage regulator maintains the output voltage level and consists of three primary circuits — a differential comparator that compares a sample of the output voltage to a reference voltage, a differential amplifier to amplify the error signal from the comparator, and a DC level-shift amplifier to sink current from the output amplifier current source.

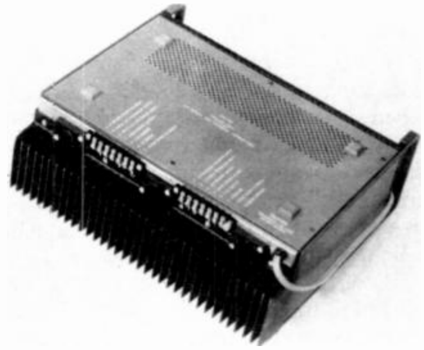
Current regulator

Current limiting is controlled by two basic circuits—an operational amplifier that compares a reference voltage to the voltage drop across the current sense resistor, and a DC level-shift amplifier to sink current from the output amplifier current source.

As the output current exceeds the level set by the current control, the comparator generates a positive voltage that is coupled to the base of the DC level shift amplifier (Q113). This increases the base current, which in turn increases the collector current and sinks current from the output amplifier current source. A lower current level to the output amplifier will limit the current the output amplifier can supply.

Display circuit

As we mentioned earlier there are two display options—an analog meter or a digital readout. In either case the



MASSIVE HEAT SINKS cover the entire rear panel of the power supply.

meter switch is used to read either voltage or current as desired. The analog circuit uses a conventional meter. The digital circuit is a bit more elaborate. A block diagram of this circuit is in Fig. 2. In the description that follows you will want to refer to this block diagram along with Fig. 3, which shows the functional waveforms.

The line sync signal (waveform 1) is derived from the line voltage frequency ot 50 or 60 Hz and is applied to the start circuit, a divide-by-8 counter. After 8 cycles, the start circuit generates a 1-μs pulse (waveform 2). This pulse resets the display counters to 9000, and resets the control circuit for a measurement cycle. When reset, the control circuit starts the clock (waveform 3) and switches the analog circuit to the "integrate" mode (waveform 4).

As the counters count the clock pulses, the integrator output develops a voltage on timing capacitor C (waveform 5), at a rate that is proportional to the positive input voltage (that is the charge voltage versus time increases with higher input voltage levels).

Integration continues as the counters count from 9000 to 9999. The next clock pulse "sets" the counters to 0000, which tells the control circuit to switch the analog circuit to the "reference" mode (waveform 6).

While the counters continue to count up from 0000, a negative reference voltage causes the voltage across timing capacitor C to ramp back toward zero. The ramp slope is constant, because of the fixed reference voltage.

TABLE II — ANALOG POWER SUPPLIES

Model	Max. Rated Output		Readout Range	
	Voltage	Current	Voltage	Current
IP/SP-2700	60 V	1.5 A	0 to 60	0 to 1.5
IP/SP-2710	30 V	3.0 A	0 to 30	0 to 3.0
IP/SP-2720	15 V	5.0 A	0 to 15	0 to 5.0
IP/SP-2730	7.5 V	10.0 A	0 to 7.5	0 to 10.0

TABLE III — DIGITAL POWER SUPPLIES

Model	Max. Rated Output		Readout Range	
	Voltage	Current	Voltage	Current
IP/SP-2701	60 V	1.5 A	0.00 to 19.99 20.0 to 60.00 *	.000 to 1.500
IP/SP-2711	30 V	3.0 A	0.00 to 19.99 20.0 to 30.0 *	.000 to 1.999 2.00 to 3.00 *
IP/SP-2721	15 V	5.0 A	0.00 to 15.00	.000 to 1.999 2.00 to 5.00 *
IP/SP-2731	7.5 V	10.0 A	0.00 to 7.50	.000 to 1.999 2.00 to 10.00 *

*Autoranged

When the detector senses a zero voltage across C, its output goes low (waveform 7) and signals the control circuit to turn off the clock. The count stored in the counters represents the input voltage. When the control circuit turns off the clock, it also switches the analog circuit to the "auto zero" mode (waveform 8). This lets the integrator and detector stabilize to prepare for a new measurement cycle.

During the preceding operations, the high voltage to the display tubes was low, as represented by the dotted portion of waveform 9, and the display was not lit. As the high voltage goes more positive, a level is reached where the gas in the tubes ionizes waveform 10) and the seven-segment digits display the count stored in the counters. Each of the next seven positive portions of the high voltage signal relight the display tubes.

If, during the "reference" mode of operation, the count exceeds 1999, the overrange (O/R) output of the counters turns the clock off and triggers the ranging circuit. This increased the reference voltage level by a factor of 10, and shifts the decimal point (DP) position. Thus, on the next measurement cycle, the timing capacitor will discharge 10 times more quickly and the count will be displayed with one decade less resolution.

Figure 4 shows a front panel diagram of one of the digital power supplies. Note that all front-panel control functions are clearly illustrated. These are the same for all four digital readout units.

Figure 5 shows the rear panel of the power supply. Each output terminal is identified to give you a better idea of the capabilities of these units.

Summary

There is little doubt that if you have been looking for a first-rate power supply for your bench at a practical price these new Heath units are what you have been looking for.

The manuals for assembly are just as easy to follow and as complete in detail as we have grown to expect from Heath. And while I haven't built one of these power supplies yet, I'm confident it will be as straightforward a job as all of the previous Heathkits.

Finally, all major circuitry is on individual circuit boards and wiring harnesses are provided to reduce complicated point-to-point wiring to a minimum.

Prices for all four analog units are $169.95 and the digital units are $219.95 in kit form. All eight are also available completely assembled at somewhat higher prices. I'm sure you'll be wanting to add one of these power supplies to your bench. R-E

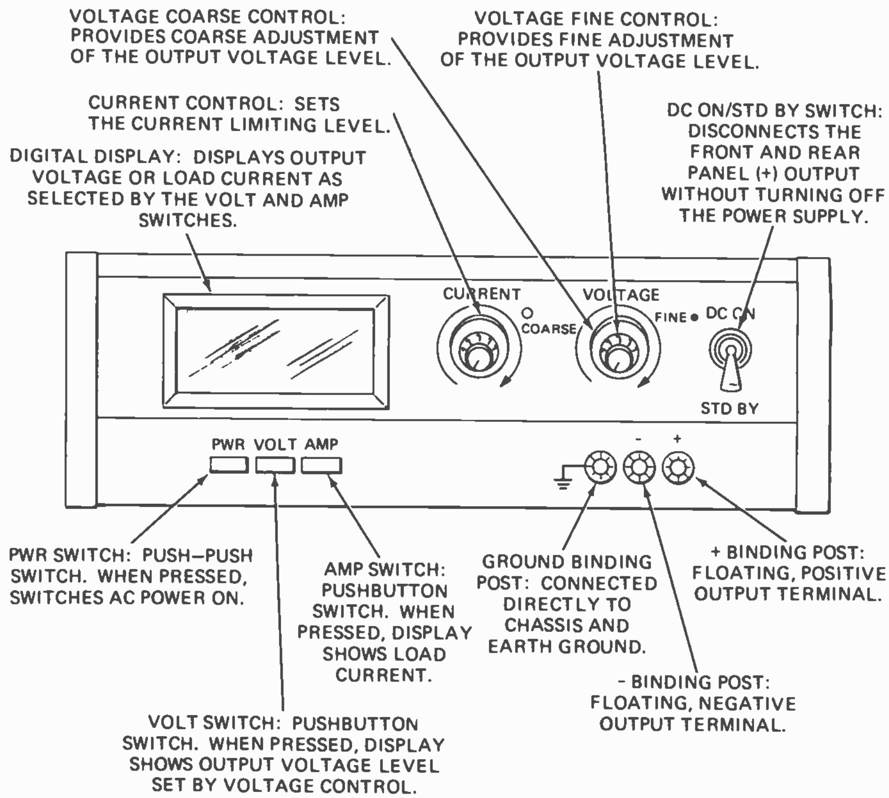


FIG. 4—FRONT PANEL CONTROLS ARE IDENTIFIED in this diagram and their functions are detailed. The units are easy to use yet versatile.

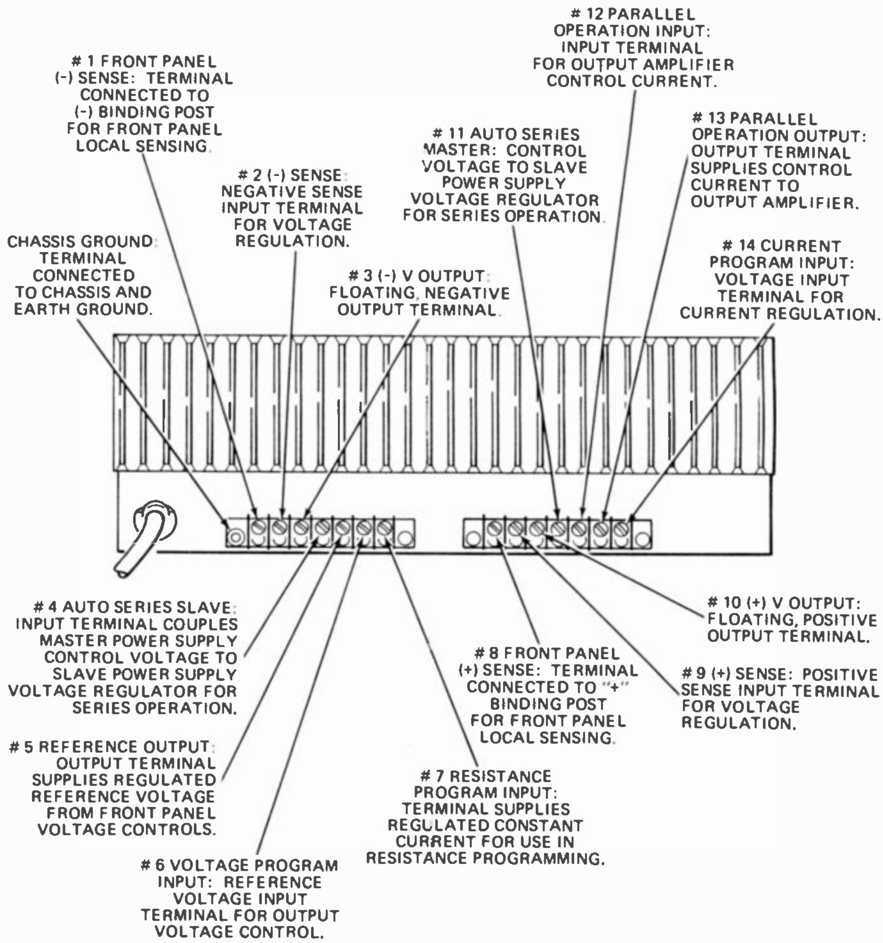


FIG. 5—OUTPUT TERMINALS OF THE LAB POWER SUPPLY are shown here. Again this helps give a picture of what the units can do.

Servicing MATV Systems

The MATV industry is rapidly expanding. Technicians should be prepared to service these systems. Here's how you can get started

by BERT WOLF*

AUTHOR shown using a field-strength meter.

HIGH INTEREST RATES AND GALLOPING inflation are beginning to put single family houses out of reach of most Americans. Therefore, more and more Americans are turning to apartment houses, condominiums and trailer parks, all of which require Master Antenna TV (MATV) systems. MATV systems are also used in hotels, motels, schools, hospitals, municipal buildings, broadcast studios, public buildings and even private homes. Based on growth in all of these areas, the MATV business is expected to increase considerably.

All of these new and old MATV systems require servicing. Most MATV systems are sold with service for the first year included in the price. After that, the building owner either takes out a service policy or takes his chances with system failure.

Many MATV system contractors are too busy to pay much attention to system servicing. Thus, there is a void which independent technicians can fill.

Servicing MATV systems is a lot easier than servicing color TV sets. It does require some specialized equipment, a working knowledge of MATV system theory and some legwork, but MATV service can be very lucrative.

Required tools

Aside from hand tools, you need only four pieces of equipment to service MATV systems successfully:

1. Field strength meter.
2. Portable TV set
3. Variable attenuator
4. Ohmmeter

The field strength meter should be battery operated, compact and portable. It should read directly in dBmV as well as microvolts and cover the entire VHF, FM and UHF spectrum. Accuracy should be ±3 dB or better.

The TV set should also be compact, portable and battery operated. The ohmmeter need not be particularly accurate, but it too should be portable. The attenuator should be a switch type, with type F connectors for fast connect/disconnect.

Troubleshooting new systems

Troubleshooting MATV systems can be divided into two distinct kinds of problems: new systems and old systems.

Let's look at new systems first. Assume that the system has been designed in accordance with good MATV practice. It's still quite possible that you will encounter some difficulties in getting good picture quality on every channel throughout the system. Here

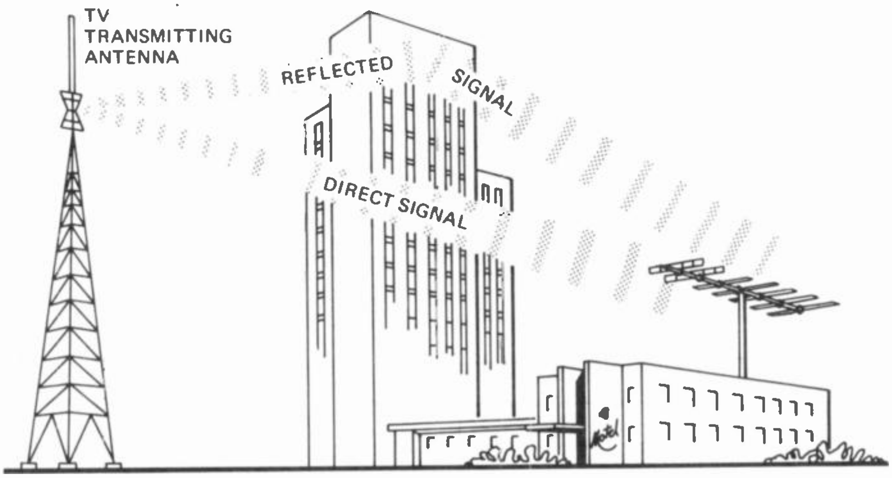


FIG. 1—GHOSTS are usually caused by an antenna simultaneously receiving a direct signal and a reflected signal.

*Manager, Jerrold DSD Division

are some of the problems you are most likely to encounter.

Ghosts and smears

The most common cause of ghosts is reflected signals, as shown in Fig. 1. Many people feel that ghosts are usually caused by mountains or tall structures many miles away, but the trouble is usually a lot closer to home. For example, a water tower 400 feet behind an antenna can cause a ghost displaced about ¼ inch to the right on a 21-inch screen. (Reflected path is actually 800 feet longer than direct path.) However, a mountain 5 miles to the side of the antenna would cause a ghost displaced 8 inches to the right on a 21-inch screen. Ghosts displaced more than an inch to the right are not as noticeable as closely spaced ghosts.

In large cities, it is possible for the reflected signal to reach the set stronger than the direct signal. This relatively rare occurrence produces a ghost displaced to the left, known as a leading ghost.

Multiple ghosts and smears are generally caused by standing waves within the MATV system. When a TV signal sees a mismatch, part of the signal is reflected back into the line. Reflected signals bouncing around in the system usually arrive at the set in evenly spaced waves. If the signals travel through a lot of coaxial cable before they reach the set, they are displaced significantly to the right of the main image. If they travel less than 200 feet extra, they are seen as smears rather than separate images.

If you did a signal survey before installing the system, you should have detected the problem of ghosts picked up by the antenna. The solution to this problem is usually bigger, better antennas, carefully oriented. In severe cases, you may have to use horizontally stacked antennas, as shown in Fig. 2. Horizontal stacking results in signal cancellation of specific angles, depending on the distance between the two antennas. You have to find a distance that will cancel signals from the direction of the ghost. This is best done by trial and error. Use a compass and a map to aim both antennas directly at the TV transmitter. Connect a TV set directly to the combined signal from the two antennas and watch it while the antennas are moved closer and further apart. The spacing is right when the ghost disappears.

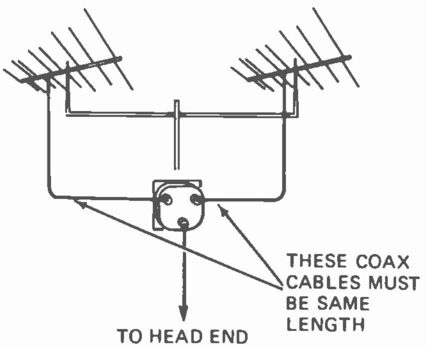


FIG. 2—HORIZONTAL STACKING of two antennas, both directed at the transmitting antenna, can reduce the reception of reflected signals. The horizontal spacing between the two antennas is important.

Multiple ghosts in a new system are generally caused by poor installation, which in turn causes a mismatch. A single strand of cable shield at a connector can cause a short. A loose connector or a center conductor that was knicked and broken can cause an open. A fast way to isolate this kind of problem is to insert a 6 dB attenuator into different parts of the system. The attenuator will improve the match, thus making the trouble diminish or disappear. Once you've located the problem, it is generally easy to correct.

FIG. 3—HERRINGBONE PATTERN usually caused by FM interference.

Some systems use wall tap-offs with 300 ohm outputs. This eliminates the need for set-matching transformers, but it means that there is a length of twinlead between the wall and the TV set. This twinlead acts as an antenna, picking up signals direct from the transmitter and causing ghosts. In weak signal areas, direct pick-up is no problem, but within about 20 miles of a transmitter, ghosting can be severe. The best way to solve this problem is to avoid it by using 75-ohm output taps if you have the slightest qualms about direct pickup. If you encounter this problem in an existing system, the only solution is to increase the signal level to each tap-off by using a more powerful head-end amplifier.

Interference

Low-frequency transmission such as Citizens band at 27 MHz, amateur radio (Ham) at 28 MHz or 50 MHz, Police or Fire at 29 to 50 MHz, can cause severe problems in MATV systems—anything from weak beats to wiggly lines that make the pictures on one or more channels impossible to view.

Since these interference sources are intermittent, it is easy to overlook them at the time of the signal survey. To identify the offending signal, tune your fiield strength meter for a maximum reading on the interferring frequency and then plug in the earphone. What you hear should enable you to pinpoint the source of the problem.

To eliminate the interference, use a sub-channel/TV splitter between the antenna and the first amplifier in the system. The splitter siphons off all frequencies below 54 MHz, keeping them out of the amplifier.

FM interference

FM interference is a problem in many areas. It usually cause a herringbone pattern such as that shown in Fig. 3. If the head-end uses single-channel amplifiers, FM interference will usually be confiined to Channel 6, though once in a while it can also affect Channel 5. In a broadband system, FM interference can cause interference on Channel 6, but it may also show up on some other low-band channel, a high-band channel or several channels.

To eliminate FM interference, you can use either a single frequency tunable trap or an FM band rejection filter. Tunable traps can give you up to 40 dB or more of signal attenuation, but they tend to drift. Band rejection filters give you only about 20 dB of attenuation, but they are drift free. Generally, it's best to use a band rejection filter if it will do the job. If not, use an FM trap, but detune it slightly to reduce attenuation to about 30 dB. This will give you a wider notch to compensate for drift. Whether you use a trap or a filter, be sure to insert it before the first amplifier in the system.

Electrical interference

Electrical interference usually shows up on the TV screen as thin bands of noise ("snow") across the picture. The bands may roll up or down or stay in place.

Electrical interference is caused by defective equipment which arcs, generating interference across the entire RF frequency spectrum. You are more likely to see the interference on low-band antennas, however, because the signal strength of electrical interference decreases with frequency. UHF, in fact, is seldom bothered by this type of interference.

If the interference is continuous, the problem probably lies with the power company. Somewhere in the vicinity there is a loose C-clamp or Kearney connector, a cracked insulator, an arcing transformer or some other type of poor connection.

These problems are not easy to solve. Try calling the power company. Sometimes they are very cooperative and locate the fault quickly. If they are not, you'll have to try to pinpoint the trouble source for them. Use a high-gain antenna and a field-strength meter to get an idea of the direction of the interference. Rotate the antenna till you get a maximum reading on the interfering signal. Relay this information to the power company. As a last resort, try driving toward the interference with your AM radio tuned to the noise between stations. If you can narrow the area down to a block or two, the power company will probably do the rest.

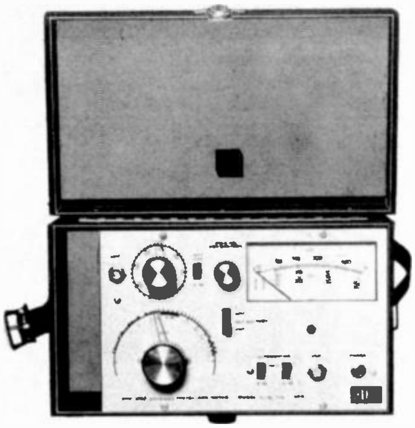
Intermittent electrical interference is usually caused by defective brushes on some electrical motor. If the interference occurs at regular time intervals, it's probably some unit that turns itself on and off periodically, like a furnace or an air conditioner. An irregular time pattern indicates a machine that requires an operator, such as a vacuum cleaner or an electrical drill.

Using the clues at hand and a little detective work, you should be able to track the culprit down eventually. Once you do, the owner of the machine is usually glad to replace the worn motor brushes.

Ignition noise

Automobile and truck ignition noise generally shows up on the TV screen as bright, broken streaks across the picture. Ignition noise is usually more a problem on home systems using twinlead than MATV systems using coaxial cable. However, ignition interference can show up on some sets in some MATV systems.

The key to eliminating ignition problems is to increase the signal-to-noise ratio. There is no way you can decrease the amount of noise generated by passing vehicles or to increase the amount of signal transmitted from the TV station. But you can increase signal pickup by using high gain antennas—vertically stacked, if necessary. Vertical stacking gives you almost 3 dB of gain and decreases noise pick-up by increasing directivity.



JERROLD MODEL AIM-719 signal-strength meter.

You can maintain a high signal-to-noise ratio by designing for more than 0 dBmV per outlet. In the case of an existing system with heavy ignition interference, try substituting an amplifier with more output and more gain.

Ribbon lead-in (300-ohm) between wall tap-offs and sets can pick up ignition noise as well as direct signals. It may be necessary to replace the tap with a 75-ohm output unit and take coax directly to the back of the set. This solution is not practical for a whole system, but if only a few tenants at the ends of the trunk lines complain, the tap-offs in their apartments can be replaced.

Converter interference

In many MATV systems, UHF channels are converted to unused VHF channels. The advantage is lower distribution system losses, especially important in very large systems. However, converters can cause interference that looks a lot like HAM, CB or FM interference. The heart of every converter is a local oscillator. The oscillator frequency is set to beat with the incoming UHF signal so the difference is the desired VHF signal. For example, a channel 14 (470 MHz) to Channel 6 (82 MHz) converter generates a local oscillator frequency of 388 MHz (470 − 82 = 388).

The best UHF to VHF converters are crystal-controlled for stability, but some are not. Even a crystal-controlled converter can cause problems. The output of the converter is usually a multiple of the fundamental oscillator frequency. Intermediate frequencies can beat with other frequencies in the system and cause interference. It's very hard to calculate all possible beat combinations, especially if more than one converter is involved. Your best bet is to get the recommendations of the manufacturer before you order specific converters. This will avoid most problems.

If you suspect converter interference in an existing system, it is easy to isolate. Simply unplug the converter and look at the pictures on the other channels. Once you know a converter is causing problems, try physically isolating it and putting it into a separate radiation proof housing. Also, reduce output levels if necessary to balance signals. This may do the trick.

Beats similar to converter interference can also be caused by modulators. The cure is the same—balance signals and isolate the modulator.

Overload

Too much signal can cause as many problems as too little signal. Overload problems occur only in active equipment such as preamplifiers, amplifiers and TV sets.

Broadband amplifiers and preamplifier overload usually results in cross-modulation. This appears on the screen as "windshield wiper" effect—bars sweeping across the picture.

