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A GERNSBACK PUBLICATION

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More than 65 years of electronics publishing

DECEMBER 1974 Vol. 45 No. 12

SEASON'S GREETINGS

The editors and staff of Radio-Electronics join in sending holiday greetings and our best wishes for a happy new year

Cover photograph by Walter Herstatt
Cover design by Louis G. Rubsamen

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looking ahead

Better TV sound

Network television will have a 15-kHz audio bandwidth in about two years. That's a promise from AT&T, which says it may also squeeze in a second sound channel for stereo or as an alternate foreign-language track. AT&T, which handles intercity transmission of television, currently provides the same 5-kHz sound for TV as it does for AM radio. After much experimentation, the telephone company now is on a crash program to choose a method of transmitting sound along with the video signal, instead of on a separate narrow-band audio line.

A subcarrier system will be used, and three different methods are currently under test. In one recent test, a wideband stereo signal was sent from New York to Los Angeles and back on a video channel, and, according to a top AT&T engineer, expert listeners couldn't tell the difference between the original signal and the one which has crossed the continent twice.

No matter how much the television sound signal is improved, it won't make much difference to the viewer unless receiver sound systems can pass them along. An industry-wide engineering committee, studying the entire subject of TV sound, concedes that it hasn't gotten very far with the manufacturers, but hopes that availability of better sound on telecasts will inspire them. An EIA panel, meanwhile, is exploring the subject of stereo sound with television manufacturers. One problem may well crop up if sound is improved substantially. Although the television signal can accommodate a high-fidelity sound channel, many existing TV sets—designed for the present limited and compressed sound signal—would be brought to the point of unintelligibility. Therefore, some thought is being given to a pilot-signal or companding system for sound compatibility with both cheap lo-fi and the hoped-for future hi-fi receivers.

Philips buys Magnavox

The worldwide electronics giant with the mouthful of a name—N. V. Philips' Gloeilampenfabrieken—has purchased controlling interest in the Magnavox Company through its American affiliate, North American Philips. The Netherlands-based parent company, considered the world's largest manufacturer of consumer electronic products, is a technologically based firm that is also strong in computers, components, picture tubes, chemicals, lighting and appliances. Philips products in the past have received exposure in the U.S. under the Norelco brandname, and more recently Philips-brand audiophile products have entered this country. Philips is expected to continue the Magnavox brand here, at the same time strengthening Magnavox's technology and marketing.

Philips' acquisition of an American television manufacturer at this time is especially significant in terms of the upcoming battle of videodisc standards. Philips is the developer of the major optical videodisc system, that it has demonstrated throughout Western Europe to wide acclaim. A version of this system designed for the NTSC color standards was recently demonstrated in Japan, and Philips has announced that the home player probably could be built to sell for less than $500 on the Japanese and American markets. Magnavox apparently will be the American launching pad for the Philips Video Long Play (VLP) disc system, that is scheduled to reach the market in 1976.

Philips' purchase of Magnavox could lead to a confrontation with RCA over videodisc standards. RCA has developed a capacitance-storage videodisc system, that also is tentatively scheduled for 1976 marketing. Both RCA and Philips are expected to attempt to license other manufacturers. Since the two systems are incompatible, you can expect to witness strong campaigns of competitive claims—reminiscent of the 45-vs-33 rpm phonograph battle. This time, even more is at stake, since it's widely believed the videodisc market will eventually be bigger than television itself.

Home VTR again

Somewhat eclipsed by all the talk of videodiscs is the videotape recorder for the home. The latest candidate for consumer do-it-yourself video was developed by Germany's BASF and is the first longitudinally-scanned VTR to be announced in 10 years. The fixed-head unit uses a relatively tiny (4.6 x 4.3 x 0.6 inch) single-reel cartridge containing ¼-inch chromium-dioxide tape. The tape has 28 parallel longitudinal tracks. Running at 120 ips, each track is scanned in sequence, the tape changing direction at the end of each track. The turnaround time is only 80 milliseconds, virtually unnoticeable. Cartridges of 90 minutes and two hours are planned. Tentative introduction date is late 1976. The principle of longitudinal scanning was described in this column in July.

Several other home VTR's may be introduced in 1975. RCA has completed in-home testing of consumer video recorders and is expected to have one on the market next year—although the exact configuration isn't yet certain. Sony, whose U-Matic videocassette system has been the most successful type in the industrial and institutional markets, is also scheduled to premiere its home version in 1975. In Japan, Toshiba and Sanyo have jointly developed a "home" videocassette system using ½-inch tape, now going into limited production and also destined eventually for the American market. While standardization is considered important in the playback-only videodisc field, it may not be a major problem in VTR—since it's expected that videotape will be mainly a record-it-yourself medium.

Muntz's projection TV

Remember Earl "Madman" Muntz, who became the leading purveyor of low-priced receivers in television's early days and later introduced stereophonic tape to the automobile? He's back in TV and he aims to be part of that incipient projection TV boom we described in October. Muntz is co-founder of Muntz-Elman Manufacturing, Inc., which is assembling the "Muntz Home TV Theatre" in Van Nuys, Cal. The Home Theatre is the first projection color TV to be offered as a single-piece furniture-styled home unit. It's mounted in a walnut-finished cabinet 54 inches wide, 25 inches deep and 36 inches high, topped by a 30-by-40-inch Kodak Ektalite aluminum reflective screen. When the set is put into use, a drawer is pulled out, and a lens and mirror system throws the picture on the screen.

The electronic part of the projection TV system is a modified Sony 15-inch remote-control color set, which is mounted in the drawer, screen upwards. The projected picture, like others which use a three-color tube as the light source, must be viewed in a darkened room. Muntz is producing sets at the rate of about 200 a month and currently is selling them only in a few areas, but hopes eventually to have nationwide distribution. The price? It's $1,995.

by DAVID LACHENBRUCH
CONTRIBUTING EDITOR

new & timely

Low-priced music for the masses supplied by "anti-profit" shop

Because they "didn't want to see a society without music," four Washington women have opened what they call "an anti-profit enterprise" to sell phonograph records at phenomenally low prices, reports the *Washington Post/Potomac.*

Named "Bread and Roses" after a line in an old worker's song, the new establishment markets records of African music, blues, folk and rock at about a 9 per cent markup.

Used LP's are also sold on consignment, at prices ranging from 25 cents to $2, depending on the record and its condition. *Bread and Roses* also sells records to its customers for taping (a perfectly legal process if the tape is for the customer's personal use). If returned in mint condition, the records are repurchased by the store at 70% of the original price, and resold at a discount. As an example, a "taped" Allman Brothers double album sells for $3.70.

Other original features of the Washington store include a newsletter, a musicians' clearing-house, and a community bulletin board.

Equipment out of warranty? New device will tell when

A warranty is designed to protect a purchaser from innate defects or short life in the equipment he buys. But the 90-day, 1-year or even 2-year warranty often fails to protect, simply because time does not indicate usage. One television set is in use a minimum of 10 hours per day, 365 days per year (except for Leap Year). Another is used about 2 hours an evening most evenings. The first customer's pix tube fails near the end of the second year, and the manufacturer accepts full responsibility. The second set runs one day over the two years, and the warranty is useless. Yet tube No. 1 has operated for more than 5000 hours and tube No. 2 has run less than 1500!

North American Philips Controls Corp. has just come out with a device that may be able to even out such difficulties. Somewhat reminiscent of gadgets that were introduced in the early days of hi-fi to measure the length of time a stylus had played, it shows how long a piece of equipment *has been in actual use.* It can be used on all types of appliances, from the lightest up to and including air conditioners.

Called an elapsed-time indicator, the device is an inch-long glass tube with metal caps. As long as current runs through it, copper builds up at one end, at a precise rate. Installed in new equipment by the manufacturer, it would cost about $1, Philips believes.

Philips has not as yet installed indicators in any appliances, but indicates interest by the very action of developing such an indicator. A spokesman for another appliance manufacturer—Whirlpool—also expressed interest and suggested that his company had also considered a similar idea.