Single-channel amplifiers, on the other hand, go into sync compression. Sync signals are carried on the blacker-than-black portion of the TV signal —the points of highest power. Nonlinearity in amplifier gain affects the highest power points first, compressing them somewhat. Sync compression starts with tearing, usually at the top of the TV picture. It causes the vertical hold controls to be very critical. In extreme cases of sync compression, the picture may break up completely.

(continued on page 69)

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20 easy-to-build COSMOS burglar alarms - part 2

Here are a few accessories that can be added to the basic alarm circuits presented last month. The options you add are entirely up to you.

by R. M. MARSTON

IN PART ONE OF THIS SERIES, FIVE basic burglar alarm projects were presented. Those basic alarm circuits were built around COSMOS logic and are very effective. This month we describe several options that can be added to the basic alarm circuits to make them even more effective.

The three circuits of Projects 3 to 5 act as excellent burglar alarm systems in their own rights. Their capabilities can be considerably expanded, however, by adding on a few simple electronic accessories, as shown in the following section.

Alarm system accessories

A problem with all burglar alarm systems is that of leaving or entering the house via a protected door once the system has been set into the STANDBY mode. A simple way around the problem is to fit a key-operated bypass switch to the outside of the door, so that the doors sensor switch can be temporarily disabled by the authorized key holder.

In this case, the proceedure for leav-the house is to first open the door and disable its sensor via the key switch, then re-enter the house and set the alarm to STANDBY, then leave the house again and close the door and re-enable its sensor via the key switch. The proceedure for re-entering the house without sounding the alarm is to simply disable the door sensor via the key-switch, then enter the house and turn the alarm system off.

Most of the tedium of this proceedure can be eliminated by equipping the alarm system with an exit-delay facility, which automatically disables the door sensor for a pre-set period after the main alarm system is switched to STANDBY. This facility enables the owner to simply switch the alarm system to STANDBY and then leave the house without sounding the alarm, but it is still necessary for the owner to manually disable the door sensor switch on re-entry if entry is to be made without sounding the alarm.

If required, even this re-entry proceedure can be eliminated by equipping the alarm system with a combined exit-delay and entry-delay facility. This facility ensures that the alarm will not sound until a pre-set time after the door sensor is initially activated by the entry action, thus giving the owner time to enter the house and turn off or reset the alarm system before the alarm actually sounds.

Practical exit-delay facility and exit-and-entry-delay facility circuits are shown in Projects 6 and 7. These facilities can readily be added to any of the main alarm system circuits shown in Projects 3 through 5.

The exit-delay facility of Project 6 uses three gates of a CD4001AE IC. Door sensor switch S7 can be of either the n.o. or n.c. types, and is connected in such a way that the input to pin 1 of gate A is at the positive supply voltage when the door is closed, and is at ground potential when the door is open. Gate A is wired as a simple NOR gate, which gives a low output when either input is high, and time-delay network C1-R3 is connected to the pin 2 input of the gate via R4. When power is first applied to the circuit, capacitor C1 is fully discharged, so pin 2 is effectively shorted to the positive supply line via R4, and the output of the gate is at ground potential, independent of the state of the door sensor switch. After a delay determined by C1 and R3 (roughly 0.5 seconds per μF of C1) the pin 2 voltage decays to such a value that the gate is influenced by the state of the door sensor switch. If the door is closed at this point, the gate output remains low, but if the door is open the output goes high.

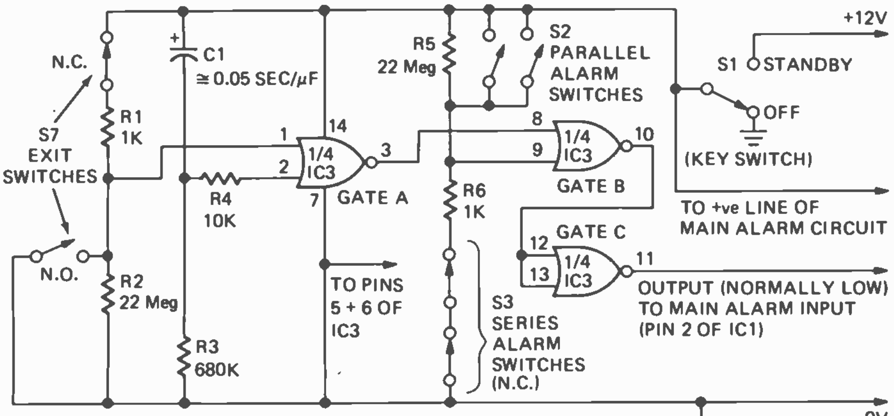
The output of gate A is taken directly to pin 8 of gate B, which is also connected as a NOR gate. The main section of the alarm system sensor circuitry is taken to pin 9 of gate B in such a way that this pin is effectively grounded under normal conditions. The output of gate B is inverted by gate C, which thus gives an output that is normally low. This output is passed on directly to pin 2 of IC1 in the main alarm circuit.

Thus, the action of the Project 6 circuit is such that all sensor switches except S7 are enabled as soon as S1 is set to the STANDBY position, and S7 is disabled for a pre-set period. At the end of this period S7 is automatically enabled, and the alarm is able to respond to the actions of S7.

The combined exit-and-entry-delay facility circuit of Project 7 is similar to that of Project 6, except that R1 is increased to 10K, gate A is converted into a self-latching switch with the aid of D1 and gate D, and the output of gate A is fed to the input of gate B via time-delay network C2-R7 and R8. The circuit works as follows.

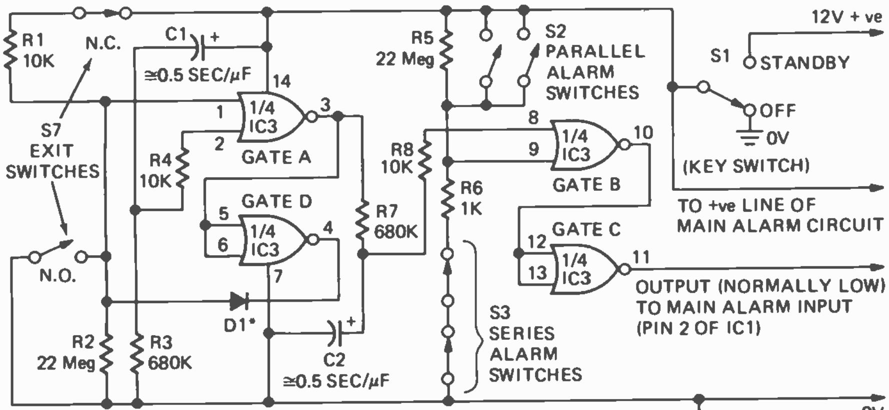
When power is first applied to the circuit, all sensor switches are enabled except S7, which is disabled for a pre-set period via time-delay network C1-R3. The output of gate A is held in the low state under this condition. At the end of this pre-set period, S7 is auto-

6. ALARM SYSTEM WITH EXIT-DELAY



NOTE: IC3 = CD4001AE

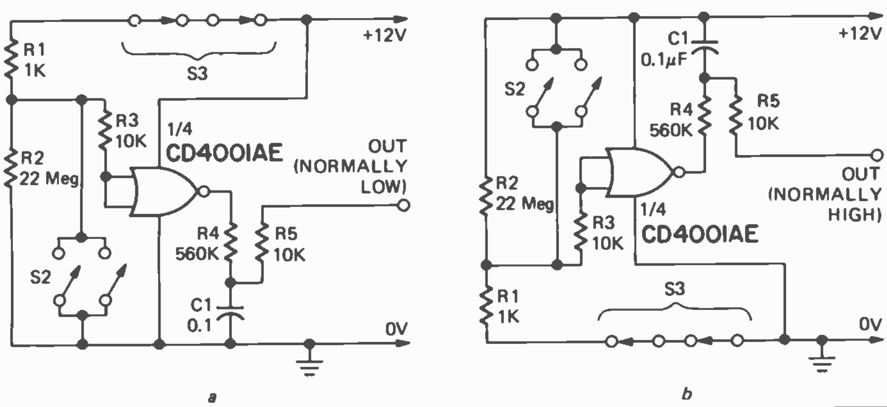
7. ALARM SYSTEM WITH EXIT-AND-ENTRY DELAY



NOTE: IC3 = CD4001AE
*D1 = GENERAL PURPOSE SILICON DIODE

8. TRANSIENT SUPPRESSOR FOR SENSORS

NOTES: S2 = N.O. ALARM SWITCHES, IN PARALLEL
S3 = N.C. ALARM SWITCHES, IN SERIES
OUTPUTS OF CIRCUITS GO TO INPUTS OF MAIN ALARM SYSTEMS



matically enabled. If S7 is activated after the end of this pre-set period, the output of gate A immediately goes high, and is locked in this state by the action of diode D1 and gate D. This high output voltage is applied to the input of gate B via time-delay network C2-R7, and after a pre-set delay (approximately equal to 0.5 seconds per μF of C2) the voltage applied to gate B rises to such a value that the alarm is activated.

The exit-delay facility or exit-and-entry-delay facility circuit of Projects 6 or 7 can be added to the main alarm circuits of Projects 3 through 5 by simply removing the existing connections to pin 2 of IC1, by rewiring the existing alarm sensors into the Project 6 or 7 circuits, and by connecting the outputs of the Projects 6 or 7 circuits to pin 2 of IC1. Note that it is also necessary to wire the OFF pin of key-switch S1 to ground if these facilities are used, so as to provide a discharge path for the timing capacitors of these circuits.

All the burglar alarm circuits that we have looked at give reliable performance and are not prone to giving false alarms under normal circumstances. One exceptional circumstance which may initiate false alarms in any type of alarm system is that of the thunderstorm, where heavy electrical discharges may induce such large energy pulses into the alarm sensor wiring that the alarm is made to trigger falsely. In COS/MOS alarm systems, this possibility can be eliminated by simply interposing sensor-transient-suppressor circuits between the outputs of the main sensor networks and the inputs of the main alarm systems. Project 8 shows practical circuits of this type.

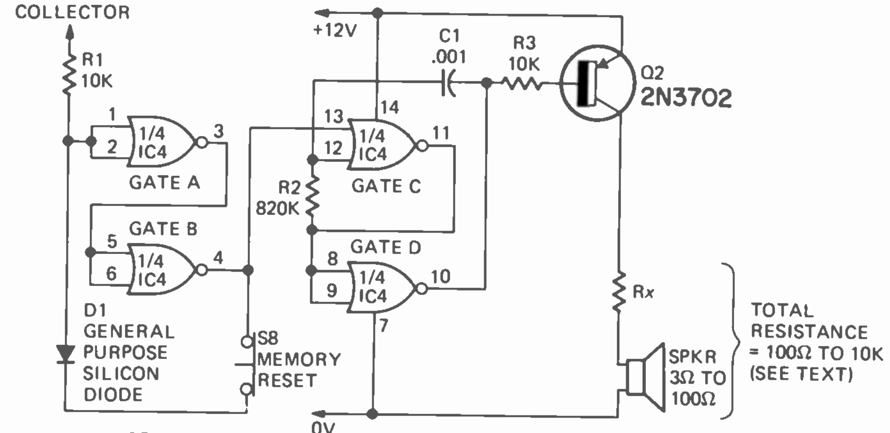
In the Project 8 circuit, a spare gate of a CD4001AE IC is wired as a simple inverter. The input of this gate is connected to the output of the main sensor network via limiting resistor R3. The output of the gate is connected to the input of the main alarm via R5 and a time-constant network formed by C1-R4. This network only passes signals that are applied to the gate input for periods greater than 50 ms. Consequently, the circuti rejects short-duration spurious pulses that are induced into the sensor wiring, but passes longer-duration signals that are generated by the activation of the sensor switches.

The Project 8-a circuit is intended for application where the sensor input to the main alarm system is required to be normally low, and the Project 8-b circuit is intended for use where the sensor input needs to be normally high. It should be noted that in practice these transient suppressor circuits are only likely to be needed in cases where the lengths of alarm sensor wiring exceeds fifty meters or so, since all the COS/MOS alarm circuits shown in this article have relatively low input impedances (1K or 10K ohms) when the sensor switches are in their normal states, and are thus not unduly sensitive to induced signals.

One final accessory that can be added to a burglar alarm system is an intrusion recorder. This gadget is intended for use in auto-turn-off alarm systems only, and consists simply of a low-power sound generator that turns on and self-latches if an intrusion occurs, thus giving a continuous indication of the intrusion. The device can tell the owner that an intrusion has occurred during his absence from the house even though the main alarm has turned off and no signs of the intrusion are visible. A practical intrusion-recorder circuit is shown in Project 9.

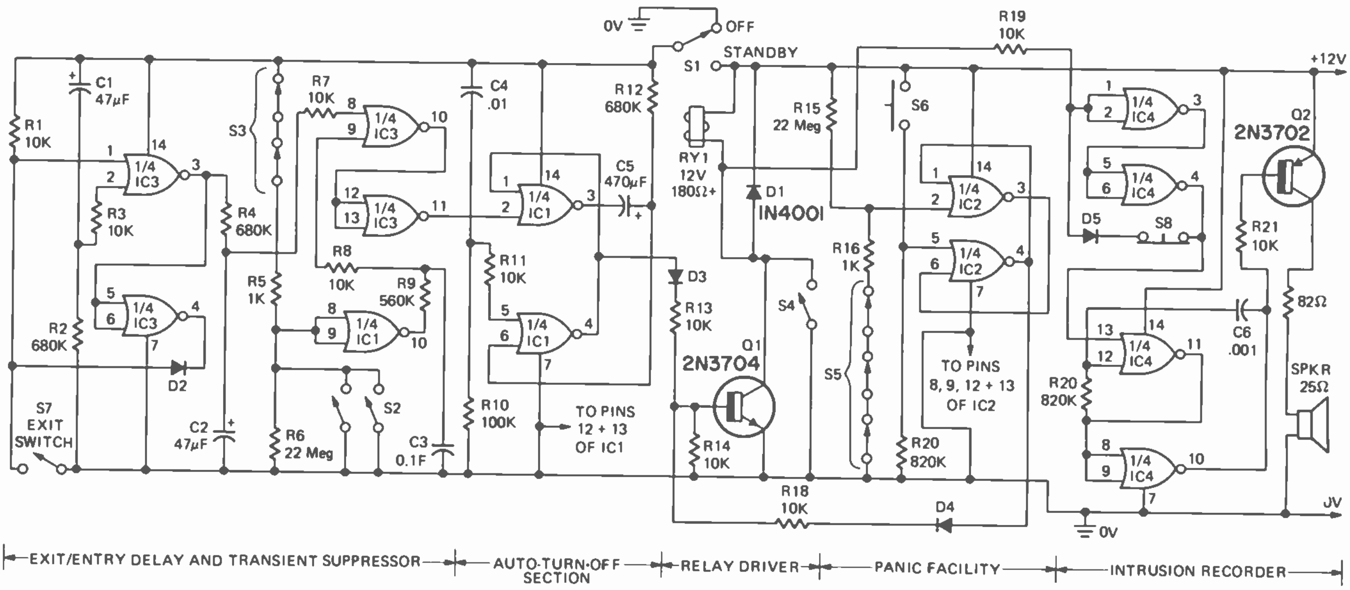
The Project 9 circuit is permanently wired across the supply lines and its operation is quite simple. Gates C and D are connected as a gated 800-Hz oscillator which drives a speaker via Q2 and R_x. This oscillator is activated

9. INTRUSION RECORDER



NOTE: IC4 = CD4001AE

10. COMPREHENSIVE ALARM SYSTEM



S1 = KEY SWITCH
S2 = N.O. ALARM SWITCHES, IN PARALLEL
S3 = N.C. ALARM SWITCHES, IN SERIES
S4 = N.O. FIRE-SENSOR SWITCHES, IN PARALLEL
S5 = N.C. 'PANIC' BUTTONS, IN SERIES
S6 = N.O. 'RESET' BUTTON FOR PANIC ALARM
S7 = N.O. EXIT SWITCH
S8 = N.C. MEMORY 'RESET' BUTTON, FOR RECORDER
D2 - D5 = GENERAL-PURPOSE SILICON DIODES
IC1 - IC4 = CD4001AE

from the collector of transistor Q1 of the main alarm system via the self-latching switch formed by gates A and B. Normally, the collector voltage of transistor Q1 is high and the alarm relay is de-activated. Under this condition, the 800-Hz oscillator is inoperative and the recorder circuit consumes a quiescent current of only 1μA. If the main alarm system is activated, the relay is energized for a pre-set period and the collector of Q1 goes high. When this occurs, gates A and B of the recorder turn on and self-latch, activating the 800-Hz oscillator, thus causing an audible signal to be generated in the speaker. Once this audible signal has been initiated, it can only be stopped by operating RESET switch S8.

The Project 9 circuit can be added to the auto-turn-off circuit of Project 4 or 5 by simply wiring it across the supply lines and connecting R1 to the collector of Q1. The speaker used in the circuit can have any impedance in the range 3-ohms to 100-ohms. The combined series value of R_x and the speaker impedance can be varied from a minimum value of 100-ohms up to about 10K-ohms, depending on the sound intensity that is required from the speaker. The maximum power output of the circuit is about 250-mW when R_x has a value of zero and a 100-ohm speaker is used, and in this case the circuit consumes roughly 50-mA of current. Proportionately lower currents are consumed at lower power levels.

A comprehensive alarm system

The alarm system accessory circuits of Projects 6 through 9 can be added to the basic alarm circuits of Projects 3 through 5 in any combination, depending on the requirements of the individual reader. The final alarm system can be as simple or as complex as the reader desires.

The comprehensive alarm system of Project 10 is shown as an example of how a number of different circuits can

(continued on page 96)

IC UPDATE

Understanding the OP AMP

This article presents the basic rules and explains how to properly design around the operational amplifier.

by DON LANCASTER

BY NOW, EVERYONE SHOULD BE MORE OR less familiar with the "741," a low cost, internally compensated operational amplifier that has an incredible variety of DC and audio uses. But, very often, the 741 won't seem to work at all in the circuit, or perhaps not as well as you expected. This often happens when some *use* rule of the 741 is broken, or you make some basic assumption about the device that either isn't true or, at best, isn't very true.

For instance, what is the *upper* —3 dB cutoff frequency of a 741? Would you believe 3 *hertz?* Is the 741 as good as a plain old transistor as an amplifier at, say, 80 kHz? No, it isn't—but some op-amps are. Why do we have two inputs on an op-amp with apparently identical input circuitry, one marked + and one marked —, and yet the — one acts like a dead short and the + one acts like a very high input impedance? Because the feedback you are supposed to use creates a virtual ground. And why, sometimes, does the output of the op-amp sit at the positive or negative supply, and apparently refuse to budge no matter what you do? Probably because you forgot to use feedback or forgot to properly DC bias the inputs.

Yet, if you follow the simple rules, the 741 and its improved offspring are extremely well behaved, low cost, easy-to-use devices, good for a wide variety of DC and AC amplification problems, integrators, ramp generators, electronic music circuits, active filters, and very much more. So, let's take a rather basic look at the operational amplifier, and build up a set of rules of the game, particularly seeing what the 741 can and can't do. From there, we'll look at some devices and manufacturers, and then we'll end up with some applications.

What is an operational amplifier?

The name *operational amplifier* came from the theory of feedback amplifiers. If you build a DC coupled amplifier with very much more gain than you could possibly want, and then use very heavy negative feedback around the amplifier, the performance of your circuit will depend almost entirely on what is doing the feeding back and what is doing the feeding in. Use resistors, and you have a simple and stable gain DC amplifier. The gain is determined by the resistor ratio only and is independent of the amplifier gain and power supply variations, *provided* that the op-amp has very much more gain than you need compared to the resistor ratio. For instance, with a 100K feedback resistor and a 10K input resistor, you can build a gain-of-ten amplifier, and if the frequency of operation gives you an op-amp gain of at least 1000, the most gain error you can get from the amplifier or power supply is only around 1%, and progressively less with higher gains.

If you use a capacitor for feedback, the capacitor has to charge and discharge in response to input currents. This gives you an *integrator,* or a ramp generator. You can use it for waveform generation, triangles, sawtooth, etc., or to mathematically find the area-under-a-curve of a time waveform. It's also a low-pass filter. Add more rseistors and capacitors to your feedback and input networks, and you can build other high performance *active* filters —highpass, bandpass, band reject, equalizers, etc.

So, if we have enough excess gain in our op-amp, we end up performing an *operation* based on the *ratio* of feedback to input impedance. If the op-amp has enough extra gain at the frequency of operation, the *operation* you are trying to do depends *only* on stable resistors and capacitors. So, we start our rules:

1. An operational amplifier is almost always used with heavy feedback. If the feedback is negative, the ratio of the feedback impedance to the input impedance decides what the circuit is to do. and . . .

2. If an operational amplifier is going to work properly, it has to have much more open loop gain at the frequencies of interest than the circuit calls for.

We'll take a closer look at the 741 and its improved offspring in just a bit, but for now, the DC gain of a 741 is around 200,000. Now this is a bunch of gain. But the frequency response starts falling off immediately. For instance, you are already three decibels down from your DC value (the - 3 dB "cutoff frequency") at 3 hertz. Still, a gain of 140,000 or so is rather respectable, so we can use the beast at higher frequencies. Gain drops by 6 dB per octave (20 dB per decade) of frequency, so by 10 kHz you only have a gain of 100 left over, and by 100 kHz, only a gain of ten. So the 741 will be hard pressed to provide the excess gain we need for proper operation in the upper audio range. We'll find out about a much better (and somewhat more expensive) beast called the LM318 later on, that easily handles any audio problem. The point is that *any* operational amplifier falls off with frequency and you have a limit beyond which you can't get enough excess gain to keep the circuit working properly. The *minimum* excess gain you should ever work with is ten times the circuit needs at the maximum frequency of interest:

3. For non-precision applications, at least ten times the circuit gain must be available from the op-amp at the highest frequency of interest. Circuit gain limits for the 741 in a non-precision circuit is ten at 10 kHz and one at 100 kHz.

By "non-precision," we mean that a five or ten percent performance error won't hurt anything. For one percent precision, use one hundred times the gain, and so on. As long as you are *lower* in frequency than these limits, you get lots of *extra* gain and proportionately more precision.

An inside look

Figure 1 shows us how we can look at the operational amplifier as three distinct gain blocks, a *differential input* stage, a high gain *intermediate* stage, and a relatively high power, low impedance *output* stage. The differential input stage accepts input signals at very high impedances and with light loading. It also provides a way to take the difference between two input signals. This is the most critical stage of the op-amp. The intermediate stage only has to provide lots of gain. The output stage has to provide drive power for the outside world, very important if circuit loading isn't going to change what gets fed back.

There are two inputs to the differential input stage. One is called the *inverting* input and is normally shown as a (–). One is called the *non-inverting* input and is normally shown as a (+). Note that this + and – has nothing to do with the supply lines. The positive supply is usually called V+; V– is the normal pin callout for the negative supply. There is no ground connection for the op-amp, and the circuit works best with split supplies of equal value, ranging from +5, –5 to +20, –20, with +15, –15 being the most common. Input signals must be limited to something halfway between the two supply levels, a specification called the *common mode range*. Thus a grounded signal reference is in the middle of the common mode range for a split supply amplifier. Another rule:

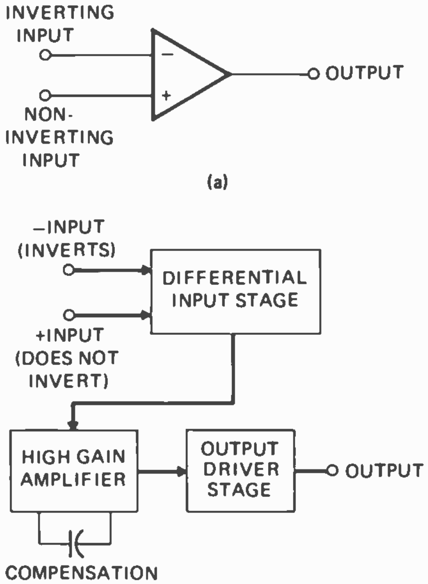


FIG. 1—SCHEMATIC SYMBOL of the operational amplifier is shown in a. The three stages of the OP-AMP is shown in b.

4. Operational amplifiers often work with a split power supply. With a split supply, input signals should be restricted to a range that is significantly less than the positive supply and significantly more than the negative supply. The common mode range for a 741 with ±15-volt supplies is ±12 volts maximum. Thus, you cannot normally ground the negative supply and apply a grounded input.

Back to those inputs. If we apply a very small positive voltage step to the + input, it drives the output *positive*, since it is *not* (or non) *inverting* the step. If we apply the same small positive step to the – input, the output gets driven in the *negative* direction since this is the *inverting* input.

Remember that there is no ground connection on the op-amp. Ground for the circuit is simply "a stake driven in the ground" that tells us where halfway between the two supply limits happens to be, and the point where we get the most common mode swing in either direction. Our circuit always amplifies the *difference* between the two inputs and ignores any *common* signal that both inputs identically share, provided, of course, that that common signal is within the proper common-mode operating range of the amplifier.

If we use both inputs, we are operating in a *differential mode*. If we ground one input, or tie it to some other reference within the allowable limits, we are working in the *single-ended* mode. Thus, the inputs are referenced only *to each other*, unless you "stake one down" to some reference voltage such as ground.

Feedback

We apparently have a choice of where we put our feedback. Usually, we apply feedback to only the (–) or inverting input. Rarely, we can apply positive feedback to the (+) or non-inverting input, but you essentially never do both at once in simple circuits.

If the feedback network goes from the output to the + input, a small positive input gets amplified, turns around and drives the input *further* positive, and builds up avalanche style. This would be *positive feedback* and is inherently unstable. You normally can use positive feedback only where a *snap-action* or speedup is desired. With positive feedback, the output usually sits as close as it can get to either the positive or the negative supply. The output is then essentially two-valued or digital.

Normally, we are more interested in having the amplifier behave linearly instead of flipping from stop to stop, digital-logic style. To do this, we use *negative feedback* from the output to the (–) input. Negative feedback always tries to *correct* any changes forced on the amplifier by the input signals. *Negative feedback always tries to force the difference between the two inputs to zero.*

If we make the + input ground for single-ended operation, the negative feedback will always force the input to *ground* continuously. For if it *wasn't* at ground, the high gain of the amplifier would immediately amplify the error signal and feed it back for correction.

If the (–) input is never allowed to go away from ground by anything but a tiny amount, we can think of it as being the *same* as ground as far as the feedback networks are concerned. The name for this is a *virtual ground*, and in a properly connected and fedback operational amplifier, the (–) input behaves as a *dead short to ground*, as far as the rest of the circuit can tell. Since there is no feedback taking place at the (+) input, it remains as a very high impedance. So, with negative feedback, the (–) input looks like a short and the (+) input looks like an open, despite apparently identical internal circuitry. Some more rules:

5. If the feedback on an operational amplifier goes from the output to the + input, you will get a snap-action and a digital-logic style output. This is useful only for comparators and other snap-action circuits.

6. If the feedback on an operational amplifier goes from the output to the – input, you will get a linear operation useful for amplifiers, integrators and filters. The output will exactly follow the ratio of the input to output impedances, provided there is enough excess gain at the operating frequency.

7. When negative feedback is used, the input impedance on the + input is normally very high. The input impedance on the – input is normally extremely low and is called a virtual ground.

Now, this virtual ground thing is extremely useful. It means you can *sum* input signals without crosstalk or interaction. It means that the input and feedback networks don't interact with signal levels or each other. And it vastly simplifies the math behind whatever you are trying to do.

Offsets

Figure 2 shows a typical differential amplifier stage from the input circuit of an operational amplifier. The + input goes through the first transistor as an emitter follower and through the second transistor as a grounded base stage to arrive at the A–B output. Neither stage inverts and the amplified signal stays the same polarity as it went in. On the other hand, the – input goes to the A–B output as a common emitter stage, which inverts the sense of the signal, so that at the output, *identical polarity signals on both inputs are cancelled, while differential polarity signals on both inputs are amplified.* We've already seen that these identical polarity signals are *common-mode* signals. If the op-amp is good enough, common-mode signals are essentially totally eliminated. Since power supply hum and voltage variations are one form of common-mode signal, this is extremely handy.

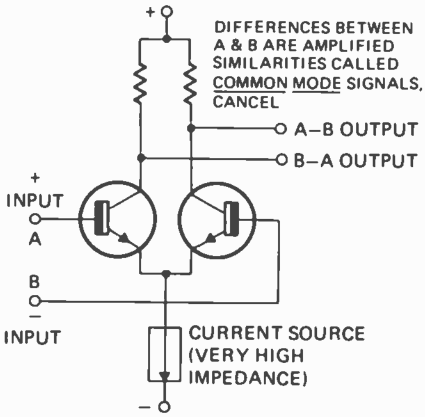


FIG. 2—THE DIFFERENTIAL INPUT STAGE provides an output signal proportional to the difference between the two input signals.

If you look at the mirror image of the inputs, you'll find that the — input ends up uninverted and amplified on the left output and the + input gets inverted by a common emitter stage. The pair of outputs will be an amplified version of only the *difference* between the two inputs, and common-mode signals will be ignored as they exactly cancel.

Now the inputs go to the bases of two NPN transistors. Where does this base current come from to run them? Well, ah, er . . ., You better have a good answer to this or your circuit won't work. The base current can come from your input circuit through a low-impedance DC path, from a resistor to ground, from a special current source, or from the output via a feedback resistor, but it MUST be provided. The most important rule and the cause of most op-amp problems:

8. DC base bias current MUST be provided for both the + and − input to an operational amplifier. This is usually done as resistors or coils to ground, back through the input, from the output, or from another reference voltage. In a 741 style amplifier, around 100 nA of current must be provided for both + and − inputs.

The input transistors are very nearly identical, being integrated and all on the same chip at essentially the same temperature. They also track very well with temperature. However; even with the best of matching, there will be a slight voltage difference (a millivolt or two) between the inputs. This is called the *input offset voltage*. The rest of the amplifier has no way of telling the difference between this offset and a legitimate input signal.

Figure 3 shows some tricks we can pull

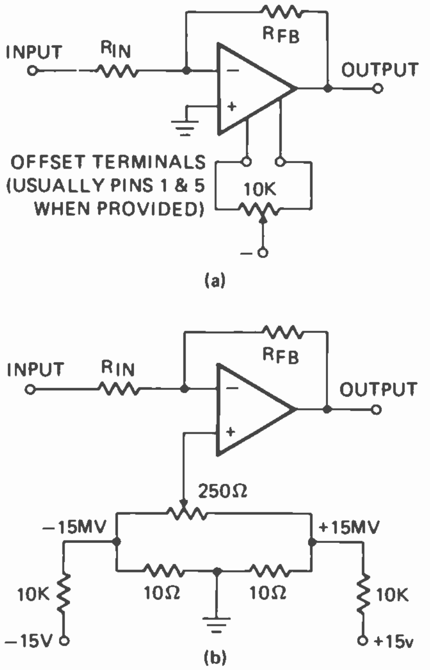


FIG. 3—INPUT OFFSET VOLTAGE results from a mismatch in the differential input stage. Two methods for reducing the voltage is shown.

to reduce the input offset. A pot can be added if pins are available for this (usually omitted on dual and quad devices), or input currents can be balanced by unbalancing impedances, or special bias sources can be added. Correction of offset will only be perfect at one temperature, but a 10:1 reduction in input offset is usually easy to do over a reasonable temperature range.

The importance of the offset depends on what you are trying to do with the operational amplifier. If you set your amplifier to a gain of 100 with feedback resistors, a 2-mV input offset becomes a 0.2-volt output offset. AC couple your output and there is no problem at all. But for DC outputs and high gain, the amplifier input offset must be allowed for. Another rule:

9. An operational amplifier such as the 741 has an input offset of one or more millivolts. This offset voltage is amplified and treated as a legitimate input signal. Input offset can be externally bucked out at one temperature if it is a problem. The remaining offset defines the minimum acceptable value for the DC input signals.

and . . .

10. The output offset in DC volts will equal the input offset times the in-circuit gain of the operational amplifier.

So we have to provide a source of base current for both the + and − inputs, and we get a DC offset voltage "free" that we have to minimize somehow.

Besides the voltage offset, we have another problem to worry about — *current offset*. Whatever resistance is doing the biasing for our inputs will produce a voltage drop across it caused by the biasing current. This biasing current is typically 100 nA, but a *difference* of as much as 20 nA typically might be exhibited by both inputs under identical conditions.

A current of 100 nA is the same as 0.1 μA. A 0.1-μA current through a 10K resistor gives you a 1-mV drop, not really very much. But a 100K resistor gives you a 10-mV drop which can get important, and a 1-megohm one gives you a full tenth of a volt, which is hard to ignore, particularly in high-gain applications. For instance. Ground the + input and use a 1-megohm input resistor and a 20-megohm feedback resistor to try to get high input impedance in an inverting gain-of-20 amplifier. The output offset will be a very hard-to-ignore 2 volts!

How do we get rid of it? Simply provide a 1-megohm resistor in the + lead as well. Now, the input bias currents provide the same drop on both sides and everything cancels out. Everything that is, but the differential offset current, and you can get a one temperature cancellation of this by making the two source impedances slightly different. Figure 4 shows how we can go about cancelling offset currents. Another rule:

11. The impedances doing the DC biasing of the op-amp inputs should be approximately the same value particularly at high gains or at high impedance levels. Input offset current can be adjusted by trimming one impedance level with respect to the other. Impedance levels above 100K on a 741 will introduce major offset problems.

TABLE OF OP-AMP MANUFACTURERS

ADVANCED MICRO DEVICES 901 Thompson Place Sunnyvale, California 94086	**RCA SOLID STATE** Box 3200 Somerville, New Jersey 08876
FAIRCHILD SEMICONDUCTOR 313 Fairchild Drive Mountain View, California 94040	**RAYTHEON SEMICONDUCTOR** 350 Ellis Street Mountain View, California 94040
MOTOROLA SEMICONDUCTOR Box 20912 Phoenix, Arizona 85036	**SIGNETICS** 811 E. Arques Avenue Sunnyvale, California 94086
NATIONAL SEMICONDUCTOR 2900 Semiconductor Drive Santa Clara, California 95015	**SILICON GENERAL** 7382 Bolsa Avenue Westminster, California 92683

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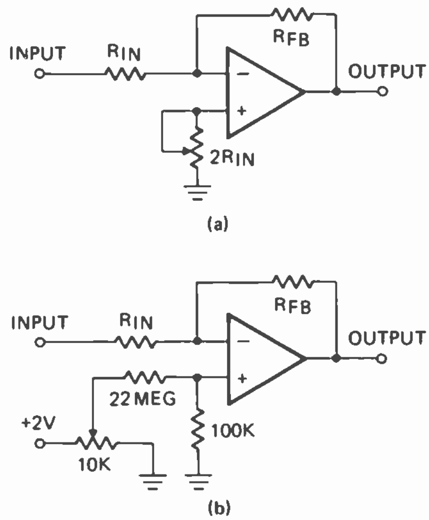

FIG. 4—INPUT OFFSET CURRENT results from a mismatch in the input stage. Two methods for reducing the current is shown.

At very low impedance levels, say 1K or so, you usually can ignore the input currents and input offset currents. As the impedance level goes up, the offset currents become more important. So, at low impedance levels, only worry about the offset voltages. At higher levels, consider both the offset voltages and currents.

Compensation

At some very high frequency of operation, the internal capacitance, delays, and storage times of any amplifier will begin adding delay or phase shift to the signal being amplified. If we ever reach a frequency that shifts the phase by 180° and still have gain, a negative feedback connection will give us *two* 180° inversions, or it will put us back *in* phase with the input. If the loop gain is high enough, we end up with an oscillator rather than an amplifier, because the added phase shift converts what is supposed to be negative feedback into positive feedback, reinforcing its own input.

This is true of any feedback amplifier. Depending on the design, the circuit can be stable, conditionally stable, or inherently unstable. One of the surprising things that turns up is that the *lower* the in-circuit gain of the amplifier, the *more* likely it is to oscillate! This is caused by a greater percentage of the input being

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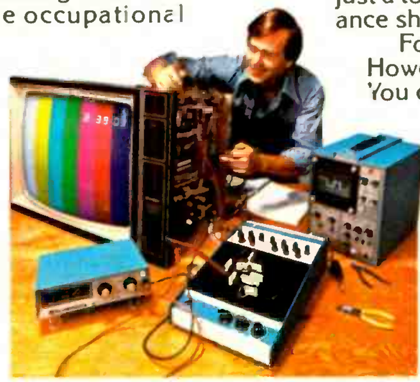

II. DIGITAL INDUSTRIAL ELECTRONICS

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fed back in lower gain situations. Unity gain of a feedback amplifier is much more likely to oscillate than say a gain of 100 or some other high value.

The process of stabilizing an amplifier is called *compensation*. The basic rule of compensation says that for any gain (open loop) above one, your amplitude versus frequency slope must always be less than −12 dB-per-octave. Hit −12 dB-per-octave, and if you do it at a frequency where the open loop gain equals one or more, you've got yourself an oscillator, not an amplifier. One obvious way to compensate is to hang a very large capacitor in the middle of the circuit. So large that it completely dominates the amplitude versus frequency response, giving you a simple and safe 6-dB-per-octave slope. This is called a *dominant pole*, and while it certainly stabilizes the amplifier, it also drastically reduces the frequency response.

The dominant pole capacitor is used in the 741. This gives you an unconditionally stable amplifier (unless you go out of your way to try to make an oscillator out of it on purpose), and results in simple and easy circuits. The price paid is the frequency response. The dominant pole breaks at 3 hertz, dropping at 6 decibels per octave eventually to reach unity gain at 1 megahertz.

Another rule:

12. Frequency compensation must be provided for any operational amplifier using negative feedback. The 741 is internally compensated at the price of a relatively poor frequency response. The LM318 offers either internal or external compensation.

Slew rate

When we are done with our compensation, we end up with another problem, called the *slew rate* problem. At small signal levels and small output swings, our normal frequency versus amplitude response curves apply. But, if we try to swing the output through larger amplitudes, the output goes into a *current-limited ramp mode* and, as Fig. 5 shows us, considerable distortion.

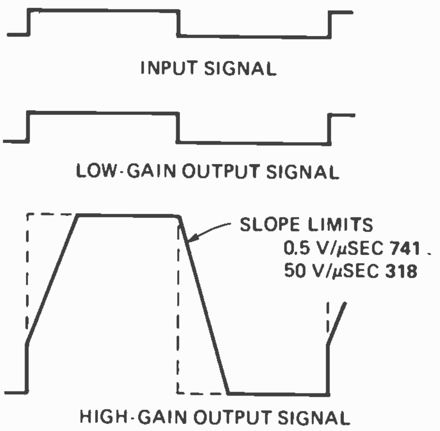


FIG. 5—THE SLEW RATE of an operational amplifier limits large output, high-frequency signals.

What this means is that you can't have high-frequency operation and large output swings at the same time. The fastest you normally can change the output of a 741 is 0.5 volt/μs. You can estimate how bad the slew-rate problem is by substituting a triangle wave of *one and one half* times the normal amplitude of your highest frequency sinewave and see what happens.

For instance, suppose you have a 4-volt peak-to-peak, 10-kHz sinewave. Approximate it with a 6-volt peak-to-peak triangle wave. The period of the waveform will be 100 μs. The half period will be 50 μs. We have to change 6 volts in 50 μs, or around an eighth of a volt per microsecond. Since the 741 can only handle 0.5 volt μs maximum, you're pretty near the reasonable limit of operation.

Note that slew rate is determined both by frequency and amplitude. Eight volts peak-to-peak at 5 kHz will have about the same needed slew rate as 2 volts peak-to-peak at 20 kHz, and so on.

If you need larger signal swings in the upper audio region, the 741 simply won't do the job. Consider the more expensive LM318 that has a 50-volt μs slew rate, or one hundred times as much for these applications. For our next rule:

13. The slew rate limits the large signal output swing to a maximum slope ramp at higher frequency. The slew rate is 0.5 V/μs for the 741 and 50 V/μs for the LM 318.

Besides these slew rate limits, there are obviously drive limits at the output stage that apply to any operataing frequency. If possible, you should keep your external output and feedback loads above 1000 ohms, although you can reduce this to several hundred ohms with lower output swings. The maximum output current you can possibly get in a limiting (clipping) mode is around 25 mA. This is beyond the normal range of linear operation.

Noise

A final limit to an operational amplifier is the input noise level which gets amplified along with the signal. All amplifiers produce some noise, and the worst of it is usually involved with the first stage. The 741 is not particularly a low-noise device, but it is useful for many small-signal amplification problems. Typical noise for a 741 referred to the input is 10 μV. Thus if you have a gain of ten, you get 100 μV of noise out. At a gain of 100, you get 1 mV out, assuming you are using the full bandwidth of the device.

If you reduce your bandwidth, the noise goes down, but only very slowly, for noise is proportional to the square root of the bandwidth. So, to get only 1 μV of noise, you have to cut your bandwidth by 100, from a nominal 100 kHz to only 1000 Hz. Regardless of your application, the final noise sets your overall signal-to-noise ratio. For instance, with a gain-of-ten circuit, you can amplify a 10-μV signal with unity signal-to-noise ratio (essentially worthless), a 100-μV one with 20 dB signal-to-noise (possibly useful) or a 1-mV one with a 40-dB signal-to-noise ratio (pretty good.)

The LM318 generally has better noise performance than the 741, although at high impedances and wide bandwidths (remember it has 100 times the bandwidth), the noise can get up to 200 μV at the input. With a 1000-ohm source on the inputs, the equivalent noise to the 741 is around 3 μV, 12 dB better than the 741, provided that you limit the bandwidth suitably. A final rule:

14. The first stage noise level of any operational amplifier sets the minimum possible signal level for a given signal-to-noise ratio. Referred to the input at a 100-kHz bandwidth, this noise is 10 μV for the 741 and 3 μV for the LM318. Noise is normally proportional to the square root of bandwidth.

(to be continued)

Virginia electronic technicians take strong stand on warranties

The Board of Directors of the Virginia Electronics Association adopted the following resolution unanimously at its meeting in Chester, VA.

"WHEREAS: The Virginia Electronics Association recognizes that warranties extended beyond a period of 90 days

1. have no bearing on the quality, serviceability or anticipated life of a product;
2. are frequently used to mask inferior product quality and/or performance;
3. are a deceptive sales tool used by some manufacturers and retailers to create a captive repair market with the customer's own money, and
4. actually hamper consumer satisfaction by frequently foisting inadequate compensation upon the servicer or less than quality service on the buyer, and

WHEREAS: the Virginia Electronics Association feels that the manufacturer, the servicer and the customer are best served by devoting more time and money to improving product performance and safety and less of the consumer's purchasing dollar on extended warranty/insurance schemes, and

WHEREAS: one major manufacturer, in the face of rising consumerist pressures, has decided to reduce its labor warranties to a more realistic 90-day period, therefore:

BE IT RESOLVED: that the Virginia Electronics Association hereby commends GTE-Sylvania for its wise and courageous decision in taking the lead to restore sanity to the field of consumer-electronics product warranties, and

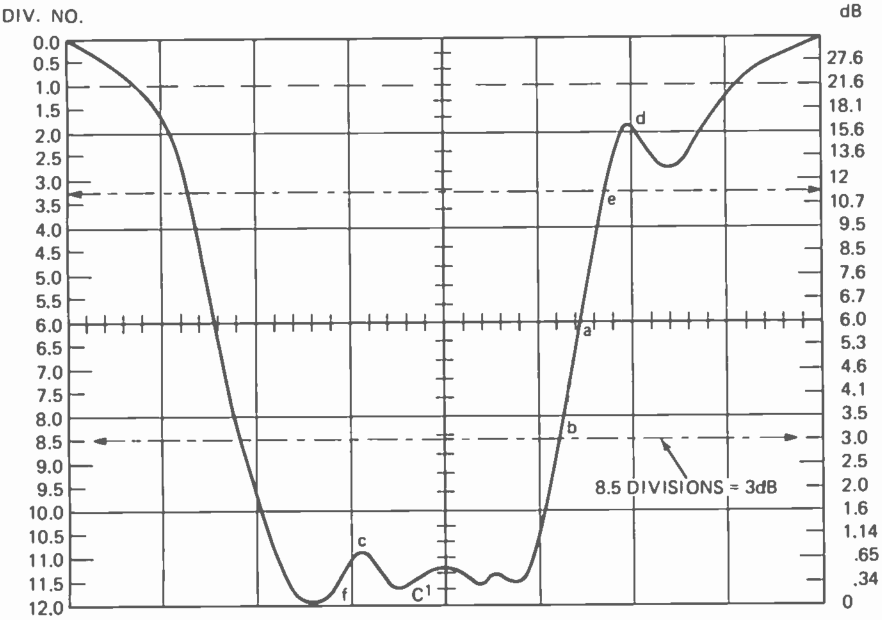
BE IT FURTHER RESOLVED: that the Virginia Electronics Association implores all such manufacturers to review their present costly, deceptive frustrating and self-defeating extended warranty programs and take similar steps to redesign and reduce those warranties to better serve the consumer and the electronics service industry."

Copies of the resolution were mailed to nearly 500 manufacturers and importers, 50 association, trade and technical publications, three national electronics associations, and to all persons who might be concerned.

measure dB's with your scope

With the simple method described in this article, you can use your oscilloscope to measure dB's quickly and accurately.

by JOHN D. GABBERT



DECIBELS MAY BE MEASURED QUICKLY and with reasonable accuracy by using an oscilloscope with the simple scale shown. No calculation is necessary. Each vertical graduation on the figure, which normally represents one centimeter, has been subdivided into four divisions. On the left side are the division numbers and on the right the corresponding value of each division in decibels.

The graticule illustrated is a standard laboratory scope scale with six vertical and eight horizontal centimeter graduations on which decibel values are calculated using the formula:

$$dB = \log \frac{V_1}{V_2}.$$

To use the scale: Set the oscilloscope controls so that the display exactly fills the graticule, with the peak amplitude of the waveform resting on the bottom graduation. Count the number of divisions to the point on the waveform that you want to measure and read from left to right on the scale to find out how many decibels of attenuation that point represents: For example, point **a** at 6 divisions equals −6 dB, point **b** at 8.5 divisions equals − 3 dB, point **f** at 12 divisions is equal to 0 dB or peak amplitude.

Some interpolation is necessary at point **d**, which is between 1.5 and 2 divisions and is equal to 16.7 dB and also at point **e** at 3.25 divisions and equal to 11.3 dB.

Points **c** and **c**^{1} represent the peak-to-peak value of the first cycle of a ripple or damped oscillation.

As the oscilloscope response is linear, the actual voltages need not be considered—only the ratio of V_1 to V_2. If the value of V_1 is considered to be 12 at peak amplitude, V_2 will be some value less than 12. For instance, at point **d**, V_1 equals 12, V_2 equals 1.75. From the formula.

$$dB = 20 \log \frac{12}{1.75}$$
$$dB = 20 \log 6.86$$
$$dB = 20 \times 0.8363$$
$$dB = 16.7 \text{ dB}$$

In most cases the 24 divisions, each representing ¼ centimeter, will supply the required degree of accuracy.