Three persons are inducted into NESDA's Hall of Fame

At its Hall of Fame banquet, held during the recent annual convention in Hawaii, the National Electronic Service Dealers Association (NESDA) elected three persons to the Association's Hall of Fame. Two of the elevations were posthumous:

Hugo Gernsback, publisher, editor, author, inventor and lifetime champion of the service technician and the amateur. He founded the first radio magazine, **Modern Electrics,** in 1909, and subsequently the first service organization, the Official Radio Service Men's Association (ORSMA). Later he started **Radio News,** and in 1929, **Radio-Craft,** which is now **Radio-Electronics.**

SPARK MATSUNAGA, US CONGRESSMAN FROM HAWAII, flew from Washington to address the Hall of Fame Banquet. He is seated at the extreme left. Next to him is Emmett Mefford, CET, chairman of the Electronics Hall of Fame. Standing is Harvey Sunada, who coordinated the convention. He is receiving a special recognition award from Dick Glass CET, NESDA's executive vice president (behind lectern) for his work during the 11-day affair. At right is C. Bryson Bush, HTSA, the owner of Bush Electronics, Honolulu.

Paul G. Lecoy, Sandusky, OH, a service dealer who during his life had been active in many Ohio trade asssociation activities. He had served as an officer of both NATESA and NEA.

Vincent J. Lutz, CET, St. Louis, MO. now 69 years old, Mr. Lutz has been in electronics 44 years, and has long been active in both state and national service technician's organizations. He is now the publisher of the Electronics Industry Yearbook and Director of Special Events for NESDA.

(continued on page 12)

A BASIC PATENT covering miniature calculators having their main electronic circuitry in a single chip has been issued to Texas Instruments, Inc. The model is shown holding (at left) the world's first mini-calculator that contained the equivalent of thousands of discrete devices. It was the first mini-calculator at the time to have the high degree of computational power found only in large machines. The 1974 version (still smaller) is the one at the right.

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Color TV repair is another big opportunity field right now and NRI can train you at home to service and repair any color or black & white TV, hi-fi equipment, AM-FM radios, and sound systems. You can choose from 5 courses, starting with a basic servicing course with 65 lessons . . . up to a Master Color TV course, complete with 25″ diagonal solid state color TV in handsome woodgrain cabinet. No other school offers so many choices or so much value.

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new & timely *(continued from page 6)*

Featured speaker at the Hall of Fame banquet was the US Congressman from Hawaii, Hon. Spark Matsunga.

Gernsback Scholarship winners

Winner of this months 1974 Hugo Gernsback Scholarship Award, a prize of $125 granted annually to the most deserving student in each of eight leading home-study electronics schools, is James Michael Kupchik, of Louisville, KY. A

Michael Kupchik

Frank Fitzgerald

graduate of Valley High School in 1963, he joined the Air Force in 1964, working in guided missiles, and later worked on government contract Autovon Systems.

His contacts with electronics inspired him to refresh his knowledge of that subject. At the same time, he wished to learn something of color television for his own use. Mr. Kupchik therefore enrolled in the GTE Sylvania Home Study Master Color TV Servicing Program in June 1970 and graduated with an equivalent A average in December 1973. He is now working at South Central Bell Telephone Co. on data systems and private line services.

Runner-up and winner of the second award, an RCA WV-529A service special VOM, donated each month by RCA, is Frank Fitzgerald, 44, of the Bronx, NY.

He says:

"Being a school bus driver for mentally retarded children presented the time and the opportunity to increase my knowledge of electronics, and I enrolled in the Basic Electronics program. Having completed my course, I feel a great sense of accomplishment. I find it easy to understand, condensed, and to the point. I am looking forward to enrolling in one of the more advanced career courses."

Electronic proofreader catches most typographical errors

A computer program designed to assist in detecting typographical errors before they appear in print has been devised by two Bell Labs researchers, Robert Morris and Lorinda L. Cherry.

The manuscript is first typed into a computer, which breaks down each word into all possible two and three-letter segments, then compiles a table showing how often each segment appears in that document. The table varies with each piece of material, since it depends on the kind of words used in the particular manuscript.

The computer then looks up each word in the document and compares its combinations of letters with those in the table. It then assigns a number from 0 to 20 to each word, as an "index of peculiarity," depending on the relative rarity of the letter combinations.

The "peculiar" words are then displayed on a tube or typed out on a list, with those having the highest peculiarity index at the top. Of course, many perfectly correct words that contain uncommon combinations may appear on the list. (For example, a word with the letter "q" not followed by a "u" would almost certainly be printed. Yet the dictionary shows at least 18 words beginning with "q" with a letter other than "u" following it.) Semantic nonsense or missing lines are also undetectable.