Keep input voltage to the scope low so that the amplifiers will not overload and flatten the trace—this could result in inaccurate measurements. **R-E**

EQUIPMENT REPORTS

(continued from page 34)

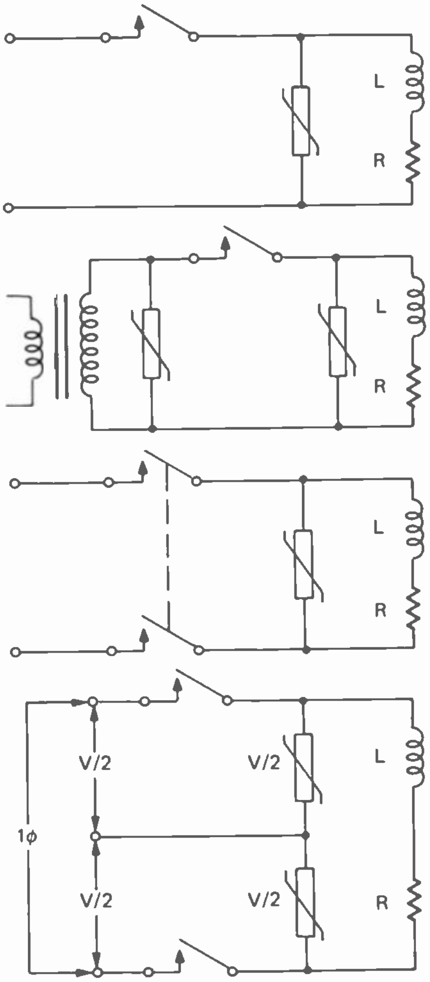
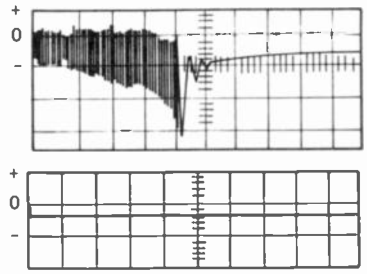


Fig. 4



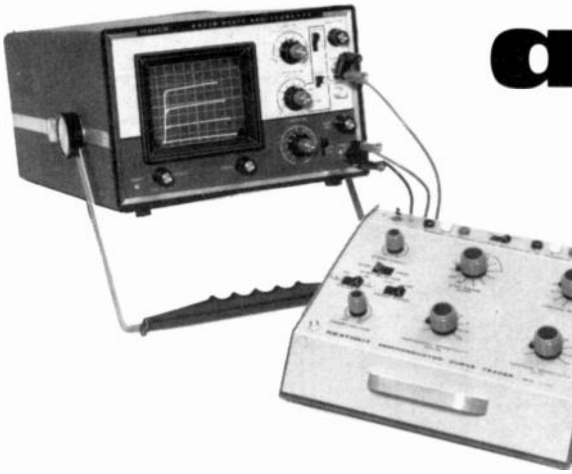
HORIZONTAL: t, 500 μsec/cm VERTICAL: V, 1.0 kV/cm

Fig. 5

field. Requests for data on the other GE-MOV varistors should be addressed to distributors of G-E industrial semiconductors. Ask for G-E application notes 200.60, 220.71 or 200.72 or for spec sheets. **R-E**

NEXT MONTH IN R-E

Tape recorders contain more than just record and playback electronics. Many modern tape transports also have a heap of electronics to direct the mechanical operations. Len Feldman explores these special electronics features of modern tape decks next month. Be sure you don't miss the June issue of Radio-Electronics.



all about curve tracers

This article tells what to look for when purchasing a curve tracer; how to test different solid-state devices, and how to interpret the resulting waveforms

by CHARLES GILMORE*

LAST MONTH WE DISCUSSED THE TESTing of diodes and bipolar transistors. We also started discussing field-effect transistors.

This month we will complete our look at field-effect transistors and conclude the article with SCR's and triacs.

One of the most important measurements that can be made for field-effect devices is gain. The gain of an FET is referred to as transconductance (gm)—ratio of the change in drain current caused by a change in gate voltage, expressed in μmhos. Figure 16 is a display of an n-channel junction FET. (2N4416). To measure transconductance, a change in drain (sweep) current, is read from the curve tracer. Since the step value causing this current change is known, the change in drain current can be divided by the change in gate (step) voltage, yielding transconductance.

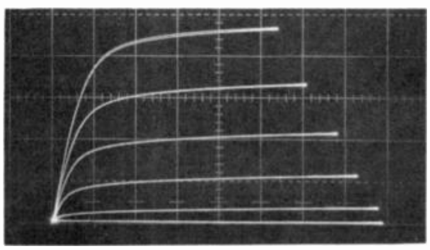


FIG. 16—A FAMILY OF CURVES for the 2N4416 n-channel JFET. The uppermost curve is the curve for step-generator output of zero volts. Succeeding downward curves represent increased voltage output from the step generator. Settings are: step generator, —0.5 volt/step; drain limiting resistance, 500 ohms; horizontal sensitivity, 2 volts/cm; vertical sensitivity, 2 mA/cm.

Note that the transconductance is not uniform from curve to curve. Therefore, transconductance must be measured at or about the normal operating current. The next most important characteristic is voltage breakdown.

*Design Engineer Heath Company, Benton Harbor, Mich.

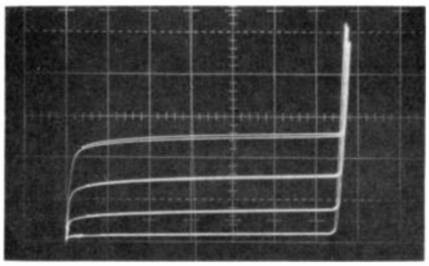


FIG. 17—BREAKDOWN CHARACTERISTICS OF A 2N4416 n-channel JFET. Settings are: step generator, —0.5 volts/step; drain limiting resistance, 500 ohms; horizontal sensitivity, 10 volts/cm; vertical sensitivity, 2 mA/cm. The drain to source breakdown of the 2N4416 is specified at 30 volts.

Figure 17 shows the breakdown characteristics of the 2N4416. These characteristic curves are quite similar to those of the bipolar transistor.

When FET's are used in digital applications or for switching analog signals the "on" resistance expressed as R_{ON} is important.

For an n-channel JFET, R_{ON} is the resistance from drain to source with the gate-to-source voltage at zero. The value of R_{ON} can be determined by increasing the horizontal sensitivity of the curve tracer until the resistance of the "ON" portion of the curve can be measured. (Fig. 18).

Special precautions that should be taken when testing field-effect transistors include taking extreme care with MOS devices, especially those that are unprotected, to make sure that the terminals are not exposed to static electricity. One way to do this is to wrap a fine wire around the leads of the transistor before removing it. Unwrap this wire only when the device is securely mounted in the curve tracer. If the FET is a dual-gate MOS FET, return the unused gate to the source terminal of the device. If the characteristics are specified with a certain gate-to-source voltage on the unused gate, this voltage should be supplied from an external source. Never test MOS devices with the gates unconnected.

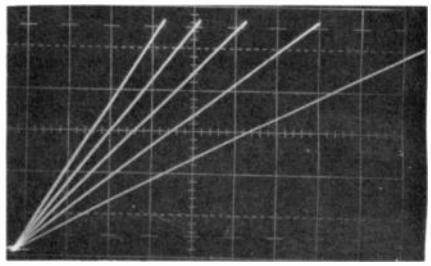


FIG. 18—THE "ON" RESISTANCE of a TI TIS-73 n-channel JFET. This device is specially designed for switching applications. Settings are: step generator,—1 volt/step; drain series limiting resistance, 10,000 ohms; horizontal sensitivity, 0.02 volts/cm (0.1 volt/cm with a X5 magnifier); vertical sensitivity, 0.5 mA/cm. The steepest curve (the first) has a slope of 24 ohms. This curve is generated by a drain sweep with the gate to source at zero. Specifications for the TIS-73 call for 25 ohms maximum resistance.

SCR's and triac's

The characteristics of silicon controlled rectifiers (SCR) and the dual version of the SCR, the triac, can be easily examined on the curve tracer. Figure 19 shows the curves of an SCR. We can use these to measure forward

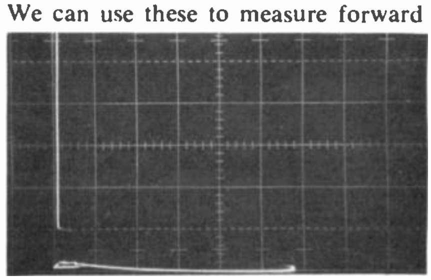


FIG. 19—THE FORWARD CHARACTERISTICS OF A TIC-44 SCR. Settings are: anode series limiting resistance, 50,000 ohms; horizontal sensitivity, 40 volts/cm (20 volts/cm with a X0.5 magnifier); vertical sensitivity, 0.5 mA/cm. The forward blocking voltage of this device is 230 volts, and the holding current is 0.5 mA.

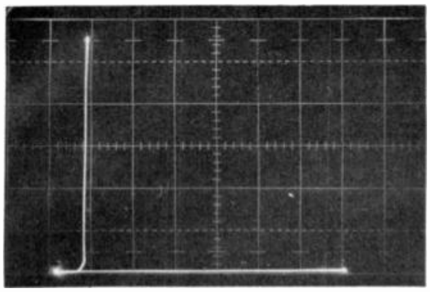


FIG. 20—"ON" RESISTANCE OF THE TIC-44 SCR. Settings are: anode series limiting resistance, 1000 ohms; horizontal sensitivity, 1 volt/cm; vertical sensitivity, 1 mA/cm.

blocking voltage and holding current. As wtih the diac, forward blocking voltage is the maximum collector voltage that can be reached. The holding current is the lowest forward current that can be maintained. When making these measurements, the step generator is set for zero current output.

Figure 20 shows a display used to measure gate trigger current and "ON" resistance of the SCR. To measure gate trigger current, reduce collector sweep voltage to a point below the forward blocking voltage of the SCR. Adjust the steps-per-family control for a known number of steps — if necessary this is the maximum number of steps available from the curve tracer. Then advance the step range control from the smallest step current to the first position at which the vertical line appears. This tells us that gate sensitivity falls between the position just prior to this and the position which caused the vertical line.

Once we see a vertical line, the on-resistance of the SCR is measured by expanding the horizontal sensitivity and computing the resistance the vertical line represents.

With the SCR, the reverse blocking voltage is essentially the reverse voltage of the main diode portion of the SCR. This is measured in exactly the same manner as the reverse breakdown voltage of a diode.

Make forward measurements on a triac in the same way as for an SCR. Reverse measurements will produce curves identical to the forward set, but inverted; as the triac acts like two SCR's in parallel, with one reversed.

Figure 21 is the characteristics of a unijunction transistor (UJT), connected as indicated on the set-up chart. The slope of this curve shows the inter-base resistance of the device.

Wrap-up

The number of devices that can be analyzed with curve tracer are limitless. All measurements that have been discussed can be applied in one form or another as in-circuit measurements as well as measurements on devices. When making in-circuit measurements, the power supplies should be turned off, and if possible disconnected from the device under test. Remember, resistances in the circuit, in addition to those of the device, can affect the characteristic curves.

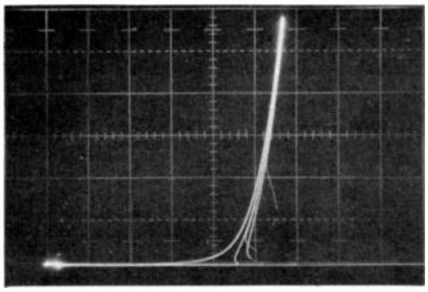
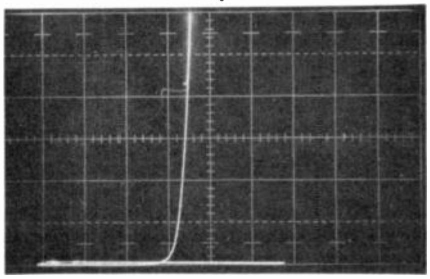
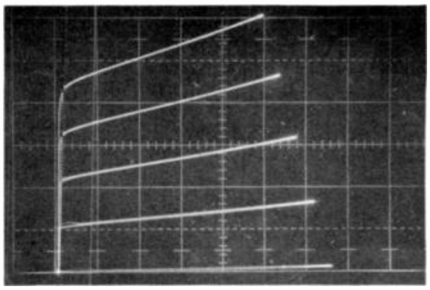


FIG. 21 — INTER-BASE RESISTANCE OF THE 2N2646 unijunction transistor. The unijunction is connected to the curve tracer terminals as follows; B1 to E, B2 to B, and E to C. Settings are: step generator, O mA/step; emitter series limiting resistance, 500 ohms; horizontal sensitivity 0.2 volts/cm; vertical sensitivity, 0.5 mA/cm.

Virtually any device can be measured with a curve tracer. Neon lamps, tungsten lamps, LED's, vacuum tubes and even IC's can yield characteristic traces that may tell a great deal about their function.



BREAKDOWN AND HOLDING VOLTAGE of an NE-2H neon lamp. Settings are: series limiting resistance, 10,000 ohms; horizontal sensitivity, 20 volts/cm; vertical sensitivity, 1 mA/cm. For this particular lamp, breakdown occurs at 130 volts and holding voltage is 65 volts at 1 mA.



FAMILY OF CURVES FOR A HIGH-GAIN silicon pnp transistor (MPS-6522). Curve tracer settings are: step generator, 0.005 mA/step; collector series limiting resistance, 1000 ohms; horizontal sensitivity, 4 volts/cm; vertical sensitivity, 1 mA/cm. At 8 volts V_{CE} and an average collector current of 3.5 mA, beta is calculated to be 1.45 mA/0.005 mA, or 290.

Once you feel that you have a solid grasp of the fundamentals of curve tracer measurements, and a good knowledge of the limitations of your curve tracer, a great number of measurements can be made. These are bound only by the specifications of your curve tracer.

Because of its fundamental measuring concepts, the curve tracer will probably be directly applicable to new devices as they are developed. Applying fundamental curve tracer measurement principles to the new device will produce a set of characteristic curves that may be used for comparing devices and measuring their varied parameters. R-E

NEXT ISSUE SCOPES

SET-UP TABLE

Table describes the setup of the curve tracer for each particular device.

Device	Terminals	Sweep	Step Generator	Initial Spot Position	
NPN	C B E	+	+ Current	Lower left	
PNP	C B E	—	— Current	Upper Right	
N-CHANNEL JFET	D G S	+	— Volts	Lower Left	
P-CHANNEL JFET	D G S	—	+ Volts	Upper Right	
N-CHANNEL MOS FET (depletion)	D G S	+	— Volts	Lower Left	
P-CHANNEL MOS FET (depletion)	D G S	—	+ Volts	Upper Right	
N-CHANNEL MOS FET (enhancement)	D G S	+	+ Volts	Lower Left	
P-CHANNEL MOS FET (enhancement)	D G S	—	— Volts	Upper Right	
Forward Diode	A Nc C	+	None	Lower Left	small-signal diode rectifier
Reverse Diode	A Nc C	—	None	Upper Right	Zener diode or checking reverse breakdown
SCR Forward	A G C	+	Current	Lower Left	½ of Triac
SCR Reverse	A G C	+	Current	Upper Right	½ of Triac

SHERLOCK & OHMS

When servicing television receivers with Sherlock won't help. It requires good circuit analysis to find the solution.

THE OLD-TIMER SAT IN THE MIDDLE OF a spider web of extension cables and scowled at the underside of the big Magnavox chassis on the bench. The cabinet sat on a bench-high cart. Peering around the end of it, he checked the picture in the mirror. Yes, it was still going up and down with that queer jerky motion that he'd been trying to dig out for quite a while. He frowned at the screen of the scope; this showed a very peculiar pattern. The probe was clipped to the open end of a resistor.

He growled a few choice words that were answered by a not-too-muffled snort from the doorway. He looked up.

"Hi, Henry! Didn't hear you come in."

"I heard *you*," said Henry, grinning. "What did you tell us about calling them names when you were lecturing us the other night? That's not supposed to be the way to do it, remember?"

"Yeah, yeah," said the Old-Timer, reluctantly. "Actually, I was really calling myself names! It looks like I'm going to start another one of my Stupid Days. I can tell by the way this chassis is acting, that it's gonna turn out to be something *so* simple that I'll really feel foolish! They always do. And no matter how I try to hide, there's always some snoop like you that comes in and catches me!"

"Actually, all I wanted was to borrow a 6JE6 tube; I'm out," said Henry. "Anyway, let me prescribe a dose of your favorite remedy for *you*; a good cuppa cawfee!"

"What a salesman," said the Old-Timer, unwinding himself from the extension cables and getting up. "You got a deal".

Settled over their coffee cups, Henry laughed at the sour look on the older man's face. "OK, tell me the sad story. I have a dry shoulder for you to cry on."

"Well, you asked for it," said the Old-Timer. "That thing has no vertical sync at all. The darn picture jumps and jiggles up and down, but won't lock. Oscillator's OK, rolls up or down with the hold control. BUT! I have the screwiest symptom I can ever remember seeing. There is absolutely NO vertical sync in the composite-sync waveform out of the sync-separator!"

"Huh?" said Henry, puzzled. "How is the peak-to-peak amplitude?"

"Just right!" said the Old-Timer. Makes a good bar pattern on the scope, just like it should. And the horizontal sync is steady as a rock! Perfect sawtooth, plenty of hold, color. and everything else. With the scope on the integrator input, all I can see is a smooth bar. There isn't a single vertical sync spike in it!" (Fig. 1.)

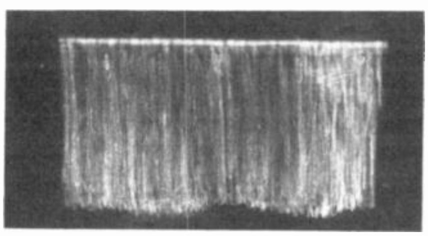


FIG. 1—COMPOSITE-SYNC WAVEFORM at the integrater input shows a complete lack of any vertical sync spikes.

"How in the world could that happen?" asked Henry, bewildered. "It looks like anything that took out the vertical sync would get the whole composite sync waveform."

"That's what I've been trying to find out for an hour," said the Old-Timer, gulping the last of his coffee. "And I had the scope on the open end of the vertical integrator; not a sign of any vertical sync, or anything else for that matter. It just isn't there. All of the integrator components check out good. Also, did you notice how the picture was acting when you came in? Sort of jumping and jerking at two points on the screen, looked almost like it *did* have some kind of sync. Well, it did not, at least not from the set; I had one end of the integrator completely *open!*"

Henry tut-tutted sympathetically as they walked back across the alley, and into the shop. The Old-Timer turned the set on again, and they watched the picture jumping and jerking as it rolled slowly downward.

"Makes my head ache," said the Old-Timer. "What's worse, I know it's going to be something that is so blasted simple that I should be kicked for not being able to see it."

The Old-Timer poked the scope here and there in the chassis, showing Henry the waveforms. Henry studied the jerking picture intently. Suddenly he cried "Hey! Your picture just turned bright *blue!*" and it had.

"Oh, that," said the Old-Timer wearily. "It just does that now and then to annoy me", and he slapped the rear apron of the chassis smartly with his fingers. The picture went back to normal. "I'll dig that out just as soon as I find out what's cancelling the sync—HEY! I think I just said the secret word. That's the only thing that *could* be happening! Somehow or other, I'm gittin' an opposite-polarity pulse into that circuit and it's *cancelling-out* the vertical sync!"

"Well, it's gotta be something like that," agreed Henry. "You sure couldn't filter it out. There isn't a filter anywhere that's sharp enough to—what are you doing?" The Old-Timer had gotten up from his stool, walked around and bent over in front of Henry.

"I said I'd kick myself, didn't I?" he said. "Well, I'm tired! Will you do the honors?" Henry gave him a carefully adjusted kick, then looked inquiringly at him. The Old-Timer sat down again. "I knew it! I knew it! After all the time I've spent lecturing you guys about it, and then I blow it. Now look here," and he reached over the set to flip the Service switch to the RASTER position.

The picture disappeared, leaving a smooth blank raster, with shading on it. "See there! Look! If those aren't 120-Hz hum-bars I'll eat my hat!" They weren't too plain, but they were

The Case of the Substitute Sync

problems like this one, even the real troubleshooting procedures and solid Here's how the Old-Timer did it.

by JACK DARR
SERVICE EDITOR

unmistakably hum-bars. Two of them showed on the screen, rolling slowly and jerkily. "I noticed that when it was having a spell of flashing blue a while ago, but it didn't get through my thick skull! How many times have I said it? If you find a lot of unexplained symptoms all over the set, go and look at the FILTERS! You just said it! Filters. You want to kick me again?" Henry shook his head, grinning. The Old-Timer picked up the scope probe again, then sat there.

"Let's try analyzing it; it'll be quite a novelty, but I'll try. Let's just see how close we can get *before* we check. Now; we're obviously getting a very sharp vertical-frequency spike into that circuit somewhere. Since the normal sync is about 30-40 volts and negative-going, we're getting enough positive-going spikes in there to cancel it. Now, where could these spikes come from? That's right," he said as Henry opened his mouth. "From the vertical *output!* There's a perfectly normal, very high voltage spike in that circuit. So, where's a likely path for this to get back to somewhere that it isn't wanted? Right again."

Henry closed his mouth again. "Back through the power supply. If one of the filters opens up, It leaves such a high impedance that you can get all kinds of frightfulness all the way back to the front end!"

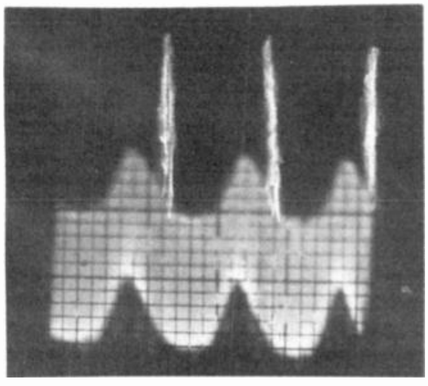


FIG. 2—VERTICAL SPIKES appear among hash at the terminal of one of the filter capacitors in the power supply.

He bent over the schematic diagram. "Let's see. That would be either this" and he touched the scope-probe to the terminal of a large multiple electrolytic capacitor. A straight line showed up on the scope screen. "Nope. Well, then, how about *this* one?" touching another terminal in the same can. The straight line disappeared, leaving the scope full of blurs. The Old-Timer beamed at it, and cut the vertical gain until the pattern appeared; See Fig. 2.

"Hoo, hoo, hee hee!" he crowed. "Look at that! Look at all those big fat vertical *spikes* in there with all of the rest of the hash. Hand me the electrolytic capacitor sub box. It's right behind you. Let's see. Half-moon capacitor in C107, which is—80 microfarads. OK! We set the box to 80 microfarads, and now we push the switch! Wait a minute. Let's see something." He clipped the scope-probe to the open end of the vertical integrator resistor; nothing showed at that point.

"Now we push the switch." He did. The scope pattern suddenly jumped; a thick baseline appeared, with long, clean spikes coming down from it. See Fig. 3. The Old-Timer crowed hap-

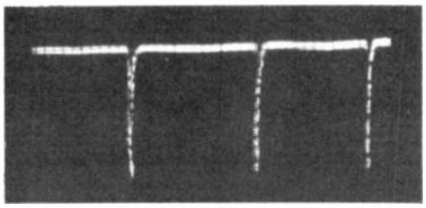


FIG. 3—NORMAL WAVEFORM appears at the output of the vertical integrater when a substitute filter capacitor is used.

pily. He released the switch, unhooked the probe, and soldered the integrator resistor back in place. Pushing the sub-box switch again, the picture suddenly locked tightly into place.

"Just a minute," said the Old-Timer. "Before we sew up the patient, I want to show you something. I didn't believe it the first time I saw it, and I want you for a witness. I have *never* seen exactly this symptom before. He connected the scope probe to the composite-sync output, adjusted the sweep, and said "There! There's your composite sync *without* a bit of vertical sync; same one you saw before. (Fig. 1) Now, we put in the good capacitor and boom. Plenty of vertical sync. (Fig. 4) BUT! When we take out the

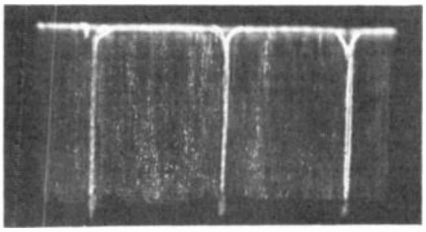


FIG. 4—NORMAL COMPOSITE-SYNC waveform shows plenty of vertical sync when a substitute filter capacitor is used.

capacitor, out goes the *normal* vertical sync, and the picture is trying to lock in on the spikes leaking through into the oscillator circuit! Notice that the picture jerks and tries to lock at two points as it rolls? One for each peak in the 120-Hz spike from the power supply!"