The human proofreader then simply scans the list and corrects the errors, at a great saving of time. In one case, a 20,000-word document was examined by the computer in 3 minutes. The author then needed less than 10 minutes to correct 30 misspellings—23 of them in the first 100 words on the list.

NESDA elects new officers

The 1974/75 officers of the National Electronic Service Dealers Association, elected at the Honolulu convention, are:

President, **Charles R. Couch, Jr.**, CET, Gainesville, FL; Senior Vice President, **Leroy Ragsdale**, CET, Fort Smith, AR; Secretary, **Virgil Gaither**, CET, Los Angeles, CA; Treasurer, **Jack Kelly**, CET, Litchfield Park, AZ. **Richard L. Glass**, CET, remains as Executive Vice President.

The regional vice presidents are: Region 1: **Norman Smith**, CET, West Hartford, CN; Region 2: **Warren Baker**, CET, Albany, NY; Region 3: **John McPherson**, CET, Yorktown, VA; Region 4: **Tom Ruth**, CET, Charlotte, NC; Region 5: **Gerald J. Hall**, Milwaukee, WI; Region 6: **George Simpson**, Ft. Worth, TX; Region 7: **Charles Varble, Jr.**, St. Ann, MO; Region 8: **Paul Dontje**, CET, Wheatridge, CO; Region 9: **Jim Rolison**, Portland, OR; Region 10: **Everett O. Pershing**, Burbank, CA.

Officers for the International Society of Certified Electronic Technicians (ISCET) were also elected at the Convention. They are: Chairman, **Larry Steckler**, CET (Editor of Radio-Electronics) New York, NY; Vice Chairman: **Bob Cook**, CET, Garden Grove, CA; Secretary, **Gordon W. Turnbull**, CET, Winnipeg, Canada; Treasurer, **Jesse B. Leach, Jr.** CET, Linthicum, MD.

THIS AWARD TO LARRY STECKLER, Editor of Radio-Electronics, was voted to him at the annual convention of NATESA, the National Alliance of Television and Electronic Service Technicians, in Chicago last August.

Awards to outstanding members voted at NESDA convention

At its first annual convention, held in Kauai, Hawaii, the following awards *(continued on page 14)*

Jerrold's new Universal TV Remote Control

The Hottest New Product Since The Calculator...

- ■ **Makes every set on your floor a remote control model**
- ☐ Universal— Attaches to any set in minutes
- ☐ Changes channel instantly and fine tunes
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MIDWESTERN OFFICE 1334 Atlantic Street, North Kansas City, Mo. 64116, (816) 842-1555

Circle 5 on reader service card

new & timely

(continued from page 12)

were made to members who had rendered more than ordinary service to the organization:

Man of the Year: Leslie J. Nesvik, former director of education for NESDA, for his work in organizing and conducting business management schools all over the country during the past year.

Outstanding Officer: Charles R. Couch, Jr., CET, President of NESDA, for his industry and government work during the past year.

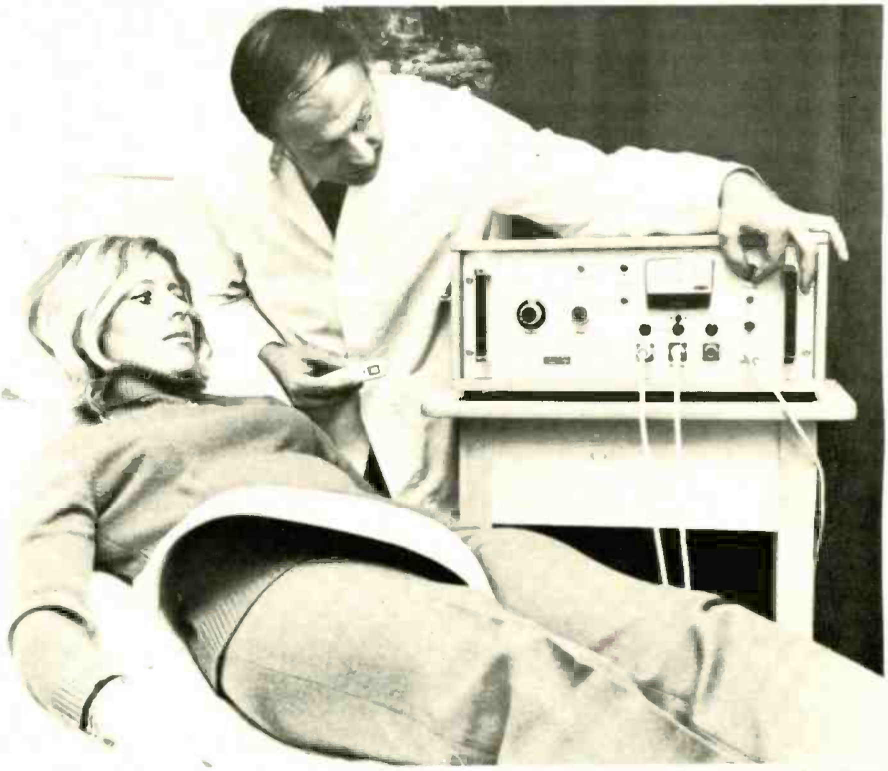
Outstanding State President: (the Hal Chase memorial award): John P. Kelley, CET, past president of the Arizona State Electronics Association (ASEA).

Outstanding Committee Chairman: Norris R. Browne, CET, who chaired the nominations committee, the Texas Electronics Association state convention and the NESDA awards committee, after chairing the NESDA merger committee for a year.

Outstanding Local Association President (the Jack Betz memorial award): Frank Grabiec, CET, president of the Maricopa chapter (Phoenix, AZ) of ASEA.

Outstanding State or Regional Periodical: The Arkansas *Anode*, state publication edited by Bill Childs of Little Rock, Arkansas. (Two runnerup publication award certificates were also awarded this year: one to the *VEA Reporter*, edited by W. H. Harrison of Norfolk, VA; the other: *Channel 1 Newsletter*, edited by Vincent J. Lutz, CET, St. Louis, MO.

MEMBERS OF HTSA (HAWAII TELEVISION SERVICE ASSOCIATION) meet and greet NESDA and ISCET as the delegates arrive at Honolulu Airport. ISCET held special sessions at the Kuilima Hotel on Oahu. Larry Steckler, CET, Editor of Radio-Electronics, was elected chairman of ISCET for the 1974-75 term, and Gordon Turnbull, CET, Winnipeg, Canada, was elected the new secretary.



A.C. HELPS BROKEN BONES TO HEAL. The broad white band around the young lady's thigh is a transformer primary. The secondary is an "electric nail" or metal core with a magnetic winding, inserted into the broken bone. The induced current is in the order of microamps. The scene is the Kreiskrankenhaus (County Hospital) in Garmisch Partenkirchen, Bavaria.

"Learn an honest trade," my old man used to say, "and you'll never have to knuckle under to any man."

(A TRUE STORY)