"Well, that's a new one," said Henry. "First time I ever saw *that*."

"True, true," said the Old-Timer, checking the schematic to find the sizes of the capacitors in the bad unit. "You think you've seen them all, and then they run another one in on you. Beats all what these things can do when they really try, doesn't it?" and he went to his stock cabinet to look up a replacement capacitor.

*In case you're still wondering about the blue flashing of the picture tube screen, this was due to an intermittent solder-joint on the socket of the 6MD8 color-difference amplifier! Pin 1, the "blue plate", was opening up. This cut off all plate-current and the plate voltage rose to the supply value of about +350 volts. This, of course, being directly coupled to the blue grid of the CRT, caused it to bias the blue gun on very hard. Brightness controls, etc. had no effect. **R-E**

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TRANSFORMERS
BUCKing or BOOSTing Voltages

Don't throw those old transformers away. Put them to work. Here's how to do it.

by LYMAN E. GREENLEE

TRANFORMERS FOR TUBE EQUIPMENT are cheap, but the newly designed ones for solid-state circuitry can be expensive, and a special transformer is not always available at any price unless we want to make one.

Suppose we need a 36-volt transformer for that new hi-fi amplifier. Easy does it . . . just hook up a 12-volt filament transformer and a 24-volt power transformer with primaries in parallel and secondaries in series. The result is shown in Fig. 1. If we use a 12-volt center-tapped transformer, we have a choice of 24-volt, 30-volt, or 36-volt outputs. Both transformers should have the same ampere rating. If they do not have the same rating, the smaller rating will apply to both secondaries when used in series. Example: If one transformer is rated at 12 volts and 2 amps., and the other one at 24 volts and 1 amp., the rating of the series combination will be 36 volts AT ONE AMPERE.

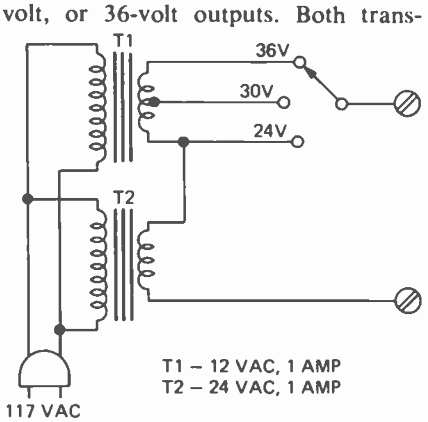


FIG. 1—THIS BOOST CONNECTION gives 24, 30, or 36 volts with a 24-volt and center-tapped 12-volt transformer. The switch will not be needed in most cases.

Hook the primaries in parallel and connect to the power lines. Now connect the secondaries in SERIES and measure the ac voltage. If it is 36, we have a BOOST connection. If it is only 12, we have a BUCKING connection. One of the windings should be reversed to get 36 volts.

If the load carrying ability of any surplus transformer is not known, let it run at no load on the bench for an hour and check the operating temperature. A hand "feel" test is usually sufficient, but in case of doubt, use a thermometer. Now, connect the *maximum* load and allow it to run an hour or so and check the operating temperature again. Use a power resistor for the load. Make this check for overheating *before* you put the transformers to work in equipment, and you will have no overheating troubles after the equipment is put to use, assuming of course that you have calculated your maximum load and have checked out the transformer at that load or a slightly greater one just to make sure it will not be overheated. (In a typical transformer, the case or core temperature should not rise more than 20—30°C above ambient at full load. Large transformers have a tendency to run hotter than small ones. *—Editor*)

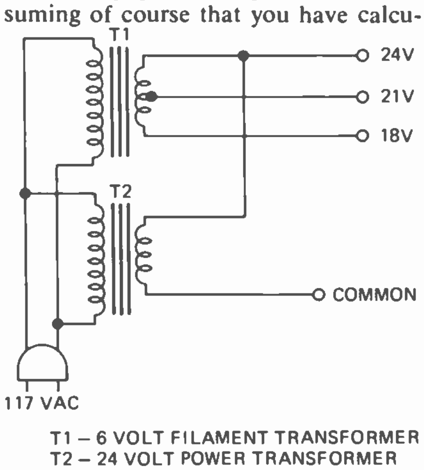


FIG. 2—THE FIG. 1 TRANSFORMERS can also be hooked up to give 18, 21 and 24 volts, simply by using a bucking connection.

The bucking connection

Suppose we need 18 volts and all we can find is a 24-volt and a 6-volt transformer. Fig. 2 shows a BUCKING connection that will give the required 18-volt output. If the 6-volt transformer is center-tapped, we will also have 21 volts available. Now we have 18, 21, and 24 volts.

Fig. 3 shows how we can get 3, 6, 9, and 12 volts from two 6-volt center-tapped filament transformers with their primaries in parallel and secondaries in series. This combination is very useful for low-voltage solid-state power supplies, and nobody has much use for a 6-volt filament transformer. You usually need at least 9 volts for transistorized equipment.

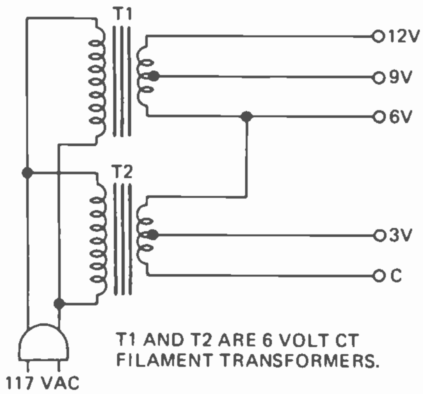


FIG. 3—ADJUSTABLE-VOLTAGE UNIT, using two center-tapped 6-volt transformers.

Fig. 4 shows two transformers connected in *parallel* for double the current (VA) output rating. Normally, if both transformers are identical, this parallel connection gives no trouble, but always check for *overheating* by allowing the transformers to run for an hour or so *with no load*, and be sure windings are properly phased—you can tell in a hurry—if they are not, fire will fly!

Identifying unknown transformers

Most transformer leads are coded according to EIA standards, as shown in the table. To check them, simply

TRANSFORMER LEAD IDENTIFICATION
(EIA code for power transformers)

Black, Black	117 volts, ac
Red, Red	High Voltage
Red with tracer	Center tap
Yellow	5-volt rectifier
Green, Green	Filament winding
Green with tracer	Center tap

(Where there is more than one filament winding, the second one may be brown, the third gray. Center taps are same color as winding, with yellow tracer. Rectifier filament center tap is yellow with green tracer.)

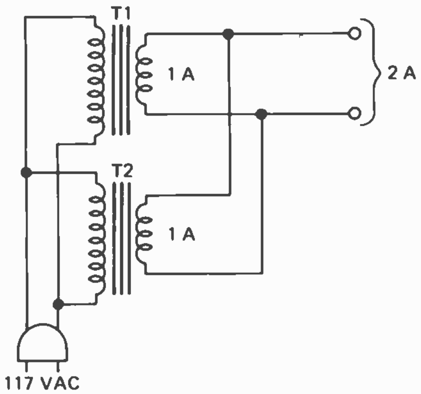


FIG. 4—A CURRENT-BOOSTING HOOKUP. Identical transformers give the best results.

connect the power line and measure the voltages. Some prefer to hook the line to the high-voltage first, to avoid fireworks if a winding (other than the high-voltage) is shorted.

For transformers that do not use a standard color code: You can usually identify windings by making a careful resistance check. The high-voltage windings will have the highest resistance. The reading to the center tap should be approximately the same on both sides. It should not be exactly the same because as the winding progresses it takes more wire to complete each turn and outer layers will contain more wire but the same number of turns. This means more resistance on the *outer* side of the winding and can be used to identify inner and outer winding layers.

The ac primary winding will measure out at some intermediate value. The heater and rectifier windings have very little resistance and are best identified by actual measurement with an ac voltmeter, after connecting the primary to the power line.

In case of doubt, and as a safety precaution, always connect the *highest resistance* winding to the power line first. Check the voltages across all other windings before trying another primary connection. THIS IS IMPORTANT. Connecting a 6.3-volt heater winding to the power line CAN BE HAZARDOUS—VERY HIGH VOLTAGE will be generated in the transformer primary. **R-E**

SERVICING MATV
(continued from page 43)

The cure of overload on a single-channel amplifier is to use a pad to decrease signal input and/or adjust the gain control for reduced output. For a broadband amplifier, careful balancing of each sound and picture carrier is called for. You may have to use a frequency splitter in front of the amplifier to adjust input channels individually.

If an individual TV receiver connected to an MATV system gets too much signal, it can be overloaded. Sets with tube-type front ends are quite tolerant of strong signals, but solid-state TV sets may overload with 10,000 μV (20 dBmV) or less. The answer to this problem is to increase tap-off isolation.

Dynamic window

Every piece of active MATV equipment can be thought of as having a "dynamic window," as illustrated in Fig. 4. The bottom of the window is

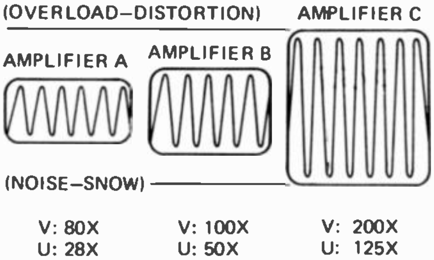


FIG. 4—THE DYNAMIC WINDOW of three different amplifiers is shown. A wide dynamic window is an important consideration in purchasing an amplifier.

the least amount of signal the device can accept and still deliver a reasonably good picture. We define "reasonably good as a 30-dB signal-to-noise ratio, which is equivalent to a passable picture by the Television Allocation Study Organization (TASO) standards. The top of the window is the maximum signal the unit can accept before it produces perceptible cross modulation.

The concept of dynamic window is especially important in home MATV amplifiers and amplified couplers. Units meant for large systems usually have a large dynamic window, but the window in many home units is pitifully small. The only cure for this type of problem is to replace the amplifier with a unit that can accept a larger range of input signals.

Troubleshooting older systems

Troubleshooting an MATV system is analogous to troubleshooting a TV set. You have to isolate the problem and then solve it. Isolating MATV problems is a lot easier than isolating TV troubles, however. For one thing, the circuits are less complicated and don't interact. For another, you can easily disconnect parts of the system without affecting the operation of the other part. This enables you to divide and conquer—to isolate the problem quickly by the process of elimination.

Every good MATV installer should make "as built" drawings. These drawings should show the entire system, with input and output signal levels at all channels noted for each piece of equipment. This is a tremendous servicing tool. If you have good "as built" drawings, all you have to do is compare the levels with what you read on your field-strength meter. Any discrepencies will pinpoint the trouble.

If you don't have "as built" drawings, troubleshooting is still not difficult. Start at the antennas, checking signals on the field-strength meter as well as the portable TV set. A good picture going into an amplifier and a poor picture coming out leaves little doubt as to the cause of the trouble.

Distribution system troubles are a little harder to track down. For one thing, you have to disturb tenants or guests to get at the tap-offs. For another, checking many tap-offs takes a lot of time and legwork. Therefore, you should try to narrow the trouble down to as small an area as possible before you leave the head end. Suppose you have eight trunklines and trouble is reported on only one of the lines. Disconnect the line from the splitter at the head end. Then, use your ohmmeter to measure from the center conductor to the shield of the troublesome trunkline.

Before you can evaluate your readings, you have to know something about the tap-offs and splitters used in the system. Use your ohmmeter to check one unit of each type. Splitters and directional couplers usually appear to be shorted to ground, as far as the ohmmeter is concerned. If this type of unit is in your system, it can set you off on a wild short chase unless you are aware of it. In most systems, you should read about 75 to 100 ohms between the center conductor and the shield of the trunk cable. If you read a short or an open, you know you have spotted a trouble.

If you read an open, split the branch in half. Go to a tap-off in the middle of the line. Remove the tap-off and disconnect the output cable. Check again for proper resistance between center conductor and ground. If you get in the neighborhood of 100 ohms, your trouble is between the splitter and the tap-off you are checking. If not, it is between the tap-off and the terminator at the end of the line. Continue to split the trunkline in half until you find the trouble.

(continued on page 90)

TAPE BIAS

What does it really mean?

You can't get the most out of your tape recorder without optimizing the equalization and bias level. This article explains bias and equalization

by LEN FELDMAN
CONTRIBUTING HIGH FIDELITY EDITOR

THE INCREASING POPULARITY OF TAPE recorders as a high-fidelity program source is not difficult to understand. Unlike other program sources, such as FM radio and phonograph records, tape offers the audio enthusiast the sense of involvement that makes the hobby all the more worthwhile. In addition, today's open-reel tape decks offer performance which is often indistinguishable from that afforded by professional studio tape recorders, and the once looked down upon cassette deck has been transformed from a portable "dictating machine" to an acceptable high-fidelity component. With such a wide interest in tape and tape recording, it is surprising how little most users of these products know regarding their operation. Unlike purely electronic products, such as amplifiers, tuners or receivers, tape decks involve an interrelation of mechanical, magnetic and electronic systems.

Today, most audiophiles have a fairly clear understanding of what phonograph equalization is all about. The amplifier or preamplifier spec sheet has drummed home the idea that the closer a phono preamp adheres to the RIAA playback curve, (shown in Fig. 1) the better the product. These

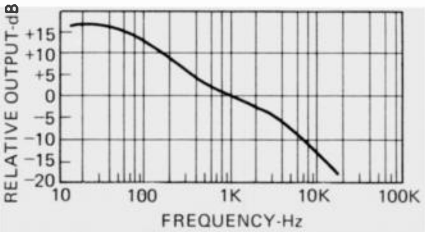


FIG. 1—STANDARD RIAA PLAYBACK CURVE used for phono disc reproduction.

same people often ask me why the tape industry cannot "get together on a single, standard equalization" for tape recording and playback. Why, in fact, are better recorders (both open-reel and cassette) equipped with multiple equalization settings? And what about those multiple bias settings on some of those same recorders?

Equalization

To begin with, a tape recorder does not reproduce signals with a flat frequency response. A tape playback head, being sensitive to the rate of change of a magnetic field, produces a greater output as frequencies increase since at higher frequencies, alternations of magnetic field become more rapid. Thus the ouptut voltage increases with frequency as illustrated in Fig. 2. Eventually, the level ceases

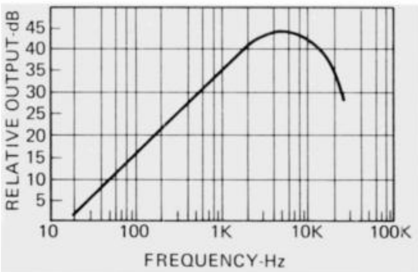


FIG. 2—TYPICAL TAPE PLAYBACK HEAD OUTPUT with constant-level signal recorded on tape.

to increase with frequency and, in fact, begins to drop off fairly rapidly. Two factors are responsible for this drop off. As the frequency to be recorded increases, the wavelength decreases. In addition, as magnetic variations increase in intensity, a point is reached where the tape itself begins to be saturated — it cannot accept greater and greater amounts of magnetization—and level begins to drop. The second of these factors is, to some degree, governed by the formulation of the tape itself, while the first is governed primarily by tape speed and the gap length of the tape head. Fig. 3 illustrates how the linearly increasing voltage output varies with

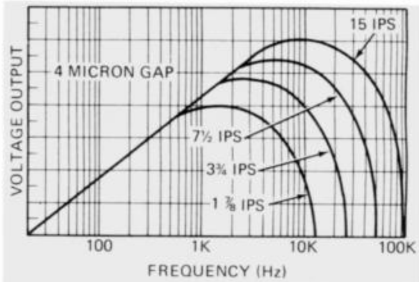


FIG. 3—LINEAR INCREASE IN OUTPUT VOLTAGE extends to higher frequencies at increased tape speed.

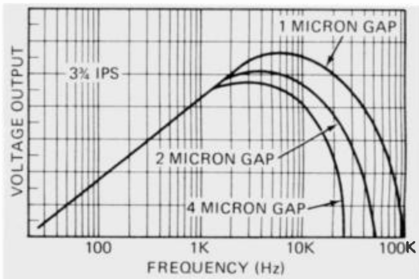
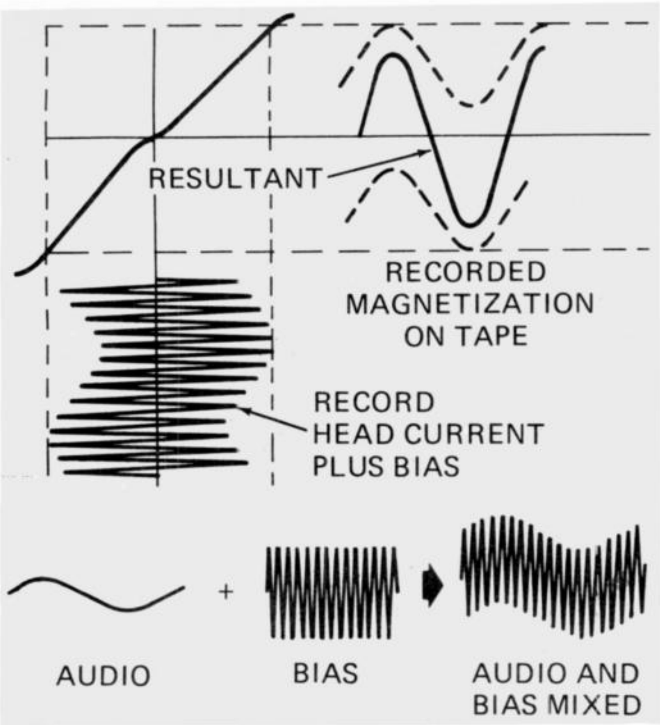


FIG. 4—REDUCING PLAYBACK HEAD GAP while maintaining constant tape speed will extend the high-frequency response.

popular tape speeds for a given tape head gap (4 microns) while Fig. 4 shows how linear output can be extended to higher frequencies at a given tape speed by decreasing the tape head gap.



Obviously, none of the curves of Figs. 2, 3 or 4 would be acceptable for high-fidelity reproduction. The process used to restore "flat" response in tape recording and playback is called *equalization*. Equalization can be applied both during the record operation and during playback. Referring again to Fig. 2, if during playback the response curve of Fig. 5 is used, the resulting overall record/playback response will be as shown in Fig. 6.

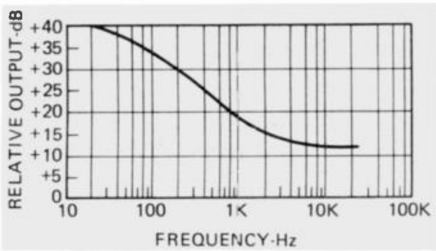


FIG. 5—TYPICAL PLAYBACK EQUALIZATION in tape deck preamp circuitry.

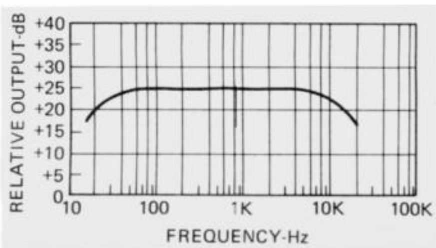


FIG. 6—COMBINING RECORDING RESPONSE (Fig. 2) with equalized playback response (Fig. 5) results in overall record/play response shown.

Note that there is still some roll-off at low and high frequencies.

Record equalization

In order to realize optimum high-frequency response, equalization is used in the record process, too. Record equalization can offset high-frequency roll-off to some degree, but if too much high-frequency pre-emphasis is used, the tape will become saturated at lower nominal recording levels and distortion and roll-off will occur anyway. Playback equalization can in theory, be used to extend high-frequency response but if highs are boosted too much during playback, increased tape hiss will be heard. The record and playback curves must therefore strike a balance to minimize problems of each.

In professional recording work, standards of record and playback equalization were developed by the NAB (National Association of Broadcasters) and the German standards organization known as DIN. These standardized curves are plotted in Fig. 7. The DIN or CCIR curves tend to

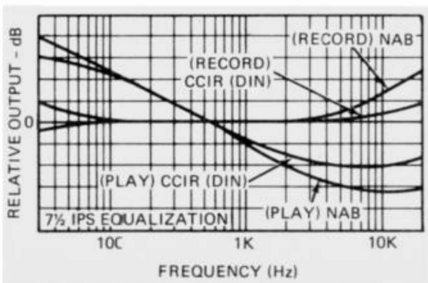


FIG. 7—RECORD AND PLAYBACK equalization standards adopted by the NAB and European standards organizations.

strive for higher frequency response. By using a bit less record equalization, tape saturation is not reached as soon. But this requires more playback equalization which results in higher tape hiss.

In the consumer audio field, manufacturers often change their equalization curves to offer "extended response" which seems to be the sole criterion by which many audiophiles judge tape deck performance. With a given tape speed and a given head gap, however, such "improvements" are invariably accompanied by either reduced level of recordings or increased tape hiss or combinations of both.

In general, frequency response curves for tape equipment are plotted not at 0 db level on the record level meters but at a level of −10 db or even −20 dB in the case of open-reel machines and at −20 dB or even −30 dB in the case of slower-speed cassette decks (which require greater high-frequency boosting during recording to compensate for reduced tape speed.)

Some years ago, the industry introduced Chromium Dioxide tape. It delivers somewhat higher frequency before saturation drop-off occurs. This characteristic produces a slight increase in high-frequency response or for improved signal-to-noise ratio (reduced tape hiss) or a combination of both.

Today, there are a great many different tape formulations, each of which requires a different record and playback equalization. Multiple switch positions are provided on many open-reel and cassette decks which adjust equalization to suit the various popular formulations. Actually, professional machines used in recording studios are often adjusted to work best with one and only one brand and type of recording tape. Conscientious studio engineers may even re-calibrate or adjust equalization when different production batches of the same brand and type of tape are used. The very least that a home user can do to ensure optimum results with an open-reel recorder or better cassette unit is to follow the manufacturer's recommended equalization settings for the type of tape being used. Most owner's manuals list a variety of tapes and their appropriate settings for machines equipped with more than one equalization switch position.

Bias

Assuming that both recording and playback equalization have been optimized with respect to each other in a given recorder, one would expect that the magnetic pattern recorded on the tape will now correspond exactly to the strength of magnetic fields generated by the record head. Unfortunately, magnetic tape is basically a non-linear medium. The magnetic pattern left on the tape is not always proportional to the instantaneous current in the recording head. The greatest amount of non-linearity occurs as the audio waveform passes through the zero axis, as shown diagramatically in

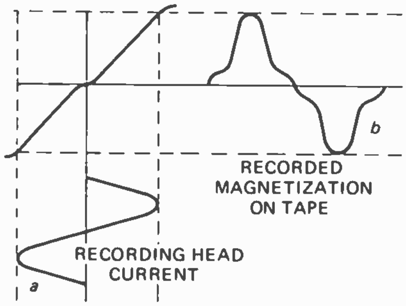


FIG. 8—DISTORTION caused by non-linear magnetization characteristics of tape is similar to crossover distortion encountered in improperly biased Class B audio amplifiers.

Fig. 8. Hysteresis effect, a sort of magnetic inertia, acts upon the particle as magnetization begins. After this initial reaction, the particle responds linearly to the applied field. If nothing were done to offset this effect, a sine wave recorded onto tape as shown in Fig. 8-a would take on the appearance of Fig. 8-b when played back. Obviously, this is a form of distortion and, what is worse, it is a very annoying form of distortion containing high order harmonics. Furthermore, it is a form of distortion that actually is more disturbing at low recording levels than at high signal levels, since the distortion components remain constant and therefore constitute a higher percentage of the total signal at lower recording levels.