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- ☐ FCC Licensing
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- ☐ Engineering
- ☐ TV Servicing
- ☐ Electronics
- ☐ Automotive
- ☐ Drafting
- ☐ ICS High School Diploma or Equivalency
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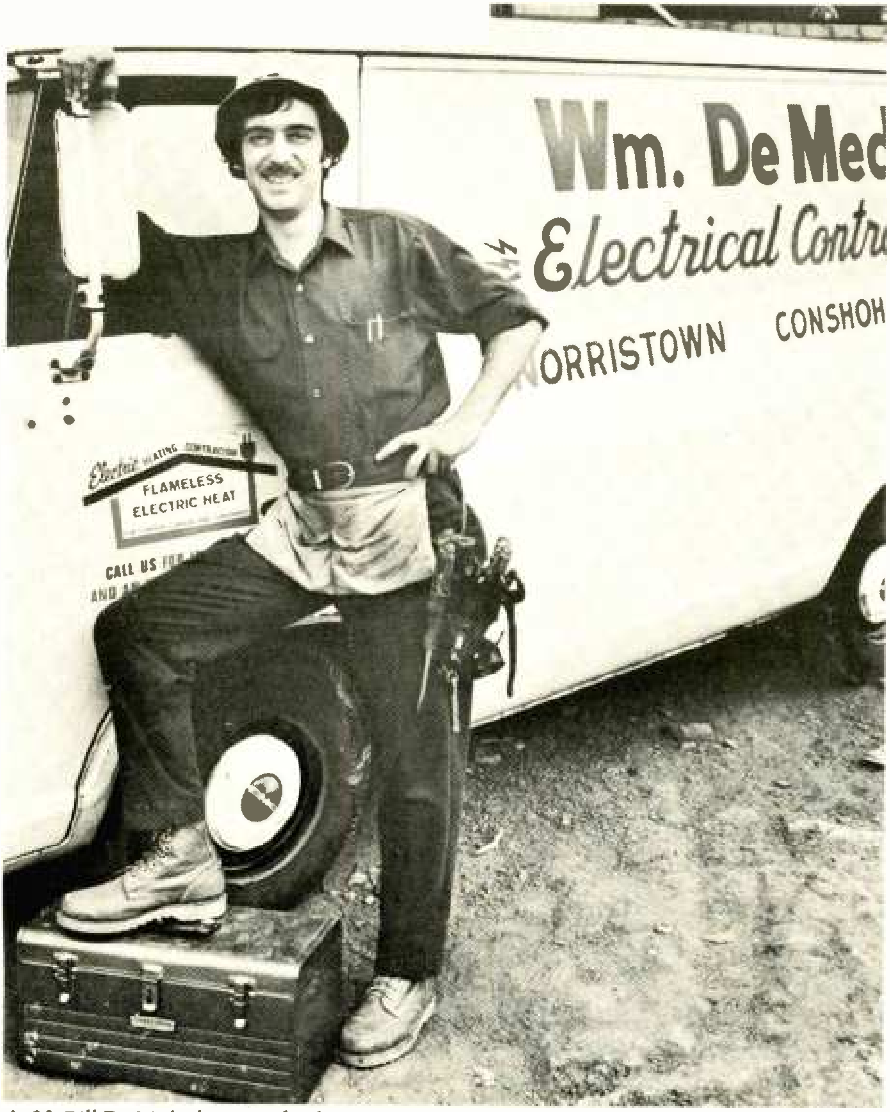


At 23, Bill De Medio has more freedom, more security, and gets more respect than guys twice his age. (Photograph by Frank Cowan.)

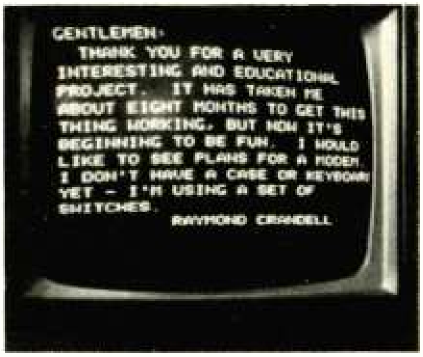
Circle 7 on reader service card

letters

TV TYPEWRITER COMMENTS

Finally! I started ordering parts for my TV Typewriter as soon as I received the booklet in September and got it working in June.

Construction was straightforward and I had few problems. I had a few solder bridges that caused trouble, but they were my own fault. I left the plastic spacers on when I soldered the connec-



tor pins, then pushed them up close to the board with a vise. I had trouble with the Zener-regulated negative supplies so I scrapped them and used LM-320 series regulators instead. I blew out one section of the video combiner (trying to use the self-test on something around −12V, I think) so I bridged across to the unused section and it's still working that way. I have both pages working, but only one at a time because I have only one 7406 clock driver. I used Molex pins for all IC's.

I had a lot of trouble with the 2524's in the main memory. I bought a total of 26 and got just 12 that work properly. Most of the rest seem "slow"—they won't accept information at the rate required but will at a slower rate.

I just finished up CIE's course in Electronics Technology and got my FCC First Class License in June. I consider building the TV Typewriter a valuable extension of my knowledge in digital electronics and well worth the cost. Thank you again for your excellent article.

RAYMOND CRANDELL
Oakdale, CA

ANOTHER TV TYPEWRITER

I have enjoyed R-E very much and have read it for many years. I have completed the recent TV Typewriter and I am now on the Mark-8 minicomputer. It

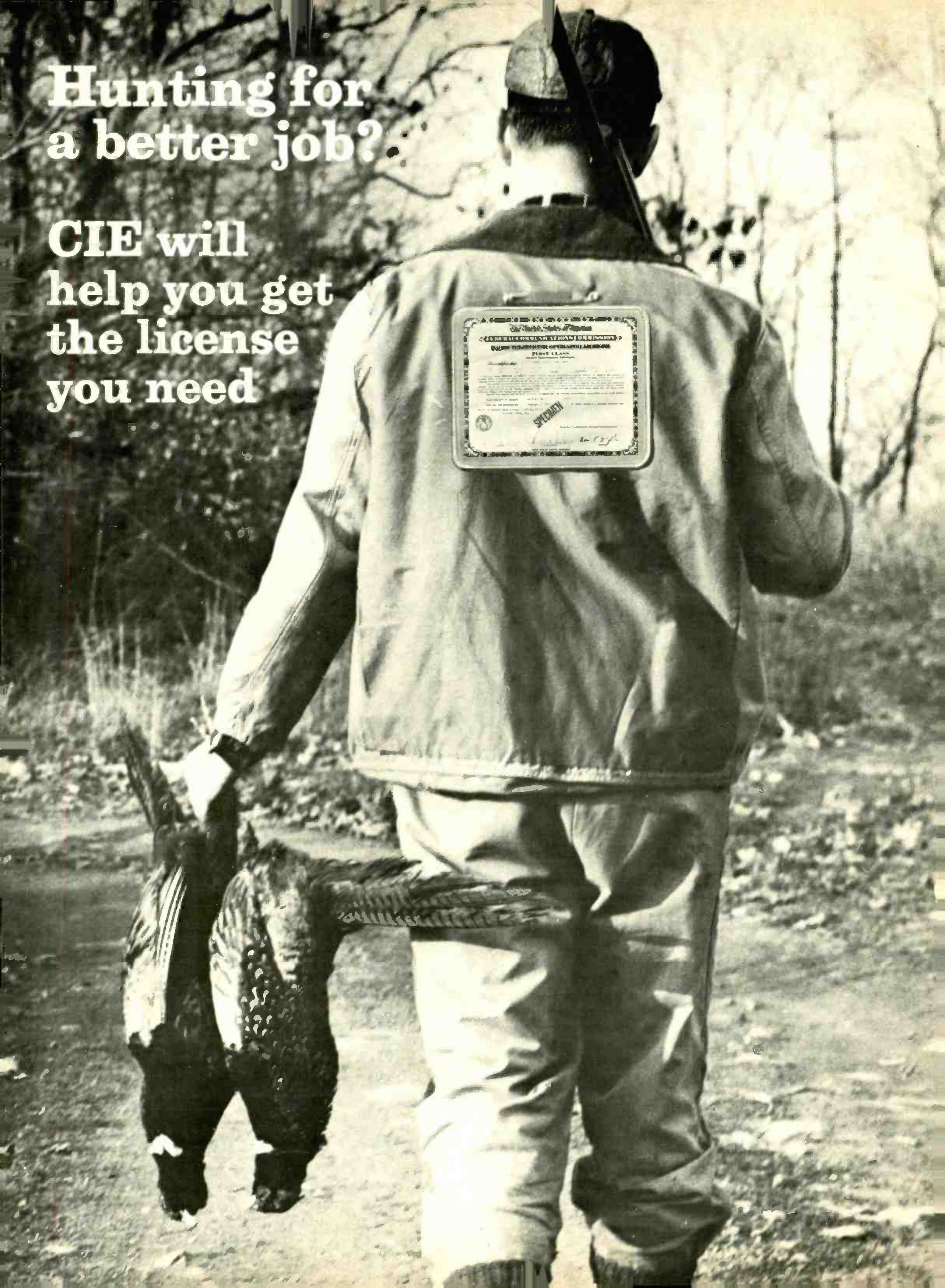
is very interesting, but getting parts up here is like looking for "hen's teeth." Duty on expensive parts also bugs me.