High-frequency bias current is used in all modern recorders to overcome this problem. Generally, this super-audible frequency should be at least four times the frequency of the highest audio signal to be recorded, but open-reel recorders will often employ bias frequencies of the order of 100 kHz to 125 kHz while modern high-quality cassette units use frequencies in the range from about 80 kHz to 105 kHz.

The combined action of the desired audio signal and inaudible bias signal can best be understood by referring to Fig. 9. The bias current magnetizes

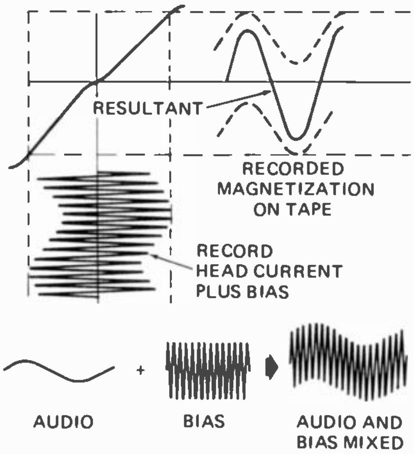


FIG. 9—COMBINING high-frequency bias with desired audio signals during recording shifts audio magnetization of tape to its linear undistorted region.

the oxide particles through the non-linear segment of the curve. Then the audio signal actually demagnetizes the particles to a level which is proportional to the signal.

Bias level changes will affect distortion level. Generally, as bias level is increased (starting from no bias) distortion will decrease rapidly at first. With further increase of bias level, distortion decreases more slowly. If bias is increased much beyond this desired point, high-frequency response will get poorer. Ideally, bias should be set as high as possible without causing severe high-frequency losses in the recorded tape. The action of bias in relation to distortion and high frequency response is shown in the gen-

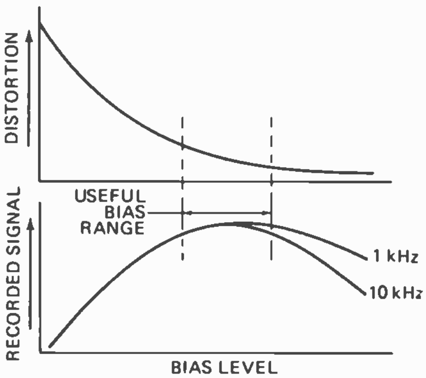


FIG. 10—INCREASING BIAS LEVEL reduces distortion, but overbiasing will reduce high-frequency response.

eral curves of Fig. 10.

Audiophiles who learn of bias for the first time often wonder why the high-frequency bias signal is not recovered as part of the playback signal. In fact, the bias signal does record a series of magnetic fields of its own, but their wavelength is so short that no playback head, however narrow its gap, can significantly respond to these high frequencies. Some small high-frequency energy is picked up by the playback head (however many dB down it may be compared to desired audio signals) and is one of the reasons why higher than necessary frequencies are now used for bias.

Much home recording is done of stereo FM programs and stereo composite signals contain varying amounts of 38-kHz signals in their output. If, for example, 45 kHz were used as a bias frequency in tape decks, a distinct 7-kHz "whistle" might be heard when playing back such recorded stereo FM programs, resulting from the beat or difference between the two otherwise inaudible high-frequency signals.

Since oxide formulations vary greatly from one tape type to another, each requires a different bias level. For this

(continued on page 81)

R-E's Substitution guide for replacement transistors

PART XXV

by ROBERT & ELIZABETH SCOTT

ARCH—Indicates the Archer brand of semiconductors sold only by Radio Shack and Allied Radio stores. Allied Radio Shack, 2725 W. 7th St., Ft. Worth, Texas 76107

DM—D. M. Semiconductor Co., P.O. Box 131, Melrose, Mass. 02176

G-E—General Electric Co., Tube Product Div., Owensboro, Ky. 42301

ICC—International Components, 10 Daniel Street, Farmingdale, N.Y. 11735

IR—International Rectifier, Semiconductor Div., 233 Kansas St., El Segundo, Calif. 90245

MAL—Mallory Distributor Products Co., 4760 Kentucky Ave., Indianapolis, Ind. 46241

MOT—Motorola Semiconductors, Box 2963, Phoenix, Ariz. 85036

RCA—RCA Electronic Components, Harrison, N.J. 07029

SPR—Sprague Products Co., 65 Marshall St., North Adams, Mass. 01247

SYL—Sylvania Electric Corp., 100 1st Ave., Waltham, Mass. 02154

WOR—Workman Electronic Products, Inc., Box 3828, Sarasota, Fla. 33578

ZEN—Zenith Sales Co., 5600 W. Jarvis Ave., Chicago, Ill. 60648

Radio-Electronics has done its utmost to insure that the listings in this directory are as accurate and reliable as possible; however, no responsibility is assumed by Radio-Electronics for its use. We have used the latest manufacturers material available to us and have asked each manufacturer covered in the listing to check its accuracy. Where we have been supplied with corrections, we have updated the listing to include them. The first part of this Guide appeared in March 1973.

	ARCH	DM	G-E	ICC	IR	MAL	MOT	RCA	SPR	SYL	WOR	ZEN
2N6012	NA	TS-3001	NA	ICC-S3001	NA	PTC 136	HEP-S3001	NA	NA	ECG 153	NA	NA
2N6013	NA	TS-3031	NA	ICC-S3031	NA	NA	HEP-S3031	NA	RT-115	NA	NA	NA
2N6014	NA	TS-3020	GE-63	ICC-S3020	NA	NA	HEP-S3020	NA	NA	NA	NA	NA
2N6015	NA	TS-3031	GE-67	ICC-S3031	NA	PTC 127	HEP-S3031	NA	RT-115	na	na	na
2N6016	NA	TS-3001	NA	ICC-S3001	NA	NA	HEP-S3001	NA	NA	NA	NA	NA
2N6017	NA	TS-3031	NA	ICC-S3031	NA	PTC 127	HEP-S3031	NA	RT-115	NA	NA	NA
2N6021	NA	TS-5006	NA	ICC-S5006	TR-77	NA	HEP-S5006	NA	RT-149	ECG 153	WEP-246	NA
2N6022	NA	TS-5006	NA	ICC-S5006	TR-77	NA	HEP-S5006	NA	RT-149	ECG 153	WEP-246	NA
2N6023	NA	TS-5007	GE-69	ICC-S5007	TR-77	PTC 157	HEP-S5007	NA	NA	ECG 153	WEP-246	ZEN 211
2N6024	NA	TS-5007	GE-69	ICC-S5007	TR-77	PTC 157	HEP-S5007	NA	RT-153	ECG 153	WEP-246	ZEN 211
2N6025	NA	TS-5006	GE-69	ICC-S5006	NA	PTC 157	HEP-S5006	NA	RT-149	ECG 180	NA	ZEN 211
2N6026	NA	TS-5006	GE-69	ICC-S5006	TR-77	PTC 157	HEP-S5006	NA	RT-149	ECG 153	WEP-246	NA
2N6027	NA	NA	GE-X17	ICC-52	NA	NA	HEP-52	NA	NA	ECG 6402	NA	NA
2N6067	NA	T-52	NA	NA	NA	PTC 103	NA	NA	NA	NA	NA	NA
2N6068	NA	SR-1721	NA	ICC-R1721	NA	NA	HEP-R1721	NA	NA	ECG 5600	NA	NA
2N6069	NA	SR-1721	NA	ICC-R1721	NA	NA	HEP-R1721	NA	NA	ECG 5601	NA	NA
2N6070	NA	SR-1722	NA	ICC-R1722	NA	NA	HEP-R1722	NA	NA	ECG 5602	NA	NA
2n6071	NA	SR-1723	NA	ICC-R1723	NA	NA	HEP-R1723	NA	NA	ECG 5603	NA	NA
2N6072	NA	SR-1725	NA	ICC-R1725	NA	NA	HEP-R1725	NA	NA	ECG 5604	NA	NA
2N6073	NA	SR-1725	NA	ICC-R1725	NA	NA	HEP-R1725	NA	NA	ECG 5605	NA	NA
2N6074	NA	NA	NA	NA	NA	NA	NA	NA	NA	ECG 5606	NA	NA
2N6075	NA	NA	NA	NA	NA	NA	NA	NA	NA	ECG 5607	NA	NA
2N6076	NA	T-723	GE-67	ICC-723	NA	PTC 121	HEP-723	NA	NA	NA	NA	ZEN 111
2N6080	NA	NA	NA	ICC-S3005	NA	NA	HEP-S3005	NA	NA	NA	NA	NA
2N6081	NA	NA	NA	ICC-S3006	NA	NA	HEP-S3006	NA	NA	NA	NA	NA
2N6082	NA	NA	NA	ICC-S3007	NA	NA	HEP-S3007	NA	NA	NA	NA	NA
2N6083	NA	NA	NA	ICC-S3007	NA	NA	HEP-S3007	NA	NA	NA	NA	NA
2N6084	NA	NA	NA	ICC-S3009	NA	NA	HEP-S3009	NA	NA	NA	NA	NA
2N6085*	NA	T-729	NA	ICC-729	NA	NA	HEP-729	NA	NA	NA	NA	ZEN 115
2N6086*	NA	T-728	NA	ICC-728	NA	NA	HEP-728	NA	RT-109	NA	NA	ZEN 114
2N6087*	NA	T-729	NA	ICC-729	NA	PTC 139	HEP-729	NA	RT-109	NA	NA	ZEN 115
2N6088*	NA	T-728	NA	ICC-728	NA	PTC 139	HEP-728	NA	RT-109	NA	NA	ZEN 114
2N6089*	NA	T-729	NA	ICC-729	NA	PTC 139	HEP-729	NA	RT-109	NA	NA	ZEN 115
2N6090*	NA	T-728	NA	ICC-728	NA	PTC 139	HEP-728	NA	RT-109	NA	NA	ZEN 114
2N6091*	NA	T-729	NA	ICC-729	NA	PTC 139	HEP-729	NA	RT-109	NA	NA	ZEN 115
2N6092*	NA	TS-0007	NA	ICC-S0007	NA	NA	HEP-S0007	NA	RT-109	NA	NA	NA
2N6099	NA	TS-5001	NA	ICC-S5001	NA	NA	HEP-S5001	SK 3534	NA	NA	NA	ZEN 209
2N6101	NA	TS-5004	NA	ICC-S5004	NA	NA	HEP-S5004	SK 3534	NA	NA	NA	NA
2N6105	NA	NA	NA	ICC-S0007	NA	NA	HEP-S0007	NA	NA	NA	NA	NA
2N6106	NA	TS-5005	NA	ICC-S5005	NA	NA	HEP-S5005	SK 3083	RT-153	ECG 197	WEP-246	NA
2N6107	NA	TS-5005	NA	ICC-S5005	NA	NA	HEP-5005	SK 3083	RT-153	ECG 197	WEP-246	NA
2N6108	NA	TS-5002	NA	ICC-S5002	NA	NA	HEP-S5002	SK 3083	RT-153	ECG 197	WEP-246	NA
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2N6110	NA	TS-5002	NA	ICC-S5002	NA	PTC 157	HEP-S5002	SK 3084	RT-153	ECG 197	WEP-246	NA
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2N6121	NA	T-701	NA	ICC-701	TR-76	NA	HEP-701	NA	NA	ECG 152	WEP-245	NA
2N6122	NA	TS-5003	NA	ICC-S5003	TR-76	PTC 154	HEP-S5003	NA	RT-154	ECG 152	WEP-245	ZEN 210
2N6123	NA	TS-5000	NA	ICC-S5000	NA	PTC 154	HEP-S5000	NA	RT-150	NA	WEP-245	NA
2N6124	NA	T-700	NA	ICC-700	TR-77	NA	HEP-700	NA	RT-155	ECG 153	WEP-246	NA
2N6125	NA	TS-5007	NA	ICC-S5007	TR-77	NA	HEP-S5007	NA	RT-155	ECG 153	WEP-246	ZEN 211
2N6126	NA	TS-5006	NA	ICC-S5006	TR-77	NA	HEP-S5006	NA	RT-155	ECG 153	WEP-246	NA
2N6129	NA	TS-5001	NA	ICC-S5001	NA	PTC 137	HEP-S5001	NA	NA	NA	NA	ZEN 209
2N6130	NA	TS-5001	NA	ICC-S5001	NA	PTC 154	HEP-S5001	NA	NA	NA	NA	ZEN 209
2N6131	NA	TS-5004	NA	ICC-S5004	NA	PTC 154	HEP-S5004	NA	NA	NA	NA	NA
2N6132	NA	TS-5008	NA	ICC-S5008	NA	NA	HEP-S5008	NA	RT-153	ECG 197	WEP-246	NA
2N6133	NA	TS-5002	NA	ICC-S5002	NA	NA	HEP-S5002	NA	RT-153	ECG 197	WEP-246	NA
2N6134	NA	TS-5005	NA	ICC-S5005	NA	PTC 143	HEP-S5005	NA	RT-153	ECG 197	WEP-246	NA
2N6139	NA	SR-1751	NA	ICC-R1751	NA	NA	HEP-R1751	NA	NA	ECG 5663	NA	NA
2N6140	NA	NA	NA	NA	NA	NA	NA	NA	NA	ECG 5665	NA	NA
2N6141	NA	NA	NA	NA	NA	NA	NA	NA	NA	ECG 5667	NA	NA
2N6146	NA	NA	NA	NA	NA	NA	NA	NA	NA	ECG 5675	NA	NA
2N6151	NA	NA	NA	NA	NA	NA	NA	NA	NA	ECG 5614	NA	NA
2N6152	NA	NA	NA	NA	NA	NA	NA	NA	NA	ECG 5616	NA	NA
2N6153	NA	NA	NA	NA	NA	NA	NA	NA	NA	ECG 5618	NA	NA
2N6154	NA	NA	NA	NA	NA	NA	NA	NA	NA	ECG 5624	NA	NA
2N6155	NA	NA	NA	NA	NA	NA	NA	NA	NA	ECG 5624	NA	NA
2N6156	NA	NA	NA	NA	NA	NA	NA	NA	NA	ECG 5628	NA	NA
2N6160	NA	SR-1783	NA	ICC-R1783	NA	NA	HEP-R1783	NA	NA	ECG 5693	NA	NA
2N6161	NA	SR-1785	NA	ICC-R1785	NA	NA	HEP-R1785	NA	NA	ECG 5682	NA	NA
2N6162	NA	NA	NA	NA	NA	NA	NA	NA	NA	ECG 5697	NA	NA
2N6165	NA	NA	NA	NA	NA	NA	NA	NA	NA	ECG 5697	NA	NA
2N6167	NA	NA	NA	NA	NA	NA	NA	NA	NA	ECG 5673	NA	NA
2N6169	NA	NA	NA	NA	NA	NA	NA	NA	NA	ECG 5675	NA	NA
2N6175	NA	T-244	NA	ICC-244	NA	NA	HEP-244	SK 3104	RT-135	NA	NA	ZEN 201
2N6176	NA	T-244	NA	ICC-244	NA	NA	HEP-244	SK 3103	RT-135	NA	NA	ZEN 201
2N6177	NA	NA	NA	NA	NA	NA	NA	SK 3103	RT-131	NA	NA	NA
2N6178	NA	TS-5000	NA	ICC-S5000	NA	NA	HEP-S5000	SK 3024	RT-150	NA	NA	NA
2N6179	NA	TS-5000	NA	ICC-S5000	NA	NA	HEP-S5000	SK 3024	RT-150	NA	NA	NA
2N6180	NA	TS-5006	NA	ICC-S5006	NA	NA	HEP-S5006	SK 3025	RT-149	NA	NA	NA

(to be continued)

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Circle 90 on reader service card

RE's Service Clinic

Those new HEW circuits

Redundancy in the high-voltage supply

by JACK DARR
SERVICE EDITOR

> **This column is for your service problems—TV, radio, audio or general and industrial electronics. We answer all questions individually by mail, free of charge and the more interesting ones will be printed here.**
>
> **If you're really stuck, write us. We'll do our best to help you. Don't forget to enclose a stamped, self-addressed envelope. If return postage is not included, we cannot process your question. Write: Service Editor, Radio-Electronics, 200 Park Ave. South, N.Y. 10003.**

IF WE WANT TO ANALYZE TROUBLE IN A circuit, we've got to know what's in it! If "something new has been added" that we don't know about, we're in deep trouble. This is specially true if the added circuits duplicate the functions of circuits that are already in there.

In quite a few color TV sets, we're already in that shape. Any set built in 1971 or later may have extra circuits that many of us don't know about. These were added to comply with HEW (Department of Health, Education and Welfare) regulations. The idea is to control the high voltage, so that it cannot rise above the rated level.

I don't know what these will do for our health, the effect on our welfare is yet to be determined, but if you don't know they're in there, they can be highly educational! (Voice of Experience!)

Practically all color TV sets use some kind of high-voltage regulator. However, the new circuits are *added* to existing ones. They're in the form of "redundant regulators" (which translates into "two circuits doing the same thing" or a sort of belt-and-suspenders action.) In some, you'll find as many as *three* separate regulator or control circuits, all doing, in effect, the same work.

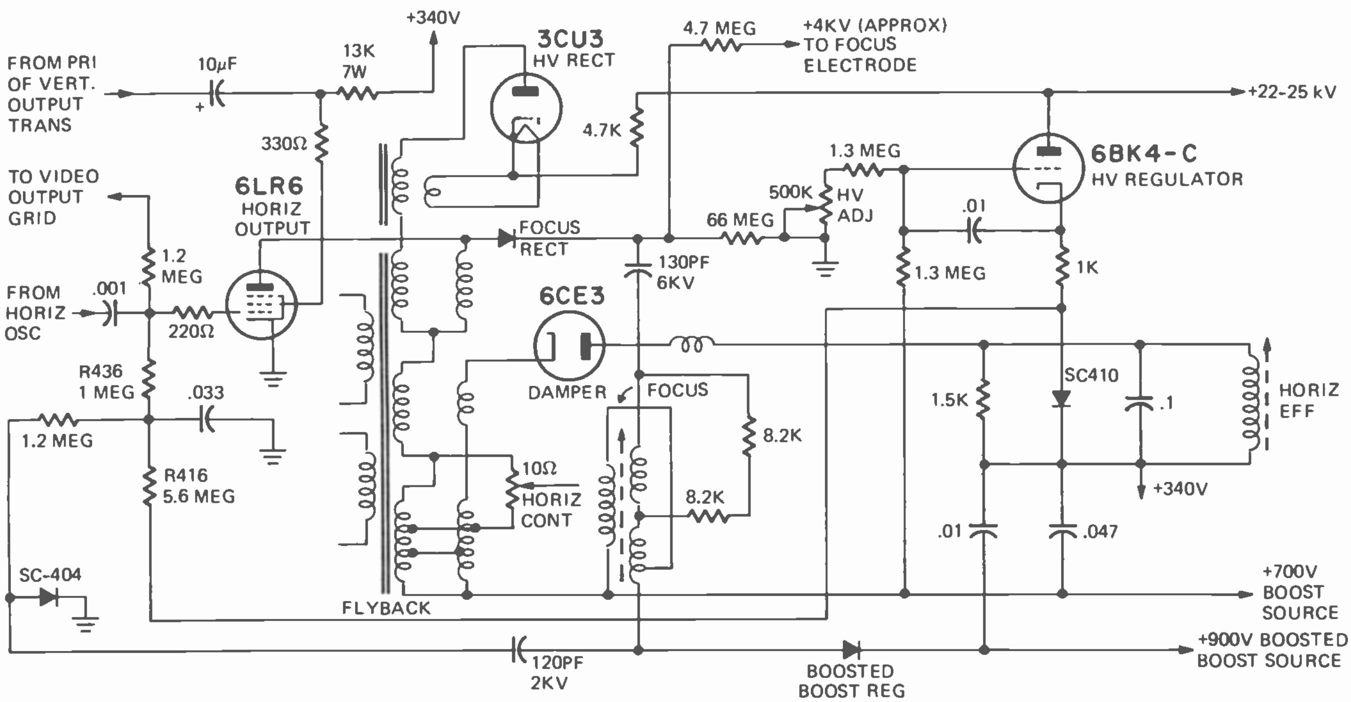
The operation of these circuits isn't complicated, any more than the original high-voltage regulators. However, if you don't know they're there, they can lead you far from the correct conclusions when trying to diagnose troubles! So, let's look at a few typical redundant-regulator circuits and see how they work.

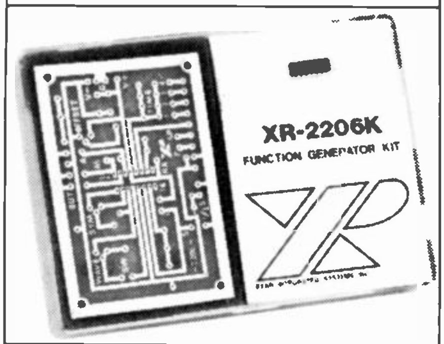
All of them are basically "hold-down". If he high voltage rises above the correct level, they go into action. Some are simple clamp types; some are designed to kill the high voltage entirely, if it goes up. Still others are designed to disable some other circuit, to prevent the set from operating; the video, sync, and in one case the horizontal oscillator.

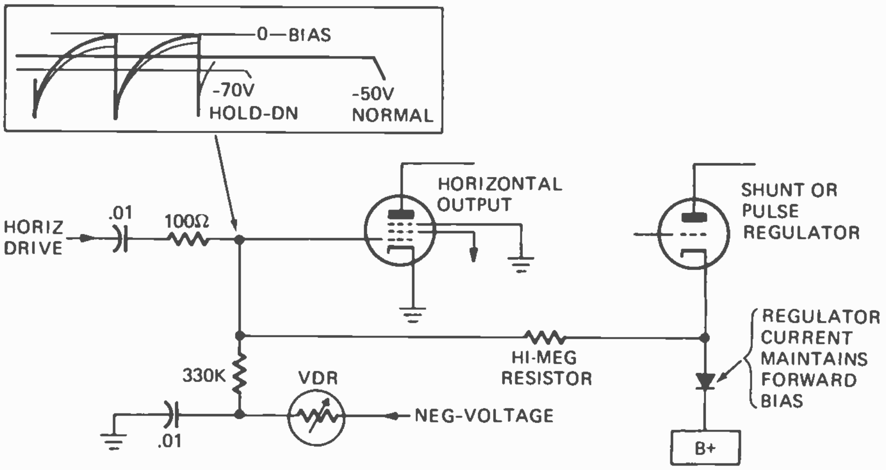
How the circuits work

The Sylvania D-12 chassis would be a good one to start with. At first glance, this looks like our old friend the 6BK4 shunt regulator; it is, but with differences. Figure 1 shows the important parts. Note the diode in the cathode circuit of the 6BK4. This is called the "Regulator Limiter" SC-410. In normal operation, the 6BK4 conducts *through* this diode. So, the 6BK4 cathode, and the diode anode, will be about +340 volts. This is fed back to the 6LR6 control-grid circuit, through R416, 5.6 megohms, and R436, 1.0 megohms. This positive voltage would tend to turn on the 6LR6.

However, there is additional circuitry: Diode SC-404, and R412 are also connected to the bottom of the grid resistor R436. A high pulse voltage from the flyback is fed to the diode anode. This develops a very high *negative* voltage, to buck out the positive voltage. So, the 6LR6 grid develops its normal bias by grid-leak action, from the drive signal. The result of all this is a grid voltage of about −45 volts.







Now what happens if the 6BK4 tube fails? It stops conducting. (I love those nice obvious statements. Nobody can contradict me). No current flow, SC-410 becomes reversed-biased and the 6BK4 cathode goes far more negative. This negative shift is fed to the 6LR6 through the resistor network, cutting down the output, high voltage, etc. In the original circuit, of course, a dead 6BK4 would let the high voltage jump to about 32-33 kV. The belt and suspenders action of the other negative voltage, from SC-404, is also shoved in there to make sure that the tube is cut off.

The negative voltage from SC-404 is also fed to the grid of the video amplifier tube. It cuts *this* tube off as well. Its plate voltage rises, the picture-tube cathodes go far more positive (same as negative grid voltage) and the beam current is held down, reducing brightness.

The end result of all these actions is an old symptom—narrow raster, about an inch short on each side, and a severe loss of brightness. If you run into one of these, you'll probably try a new horizontal output tube first, just as I did. If this doesnt help, even though all of the symptoms seem to be pointing to it, *don't* pull the chassis—not yet.

Step 1: Read the grid voltage on the 6LR6. If this is up to about −95 volts, try a new 6BK4 tube. High-voltage will drop to about 17 kV, by the way. If the new regulator tube doesn't help, check both diodes, SC-410 and SC-404. Failure of either one of these (short or open!) will cause the trouble. SC-410, if it's open, will cause the same symptoms as a dead 6BK4, and so on.

RCA uses a very similar circuit in their CTC 38 chassis and others. Figure 2 shows the basic circuit. The bucking voltage from the high-voltage regulator cathode (either the shunt, as with 6BK4, or "pulse", with 6HS5 etc.). Once again, this voltage goes to the grid return of the horizontal output tube.

The positive voltage is again bucked out by a negative voltage developed from a flyback pulse. This time, a VDR is used instead of a diode. In this set, the symptoms are the same as before. Narrow, dim raster, and high negative bias on the horizontal output tube. **R-E**

reader questions

DOUBLE DOTS

I get two dots, or two lines, on my PACO S-50 scope, with no signal input. What's wrong? — A.D., Harvey, La.

You're obviously getting some vertical deflection that you should not be getting. This could be due to an unbalance in the vertical output tubes; perhaps a bad peaking coil in one of them. Check these tubes for any sign of heater-cathode leakage.

(continued on page 78)

READER QUESTIONS

(continued from page 76)

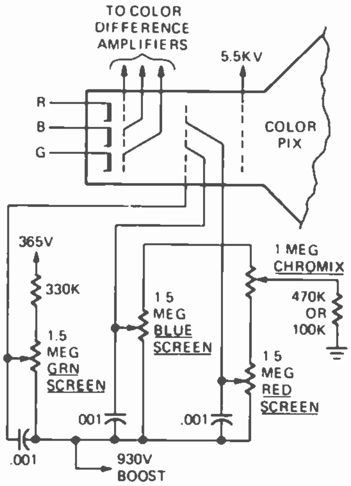
Also. In this scope, you have "links" on the back of the chassis, which can be opened to get directly to the crt vertical deflection plates. In some scopes, these links have caused trouble by getting loose, corroded or dirty. Take them off, clean them, and retighten the screws securely.

PURPLE PICTURE

After replacing a bad picture tube in a Sears 7185, I have setup problems. I get a purple picture, mostly reddish, with all of the screen and drive controls turned off. Only way I can get anything near normal is to turn up only the green screen. I checked it on a test-jig, and got the same symptoms; they showed up in the old tube, too.

I'm enclosing a table of the dc voltages I found on the picture tube base. Any help will be appreciated. — J.S., Dallas, Tex.

I think I see the difficulty. Note that your *screens* are all far too high —950 to 1000 volts, with the control turned all the way off. With screen voltages this far above normal (about 740 to 800 volts) your picture tube cutoff will be away up, and you will lose control of the raster.

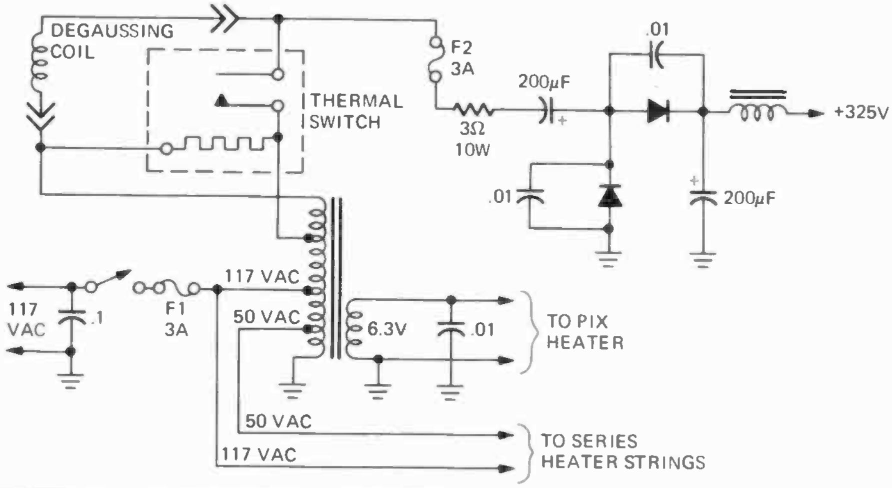


The diagram shows the screen control circuit of this one, which is a voltage *divider* between B+400 volts and B++950 volts. You obviously have the boost-boost voltage on these controls; it looks very much as if the circuit to B+ 400 volts is *open*. Check; you should be able to get those screen voltages down to around +400 volts. If you can't, find out why.

There is another possibility. Check that 470K resistor from the CHROMIX controls to ground. If it is open, it would let the red and blue screens go higher than they should; this, of course would give you a purple (red + blue) raster.

CLINIC Q'S

(continued from page 78)



LIGHT BARS MOVING THROUGH RASTER

I've got light, horizontal bars moving slowly through the raster on an Olympic CT-910. They're not humbars, for these are darker than the rest of the picture. There's a little bluish shading at one end.

Couple of notes first; "hum-bars" can be either light or dark. They're caused by ripple in the dc power supply; in other words, a "pulse" of voltage on what should be a nice smooth dc. If this pulse is of a polarity that will make the raster *brighter*, you get a light bar. If it's opposite, (tending to turn the beam off) you get dark bars.

Cause is the same; something in the dc power supply which is putting too much ripple on the B+ lines. Check that thermal switch in the degausser circuit. In some cases, it has been known to stick, and keep the degausser turned on at all times. Since this chassis has a half-wave voltage-doubler rectifier circuit, your ripple will have a slightly different waveform than the more common full-wave bridge rectifier. This is probably the cause of the two-bar symptom. **R-E**

TAPE BIAS

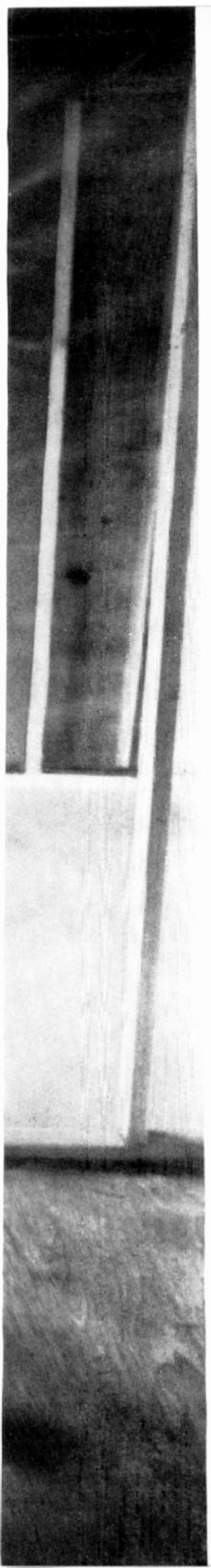
(continued from page 72)

reason, home tape recorders now come equipped with separate bias switches to match the various bias requirements of different tapes. In the case of professional machines, bias adjustment is usually continuously variable and professionals will often apply a slight amount of excess bias. This practice can reduce recording drop outs that sometimes occur because of poor or non-uniform dispersion of oxide particles on the tape surface. Again, the professional recording engineer will often choose a slight reduction of high-frequency response if that choice means reduced overall distortion and the elimination of other bias related problems.

In a subsequent article, we will explore some of the ambiguities and confusion that exist in the tape field in specifying signal-to-noise ratios. We'll see how one tape deck's 55-db S/N spec may well give quieter performance than another deck's published 60-dB S/N specification. **R-E**

NEXT MONTH IN R-E

Len Feldman explores the special electronic features of modern tape deck transports next month. Be sure you don't miss the June issue of Radio-Electronics.



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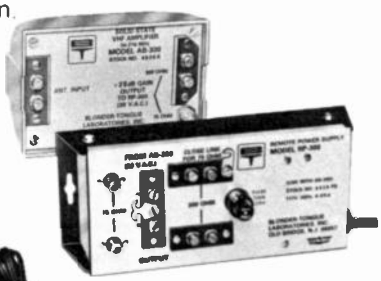

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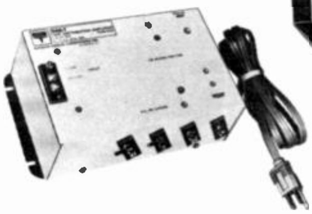

2. DA8-T—famous DA8B fully transistorized. 13dB gain. Lower noise. 1 input/8 outputs. VHF/FM. Universal 300 ohm/75 ohm.

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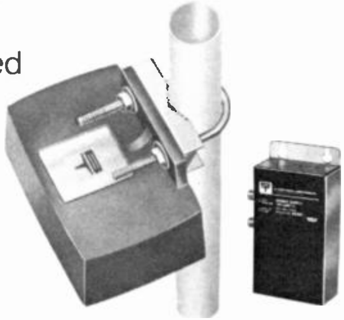

5. Vamp T-75 Mast-Mounted Preamp—17dB gain. Patented ICEF overload protection circuit. 6dB noise figure 75 ohm downlead 2-13.

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Circle 69 on reader service card

new products

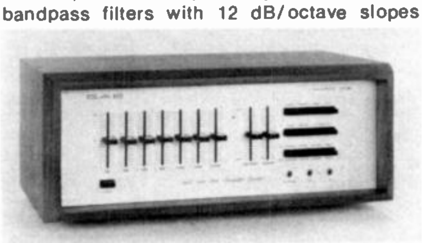
More information on new products is available from the manufacturers of items identified by a Reader Service number. Use the Reader Service Card inside the back cover.

PHOTOELECTRIC BEAM RELAY KIT, *model GD-1021* is used around home, office, stores, factories, warehouses and garages as an alarm against instruders, for activating door openers, turning on lights, counting people entering or leaving an area, counting units on production lines, etc.

Consists of a light source, mirror assembly and a photocell-controlled relay that is activated when reflected light beam is broken, energizing the AC socket. When beam again becomes unobstructed, relay turns off power to alarm or other devices. Unit will activate any external 120-volt alarm or lamps up to 150 watts. Built-in light source operates at distances of up to 25 feet from reflecting mirror. $14.95.—**Heath Co.,** Benton Harbor, MI 49022.

Circle 100 on reader service card

STEREO PREAMPLIFIER EQUALIZER, *model IXB.* This 7-band graphic equalizer uses professional-type slidepots and pushbuttons instead of conventional rotary-type controls. Center frequency of each band is 40 Hz, 120 Hz, 320 Hz, 960 Hz, 2500 Hz, 7500 Hz and 15,000 Hz respectively. Torroidal LC bandpass filters with 12 dB/octave slopes are used. Each slidepot has a dual range: variable to ±16 dB or ±8 dB. Equalizer defeat switch is provided to electrically remove equalizer from circuit. Tape copy facility is provided to eliminate patching to rear of chassis.



Frequency response: high level inputs is ±0.25-dB 10-Hz to 100-kHz and low level inputs is ±1-dB 20-Hz to 20-kHz. RMS harmonic distortion is less than 0.02% between 20 Hz and 20 kHz at the rated output of 2.5 volts. IM distortion is less than 0.02% at rated output. S/N level: low-level is 75-dB below a 10-mV input and high-level is 90-dB below rated output. Maximum output is 18V into high impedance. 5.75 × 17 × 7 in. —**Scientific Audio Electronic, Inc.,** 701 Macy Street, Los Angeles, CA 90012.

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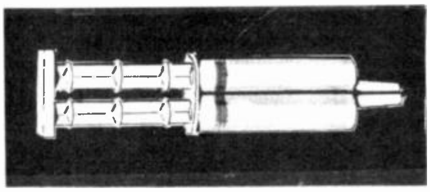
DOUBLE BARREL EPOXY, *model 33-104.* Epoxy glue has always been supplied in two tubes requiring the exact mixture of both tubes. Now, double barrel epoxy is contained in a double-nozzled, self-measuring dispenser. Easy-to-use, all that is required is to push the piston to meter equal parts of hardener and resin. Cap is replaced and product is stored until needed. —**Workman Electronic Products, Inc.,** Box 3828, Sarasota, FL 33578.



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MASTER RIG, *model MJ-195* is a complete test rig for both tube and solid-state chassis. Features include: built-in hi-voltage meter, speaker, front panel connections and metal cabinet. When equipped with the proper CRT, they are capable of operating with late model chassis that delivers over 30 kV. Comes complete with all components for the deflection circuit hookup and four solid-state yoke adapters. $149.95, less 19-in. picture tube.—**TeleMatic,** 2245 Pitkin Avenue, Brooklyn, NY 11207.

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CB RADIOTELEPHONE, *Messenger 132* extends radiotelephone operating concept to base station use. Offers all advantages of the handset design including option of private listening. If user selects, the speaker is automatically silenced when he lifts the handset to permit listening without disturbing others. Handset also provides increased clarity under noisy conditions. When group listening is desired, a switch on the front panel provides simultaneous handset and loudspeaker operation.

Also featured is an illuminated meter that indicates received signal strength as well as

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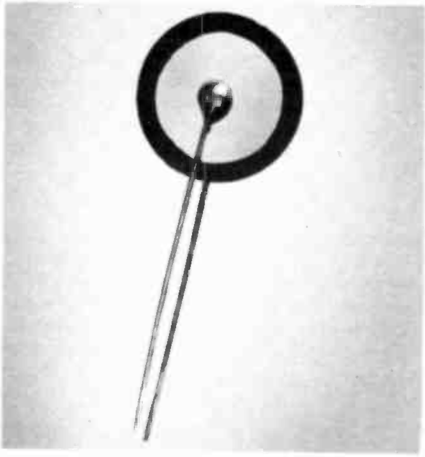
THERMISTORS, *No. GB-205* is a fast response, instant-on degaussing thermistor for use in most late model sets. Other additions include exact replacements for RCA and



other TV brands. Company makes available over 360 different semiconductors capable of replacing 90% of the industry.—**Oneida Electronic Mfg., Inc.,** 843 North Cottage Street, Meadville, PA 16335.

Circle 35 on reader service card

FUNCTION GENERATOR, *model 10* provides simultaneous outputs of sine, square and triangle waveforms. Features include: TTL

compatible output, four volt P-P triangle output and a selectable function output with the amplitude adjustable from 0V to 20V P-P into 600 ohms. Frequency range is 1 Hz to 1 MHz; sinewave distortion is less than

2% (1 Hz to 100 kHz); input power is 105-125 VAC 60 Hz at 10 watts. 6 × 4 × 3 in.; 1 lb.; $89.95.—**Advanced Electronics,** P.O. Box 63, 63 Lincoln Street, Newton, MA 02161.

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AUDIO SWEEP GENERATOR/FREQUENCY METER, *140B* is three instruments in one—audio oscillator, audio sweep generator and frequency meter. Operates manually as conventional oscillator or swept automatically as voltage controlled generator. Generator sweeps over two ranges—high range from

1 kHz to 20 kHz and extended low range from 40 Hz to 1 kHz.

Frequency may be used independently. However, when connected to output of sweep generator, the frequency reading is continuously displayed. May be used to monitor changing frequency of sweep generator or any other external frequency source. Unit is source for testing amplifier frequency response, speaker enclosures, tape recorder head alignment. Provides sinewave output that is variable from 0 to 2.5 Vp-p. Once set, amplitude remains flat over entire frequency range. Sinewave distortion is less than 1.5%; square wave output is fixed at 8 volts. $78.95.—**Production Devices,** 7857 Raytheon Road, San Diego, CA 92111.

Circle 37 on reader service card

Circle 76 on reader service card

Circle 74 on reader service card

SERVICING MATV

(continued from page 69)

Shorts are easier to track with your field-strength meter. If you read a short, re-connect the trunkline to the splitter and fire the system up again. Then, use the field-strength meter to check the signal out of each tap-off in the line. As you approach the short, the signal level will decrease markedly. The advantage of using the field-strength meter for this routine is that it is much faster and easier. You don't have to remove any tap-offs from the wall or disconnect input or output cables.

Frequent troubles

You don't always have to go through an entire troubleshooting procedure to pinpoint MATV troubles. A knowledge of what is most likely to happen as a system is used can help you to take very effective shortcuts. Here are the most common causes of MATV troubles in older systems:

Ac hum. Appears on screen as one or two stationary or rolling dark bars. One bar indicates 60 Hz hum, half-wave power supply. Two bars indicate 120 Hz hum, full-wave power supply.

Use your portable TV set to make sure the hum isn't originating from a defective filter in the tenant's set. If hum appears on all sets, the hum is probably caused by a filter in the MATV amplifier.

Picture rolling: on one channel only. Usually caused by sync compression in single-channel amplifier. As amplifier ages, tuning shifts and AGC increases gain. If you encounter this problem, use the manufacturers recommended procedure to reset the AGC tuning and reduce the gain of the amplifier.

Cross modulation in broadband system. Levels may have been set right initially, but the maintenance man or some tenant may have taken it upon himself to turn up the amplifier gain.

Ghosts. Some tenants try to compensate for aging tuners on their TV sets by getting more signal out of the MATV system. They simply short out the isolation in the tap-off. This tenant's pictures will be very good, but others along his trunkline will be bothered by ghosts.

Another common cause of ghosts is that someone has extended the line, adding a few extra outlets. This causes no problem if done properly, but most people forget to terminate the line when they add outlets. No termination means standing waves which equal ghosts.

If the ghosts are seen in only one or two apartments, it's a good bet that

(continued on page 97)

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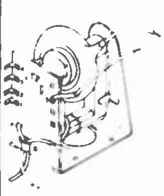

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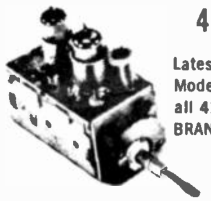

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All booklets, catalogs, charts, data sheets and other literature listed here with a Reader Service number are free. Use the Reader Service Card inside the back cover.

HARDWARE & SOFTWARE APPLICATIONS CATALOG, *Tekgraphics.* Quarterly publication delves into several scientific fields and explains how the company's computer graphics terminals and programmable calculators have liberated searchers from time-consuming chores. Major articles in October's 16-page issue includes a story on how NASA optimizes aircraft design testing with interactive computer graphics, a story on how a programmable calculator speeded up the engineering of a telescopic wing for a physician's amphibian airplane and much more.—**Tektronix, Inc.,** P.O. Box 500, Beaverton, OR 97005.

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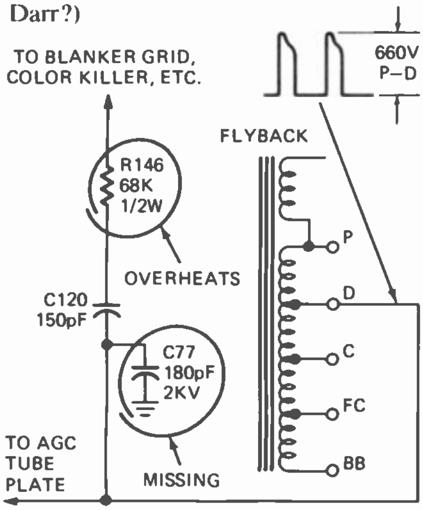
RESISTOR SMOKES: NO SHORTS!

This Magnavox 920 has a really weird symptom. R146, 68K 1/2 watt, in the pulse-feed circuit to the blanker grid, and other circuits keeps burning up. I finally got it to hold by using a 1-watt resistor. It runs pretty hot, but stays. There are no short-circuits on the load side of the resistor; blanker tube replaced, etc. I don't understand this. What makes it burn up?—L.F., Altus, Okla.

This kind of thing can be puzzling (puzzled me no end the first time I ran over it). If you do not have a dc short, causing excess current to be drawn through this resistor, there's only one logical explanation left. (Who says that TV circuits have to react logically, Darr?)



In circuits with high *pulse* voltages, an *open* bypass can cause this. The bypass capacitor reduces the amplitude of the pulse, so that the resistor can hold. Good suspect would be C77, 180 pF, which is right on the flyback terminal board. You might overlook this, because it's drawn on the schematic away up on the agc tube plate!

(Field feedback; this was right. Another victory for the Crystal Ball!)

REPLACEMENT TRANSISTORS

I have an old stereo amplifier to fix. Transistors out, and some modifications on the PC boards. It's a TEC S15. Where can I get a schematic, and what's a "B-1215" transistor?—B.A., Livingston Manor, N.Y.

You're in luck. Sams Photofacts lists exactly *one* Tec, and it's a model S-15. Company out of business, but looks fairly stock.

B-1215 transistor finally run to earth in one of my Transistor Guides. Germanium, TO-3 case, 50 volts breakdown, 7A max Ic. An SK-3009 should be a good replacement.

After you get it fixed, plug it into a variable-voltage transformer, with a current meter in the collector supply, and bring the line voltage up from zero very slowly. This will tell you if there's anything else wrong before the smoke starts to rise. **R-E**

next month

JUNE 1975

■ **Digital Memory For Your Scope**
4-channel add-on storage unit costs less than $150 to build. It displays digital pulse chains for checking digital logic circuits.

■ **Video Disc 1975**
Where does it stand today? Where will it go tomorrow? Get an expert's view.

■ **How R-E Lab Tests Hi-Fi Gear**
Yes, we will be doing laboratory tests to measure the performance of today's hi-fi equipment. We'll be presenting at least two test reports in each issue. But first, we would like to explain how our tests are performed.

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Jack Darr's Service Clinic

Radio-Electronics' Replacement Transistor Directory

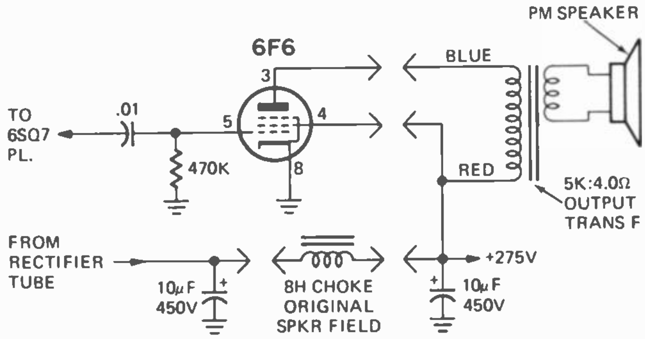
June issue goes on sale May 20, 1975

service questions

SPEAKER HOOKUP, OLD RCA RADIO

I'm working on an old RCA radio, a T62. Speaker's gone. I see three wires that might have gone to it; one to pin 4 of the 6F6 tube, one to pin 5, and one to a 10-μF electrolytic capacitor. How do these connect to the speaker?—K.Q., Syracuse, NY.

Two things here; one, to hook up the output transformer, connect the primary (red and blue wires) to the plate,



pin 3, and screen-grid, pin 4, of the 6F6. That 10-μF electrolytic capacitor should also go to the screen.

The original speaker was an electrodynamic with a 1000-ohm field. This was the choke in the B+ power supply. Replace this with about an 8-henry choke, as shown in the diagram.

POWER TRANSFORMER?

The tubes all light in this Motorola TS-908Y, but that's all. No sound, practically no dc voltages. Could this be a power transformer problem?—R.B., Toledo, OH.

Not likely; your tube heaters are fed from the power transformer. Most likely cause, a defective circuit-breaker, diode rectifier, electrolytic capacitor, etc. For quick checking, hook a dc voltmeter to the dc power supply output, then put a jumper across the circuit breaker. We have had some problems with these. (Field Feedback: it *was* a bad circuit breaker.)

CONVERGENCE: LINE? LINES?

The problem I have is in color temperature adjustments with the screen controls. When I set up the horizontal line, the red and green are perfect. But I can't get the blue line down; it's about 1/8 of an inch above. Where can I look for this problem?—L.B., Edison, NJ.

It depends on whether you mean "line" or "lines"! If this is singular, meaning the one line you see in SERVICE position, ignore it! When you set the switch to SERVICE, you kill the vertical output; also, you change the convergence waveforms. So it makes no difference whether the three (single) lines are overlapped or not.

However, if you mean "lines", as in a crosshatch pattern, this *is* misconvergence (NOT color-temperature). If the blue lines are *straight*, and won't come down to cover the yellow (R+G) lines, move them down with the static magnets. You can move the blue in any direction with these. R-E

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COSMOS BURGLER ALARMS
(continued from page 50)

be wired together to meet a specific alarm system requirement. In this case, the alarm is of the auto-turn-off type, and has a 'panic' facility and an intrusion recorder. The system is intended for use with a n.o. exit/entry switch, and the system incorporates an exit-and-entry-delay facility, giving delays of approximately 25 seconds in each mode, and has transient suppression applied to the main sensor network. The system has provision for non-latch activation via n.o. heat-sensing switches, and thus also functions as an automatic fire alarm.

The 'panic' facility is designed around IC2, and the intrusion-recorder is designed around IC4. Both of these sections of the circuit are permanently wired across the supply lines. The auto-turn-off operation is obtained via IC1, and one of the spare gates of this IC is used to provide transient-suppression for the main-sensor network. Finally, IC3 provides the exit-and-entry-delay facility. All four of the IC's used in the system are CD4001AE types. Note that the OFF terminal of key-switch S1 is connected directly to ground, to provide a discharge path for the systems timing capacitors.

(to be continued)

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SERVICING MATV

(continued from page 90)

someone has connected sets directly to coax without benefit of a matching transformer.

Snow. If the snow is throughout the whole system, suspect the amplifier immediately. Snow in a given branch can be caused by water in a splitter or tap-off.

Snow can also be caused by anything from a new building which blocks the antenna, to a defective cable, a bad coax connector, or a TV receiver with a poor front end. You should be able to isolate snow problems with your field-strength meter.

Repairing squipment

Don't waste too much time repairing MATV equipment. Passive devices should generally be discarded rather than repaired, unless the trouble is readily apparent and easy to correct.

Of course, you can't throw away amplifiers, converters and other expensive equipment. You can, however, send them to the manufacturer's repair department.

If you want to repair amplifiers yourself and have the equipment to do it, be careful. To check the frequency response of a single-channel strip, you need a sweep-frequency generator, an RF marker generator, a good scope, and an RF detector. In some cases you may even need an impedance bridge.

Broadband amplifiers are not as tricky, since they are not as frequency sensitive. However, you still have to be careful about moving wires and coils. At TV frequencies, a short piece of wire acts as an inductance and a wire parallel to the chassis acts as a capacitor. Further, parts are sometimes very specialized. You can *not* substitute a standard transistor for one of the same type in most MATV amplifiers. You have to order a selected transistor directly from the MATV manufacturer.

All in all, today's well designed, properly installed MATV systems require a minimum of service. Most troubles are caused by tenant or guest abuse of the system. Since tracking down MATV troubles is relatively easy, servicing MATV systems can be quite lucrative. R-E

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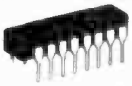

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7416	.39	7483	1.11	74173	1.65
7417	.39	7485	1.39	74175	1.89
7420	.19	7486	.44	74176	1.65
7422	.29	7489	2.75	74177	.99
7423	.35	7490	.76	74180	1.09
7425	.39	7491	1.29	74181	3.65
7426	.29	7492	.79	74182	.89
7427	.35	7493	.79	74184	2.69
7430	.22	7494	.89	74185	2.19
7432	.29	7495	.89	74190	1.59
7437	.45	7496	.89	74191	1.59
7438	.39	74100	1.65	74192	1.49
7440	.19	74105	.49	74193	1.39
7441	1.09	74107	.49	74194	1.39
7442	.99	74121	.57	74195	.99
7443	.99	74122	.53	74196	1.85
7444	1.10	74123	.99	74197	.99
7445	1.10	74125	.69	74198	2.19
7446	1.15	74126	.79	74199	2.19
				74200	7.95

LOW POWER TTL

74L00	.33	74L51	.33	74L90	1.69
74L02	.33	74L55	.33	74L91	1.45
74L03	.33	74L71	.33	74L93	1.69
74L04	.33	74L72	.49	74L95	1.69
74L06	.33	74L73	.69	74L98	2.79
74L10	.33	74L74	.69	74L164	2.79
74L20	.33	74L78	.79	74L165	2.79
74L30	.33	74L85	1.25		
74L42	1.69	74L86	.69		

HIGH SPEED TTL

74H00	.33	74H21	.33	74H55	.39
74H01	.33	74H22	.33	74H60	.39
74H04	.33	74H30	.33	74H61	.39
74H08	.33	74H40	.33	74H62	.39
74H10	.33	74H50	.33	74H72	.49
74H11	.33	74H52	.33	74H74	.59
74H20	.33	74H53	.39	74H76	.59

8000 SERIES TTL

8091	.59	8214	1.69	8811	.69
8092	.59	8220	1.69	8812	1.10
8095	1.39	8230	2.59	8822	2.59
8121	.89	8520	1.29	8830	2.59
8123	1.59	8551	1.65	8831	2.59
8130	2.19	8552	2.49	8836	.49
8200	2.59	8554	2.49	8880	1.33
8210	3.49	8810	.79		

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9002	.39	9309	.89	9601	.99
9301	1.14	9312	.89	9602	.89

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74C02	.55	74C76	1.70	74C163	3.25
74C04	.75	74C107	1.50	74C164	3.50
74C08	.75	74C151	2.90	74C173	2.90
74C10	.65	74C154	3.50	74C195	3.00
74C20	.65	74C157	2.19	80C95	1.50
74C42	2.15	74C160	3.25	80C97	1.50
74C73	1.55	74C161	3.25		

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5262	2048 bit	7.95	HP 5082	
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8038	V cont. osc.	5.95	7405 (5 DIG)	2.95
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2N5198	4.30
2N5202	2.20
2N5294	.70
2N5306	.27
2N5354	.30
2N5369	.25
2N5397	2.90
2N5407	29.00
2N5409	32.00
2N5414	6.50
2N5449	.25
2N5453	5.40
2N5457	.40
2N5458	.40
2N5467	32.00
2N5562	12.50
2N5563	9.00
2N5636	13.50
2N5637	27.00
2N5655	.85
2N5657	1.20
2N5679	1.40
2N5742	41.00
2N5778	.55
2N5923	12.80
2N6027	.50
2N6028	.65
2N6076	.20
2N6099	.95
2N6101	.85
2N6103	.90
2N6155	1.50

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Circle 103 on reader service card

Circle 104 on reader service card

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4004AE	5.85	5.85
4006AE	3.50	3.30
4007AE	.45	.39
4008AE	2.90	2.70
4009AE	.45	.39
4010AE	.55	.54
4011AE	.48	.45
4012AE	.45	.39
4013AE	.45	.39
4014AE	2.80	2.50
4015AE	2.80	2.50
4016AE	.90	.75
4017AE	1.80	1.70
4018AE	2.80	2.60
4019AE	.85	.60
4020AE	2.80	2.60
4021AE	2.20	1.90
4022AE	1.80	1.60
4023AE	.48	.45
4024AE	1.60	1.40
4025AE	.45	.32
4026AE	8.40	7.90
4027AE	.90	.80
4028AE	1.70	1.50
4029AE	2.20	2.00
4030AE	.80	.60
4033AE	3.40	2.90
4035AE	2.00	1.80
4040AE	2.20	2.00
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4043AE	1.20	1.00
4044AE	1.20	1.00
4047AE	3.10	3.00
4048AE	1.45	1.35
4049AE	1.00	.80
4050AE	1.00	.80
4051AE	3.35	2.90
4052AE	2.15	2.05
4053AE	2.90	2.80
4055AE	2.70	2.60
4056AE	3.45	3.41
4060AE	3.30	3.00
4066AE	1.20	1.00
4069AE	.80	.70
4071AE	.45	.38
4076AE	1.70	1.50
4081AE	.45	.39
4510AE	2.00	1.80
4516AE	2.90	2.80
4518AE	3.30	3.00
4520AE	1.90	1.70
4901AE	.45	.38
4911AE	.45	.38

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LM331N:
V_{io} = 6mV
I_{io} = 1000 nA
I_b = 2000 nA
Noise = 1.5dB
$2.20

7400N TTL

7400N	$.14	7444N	$1.05	7496N	$.85	74161N	1.28
7401N	.17	7445N	1.04	74100N	1.30	74162N	1.50
7402N	.14	7446N	1.10	74104N	1.25	74163N	1.48
7403N	.17	7447N	1.00	74105N	.45	74164N	1.70
7404N	.21	7448N	1.00	74107N	.40	74165N	1.78
7405N	.20	7450N	.15	74109N	.92	74166N	1.50
7406N	.35	7451N	.23	74110N	.72	74170N	2.60
7407N	.45	7453N	.20	74111N	.92	74173N	1.55
7408N	.18	7454N	.26	74114N	.92	74174N	1.20
7409N	.23	7455N	.37	74115N	.92	74175N	1.60
7410N	.14	7460N	.25	74118N	1.81	74176N	1.30
7411N	.27	7462N	.37	74121N	.50	74177N	1.50
7412N	.52	7464N	.37	74122N	.50	74180N	1.05
7413N	.72	7465N	.37	74123N	.90	74181N	3.20
7414N	2.25	7470N	.30	74125N	.60	74182N	.75
7415N	.37	7471N	.49	74126N	.64	74184N	2.90
7416N	.37	7472N	.33	74128N	1.32	74185N	2.29
7417N	.37	7473N	.38	74132N	2.06	74188N	4.90
7420N	.17	7474N	.35	74136N	.92	74190N	1.49
7421N	.60	7475N	.60	74140N	2.50	74191N	1.49
7422N	.27	7476N	.45	74141N	1.19	74192N	1.40
7423N	.48	7478N	.55	74145N	1.08	74193N	1.29
7425N	.36	7480N	.60	74147N	2.90	74194N	1.35
7426N	.27	7481N	1.19	74148N	2.20	74195N	.80
7427N	.31	7482N	.90	74150N	.99	74196N	1.90
7428N	.52	7483N	.80	74151N	.84	74197N	.80
7430N	.20	7484N	3.02	74152N	1.50	74198N	2.00
7432N	.29	7485N	2.50	74153N	1.05	74199N	2.09
7433N	.62	7486N	.40	74154N	1.48	74200N	4.90
7437N	.36	7489N	2.40	74155N	1.08	74221N	1.75
7438N	.35	7490N	.60	74156N	1.18	74251N	1.75
7439N	1.05	7491N	1.00	74157N	1.18	74278N	2.95
7440N	.16	7492N	.84	74158N	1.44	74279N	1.10
7441N	.95	7493N	.60	74160N	1.50	74293N	.95
7442N	.90	7494N	1.20			74298N	2.55
7443N	.95	7495N	.80				

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SLA11	Green	3.50
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DL81	Red	6.00
DL10	Red	6.00
DL10A	Red	4.00
DL101	Red	4.90
DL57	Red	9.90
DL61	Red	12.00
DL33	Red	4.00
DL44	Red	6.00
DL402	Red	4.00
DL701	Red	3.40
DL704	Red	2.25
DL707	Red	2.35
DL747	Red	2.50
XCITON		
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- wide viewing angle

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IL16	1.80
IL74	1.35
ILD74	1.75
ILQ74	3.40

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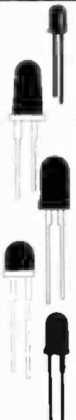

.125" dia.		
209	Red	$.25
209	Yellow	.35
209	Green	.35
.160" dia.		
216	Red	.25
216	Yellow	.30
216	Green	.30
.200" dia.		
220	Red	.25
220	Yellow	.30
220	Green	.30
LOW PROFILE		
226	Red	$.25
226	Yellow	.30
226	Green	.30
226	Orange	.30
5053	Red	.35
5053	Yellow	.40
5053	Green	.40
5053	Orange	.40

216 = MV5024
5053 = MV5053

MV50 Red $.30

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2602-18	8.00
2602-2B	8.00
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7552-1CPE	8.00
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74LS

74LS00	.58	74LS76	.92
74LS01	.58	74LS78	.92
74LS02	.58	74LS107	.92
74LS03	.58	74LS109	.92
74LS04	.63	74LS112	.92
74LS05	.63	74LS113	.92
74LS08	.58	74LS114	.92
74LS09	.58	74LS138	2.38
74LS10	.58	74LS139	2.38
74LS11	.58	74LS151	2.10
74LS15	.58	74LS153	2.38
74LS20	.58	74LS157	2.10
74LS21	.58	74LS158	2.40
74LS22	.58	74LS160	2.70
74LS27	.64	74LS161	2.70
74LS30	.58	74LS170	5.92
74LS32	.64	74LS174	3.02
74LS51	.58	74LS175	2.90
74LS54	.58	74LS181	3.72
74LS55	.58	74LS251	2.55
74LS73	.92	74LS253	3.05
74LS74	.92	74LS260	.58

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9308PC	2.50
9309PC	1.60
9310PC	1.50
9311PC	2.30
9312PC	1.20
9314PC	1.30
9316PC	1.50
9318PC	2.30
9321PC	1.20
9322PC	1.30
9324PC	2.00
9328PC	2.50
9334PC	2.95
9338PC	3.30
9340PC	5.00
9341PC	4.10
9342PC	1.15
9360PC	1.75
9366PC	1.75

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1N4004	1.30	10.00	90.00
1N4005	1.40	11.00	100.00
1N4006	1.50	12.00	110.00
1N4007	1.60	13.00	120.00

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LM567CM Mini-dip 2.10

DECODED READ/WRITE RAM

P1103 $6.20

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SCHOTTKY TTL

74S00N	.45	74S74N	1.30	74S158N	2.40
74S02N	.80	74S85N	6.10	74S160N	4.70
74S03N	.75	74S86N	2.70	74S161N	4.70
74S04N	.75	74S112N	2.20	74S174N	3.30
74S08N	.80	74S113N	1.50	74S175N	3.30
74S10N	.75	74S132N	3.60	74S181N	10.20
74S11N	.65	74S133N	.90	74S189N	5.10
74S20N	.80	74S138N	2.40	74S194N	3.30
74S30N	.80	74S139N	2.40	74S195N	3.30
74S32N	.80	74S140N	.90	74S251N	2.40
74S40N	.80	74S151N	2.40	74S253N	2.40
74S51N	.80	74S153N	2.40	74S257N	2.40
74S64N	.80	74S157N	2.40	74S258N	2.40
				74S260N	.90
				74S280N	5.70

LOW POWER TTL

74L00N	.34
74L02N	.34
74L03N	.39
74L04N	.39
74L10N	.34
74L20N	.39
74L42N	1.62
74L51N	.34
74L73N	.74
74L74N	.89
74L90N	1.62
74L93N	1.74
74L95N	1.62
93L00	1.50
93L01	1.60
93L08	3.20
93L09	1.80
93L10	2.80
93L11	4.20
93L12	1.80
93L14	1.70
93L16	3.20
93L18	3.50
93L21	1.50
93L22	1.80
93L24	2.80
93L28	3.70
93L34	4.00
93L38	4.20
93L40	6.50
93L41	6.50
93L60	3.00
93L66	2.70

HIGH SPEED TTL

74H00N	.34	74H53N	.36
74H01N	.34	74H54N	.36
74H04N	.38	74H55N	.36
74H05N	.37	74H60N	.36
74H08N	.40	74H61N	.36
74H10N	.36	74H62N	.36
74H11N	.36	74H71N	.80
74H20N	.36	74H72N	.74
74H21N	.36	74H73N	.90
74H22N	.36	74H74N	.87
74H30N	.36	74H76N	.90
74H40N	.36	74H101N	.80
74H50N	.36	74H102N	.80
74H51N	.36	74H103N	1.10
74H52N	.36	74H106N	.95

AUDIO AMPS

Type	V	W	Ω	Price
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TAA611B12	6-15	1.15	8	1.60
TAA621A12	6-27	1.40	8	2.00
TBA641B11	6-18	2.20	4	3.00
TBA800	5-30	4.70	8	2.20
TBA810AS	4-20	2.50	4	3.00
TBA820	3-16	0.75	4	1.70
TCA830	5-20	2.00	4	2.20
TCA940	6-24	6.50	8	4.40

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14 pin DIL	.26
16 pin DIL	.29
24 pin DIL	.75
28 pin DIL	1.10
36 pin DIL	1.70
40 pin DIL	1.90
WIRE WRAP-GOLD	
14 pin DIL	.40
16 pin DIL	.45
SOLDER - GOLD	
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16 pin DIL	.40
TEFLON	
3 pin TO-5	.55
4 pin TO-5	.65
6 pin TO-5	.90
8 pin TO-5	1.10
10 pin TO-5	1.40

75107

75107BN	2.60
75108BN	2.30
75109N	2.20
75110N	2.20
75115N	2.25
75138N	2.95
75150N	3.10
75154N	4.10
75208N	2.70
75234N	2.50
75450N	1.25
75451N	1.00
75452N	1.00
75453N	1.00

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7520N	4.00
7521N	2.00
7522N	4.25
7523N	1.75
7524N	2.00
7525N	4.50

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H=TO5 N=DIP M=MINI-DIP D=CER-DIP K=TO3

LM114H	3.00	LM311H	1.70	LM711CN	.90
LM300H	1.20	LM311D	1.90	LM715CH	4.30
LM300N	1.20	LM311M	1.75	LM715CD	4.60
LM301AH	.90	LM311N	2.00	LM723CH	.90
LM301AM	.80	LM312H	2.70	LM723CN	.75
LM301AN	1.10	LM318H	2.60	LM725CH	5.00
LM301M	.90	LM324N	1.90	LM725CD	5.20
LM301H	.90	LM331N	2.20	LM733CH	1.40
LM302D	3.50	LM339N	3.20	LM733CD	3.50
LM302N	1.30	LM320-5K	2.90	LM733CN	1.30
LM302H	1.50	LM320-5T	2.50	LM741CH	.45
LM304H	1.50	LM320-12K	2.90	LM741CD	1.25
LM305H	1.05	LM320-12T	2.50	LM741CM	.44
LM305AH	1.05	LM340-05K	2.60	LM741CN	.70
LM305N	1.00	LM340-06K	2.60	LM747CH	1.70
LM306H	.95	LM340-08K	2.60	LM747CN	.90
LM307H	.75	LM340-12K	2.60	LM747CD	2.50
LM307M	.95	LM340-15K	2.60	LM748CM	.55
LM307N	1.50	LM340-18K	2.60	LM748CN	.55
LM308H	1.20	LM340-24K	2.60	LM777CH	2.15
LM308AH	5.00	LM555CM	.90	LM777CM	2.10
LM308D	2.00	LM556CN	1.30	LM3046CN	.95
LM308M	1.20	LM709CH	.45	LM3054CN	1.50
LM309H	1.75	LM709CN	.45	SG4501T	2.20
LM309K	1.95	LM710CH	.90	SG4501N	2.20
LM310H	1.60	LM710CN	.90	LM5000K	7.50
LM310M	1.80	LM711CH	.90		

2524V

Recirculating 512 Bit Dynamic Shift Register
1—24: $3.90 25 up: $3.80

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1404AH	8.00	2524V	3.90
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MM

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MM507H	3.20
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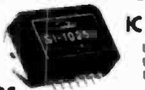
MM551H	5.60
MM555H	5.60

HYBRID Power AMPLIFIERS



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BU206	3A	1700V	5.94
BU207	6A	1300V	5.85
BU208	6A	1500V	6.93
BU209	6A	1700V	8.64

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STR, BSC, bi-sync and interleaved bi-sync modes of operation ● fully programmable ● full or half duplex operation ● fully double buffered ● directly TTL compatible ● high speed operation ● low power

PRICE:	1-9	10 up
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9614PC	2.30
9615PC	2.40
9616DC	5.00
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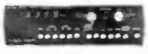
9621PC	4.00



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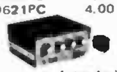

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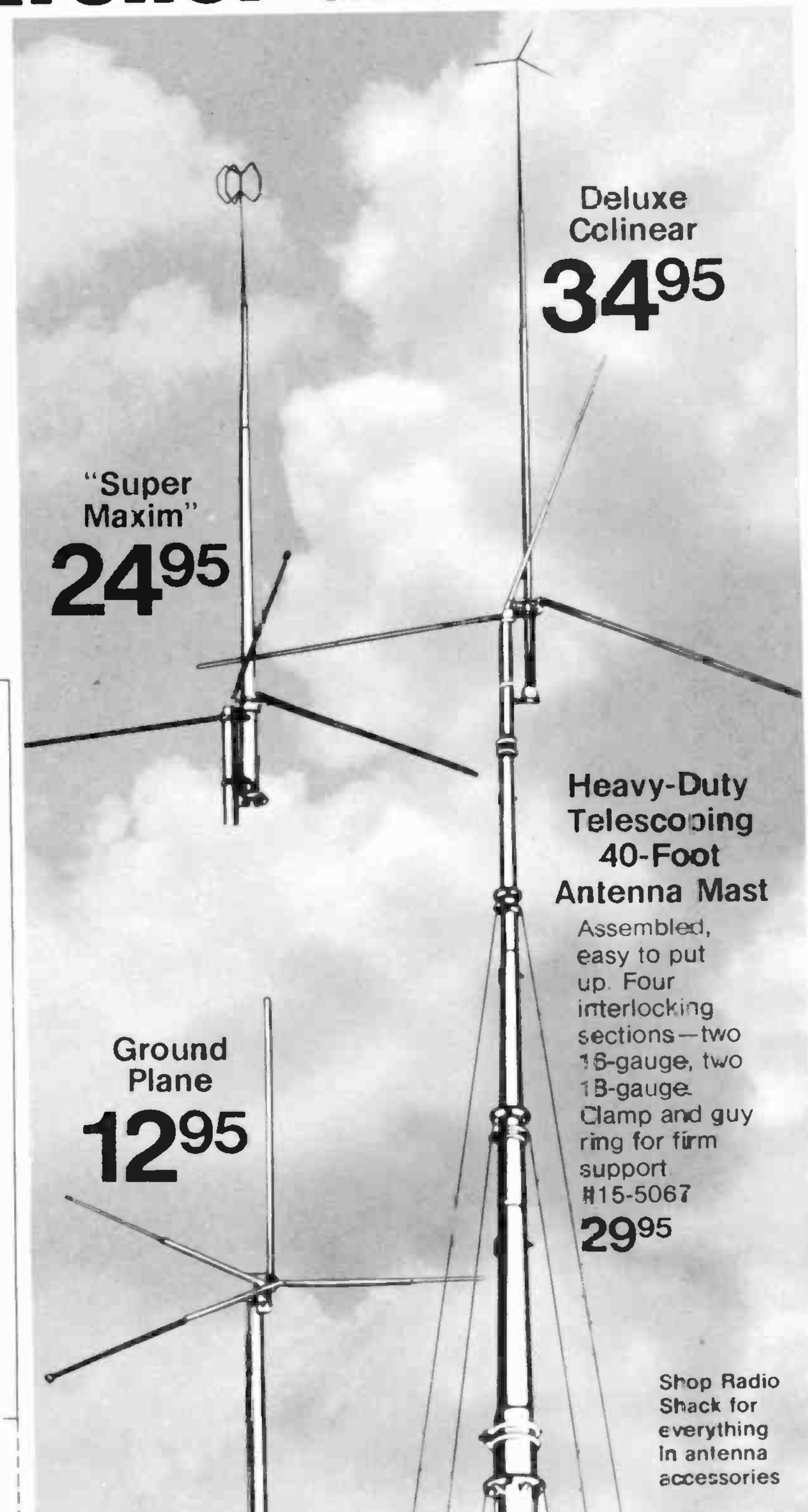

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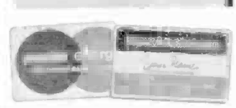

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