F. G. STONE
Ontario, Canada

MINICOMPUTER ANSWERS

Thank you for the latest batch of readers' letters. Some of the questions have *(continued on page 22)*

Circle 9 on reader service card


Hunting for a better job?
CIE will help you get the license you need
FEDERAL COMMUNICATIONS COMMISSION
FIRST CLASS
SPECIMEN

LETTERS

(continued from page 16)

been asked and answered in my other letters to you. The one point that they seem to pick up is that the connections should not be made between pins 9 through 16 between the Input Multiplexer Module and the Address/Manual Module.

This should be included as soon as possible to prevent problems with operation of the computer.

Other answers are as follows:

1. Booklet page 6, fourth paragraph, last line should be: On the following boards, install the B jumpers and only resistors R1-R4 and R21.
2. Connections are made to the Molex 09-52-3081 connectors with stripped leads or male connectors Molex 09-64-1081.
3. The Interrupt Switch register is now the only source of interrupt instructions. An external encoder could be used and bussed with the switches, but this would require external circuitry as shown in the booklet.

One reader, Stephen L. Diamond, expressed interest in forming a Mark-8 software users group. That's fine with me if he wants to do it. You can suggest that readers and builders contact him direct at 311 Carl Street, San Francisco, CA 94117.

Most of the other questions are trivial. I should have a final calculator PC layout soon and I have been giving some serious thought to using one of the new Intel 8080 chips which is more powerful than the 8008.

I also have a cassette unit and a small calculator-type printer ready to be hooked up to my Mark-8.

JONATHAN A. TITUS

MORE MEMORY

I've just received your complete instructions for the Mark-8 minicomputer and not being well versed in the construction or operation of computers, I'm confused on a point you might help me clarify. On page 2, you indicate that the microprocessor can directly address up to 16,424 words of 16K; however, on page 3, you state that the Mark-8 may be used with up to four memory modules for a maximum of 4K of storage space. Why is the storage space only one-fourth of the addressable capacity of the microprocessor? Is it possible to add on more than four memory modules?

In any case, this is the most exciting project I've seen in a long time and I fully intend to build it and the TV Typewriter. I would greatly appreciate a reply to this letter.

BRUCE E. BLAKESLEE
Scotch Plains, NJ

While the Intel 8008 microprocessor chip can directly address up to 16K of memory, using the memory printed circuit boards for the Mark-8, only 4K may be used. This keeps costs down for small systems by using the 1101 type RAM. Other types of memories may be used since the read/write signal is available as are the 14 address lines: D0-D7, A, B, C, D, A12 and A13. These may be used to add up to the 16K memory.

Larger memories may be built using cassette units or external shift registers, etc., but most systems don't require more than 4K.

JONATHAN A. TITUS

MINICOMPUTER PARTS

Concerning the Mark-8 minicomputer article, I have found a couple of sources of supply for a couple of the parts which might be of value to your readers.

The Molex connectors are once again available from Force Electronics, 343 South Hindry Avenue, Inglewood, CA 90301. The price is 35c each for Molex number 09-52-3081.

If any one has trouble locating the 8263 and 8267 IC's, they are available for $5.00 and $2.00 respectively from one of your advertisers: James Electronics, P.O. Box 822, Belmont, CA 94002.

DENNIS E. CRUNKILTON
Mare Island, CA

REPLACEMENT IC's A PROBLEM

I have a problem which I am sure other repair shops have also had on occasion to come across at one time or another. Maybe your staff could answer me or it could be made into an article in the future.

Quite a few times I have had to replace integrated circuits, but have been unable to find listings for a replacement. For example, I recently had a set which needed an IC replaced and it was manufactured by General Electric. However, it was not listed in the current GE catalog. I wrote to GE to find out where I could obtain this particular part and they advised me as follows:

". . . General Electric Company is no longer a manufacturer or supplier of integrated circuits. This product line was discontinued some time ago. Other companies have purchased the right to manufacture most of the original GE types, however, some of these have never been manufactured since GE discontinued operations on this product. Some replacements are available, however, in many cases the only available units must come from some surplus parts supplier . . ."

I think this is a bad situation. A company, not only GE, makes parts, discontinues them and a repair shop gets a unit which needs one of these discontinued parts to be replaced and he is stuck. I know, myself, that I can't afford to spend months and months trying to locate a surplus parts supplier. I try to repair my sets as soon as possible—not make the customer wait indefinitely while I try to obtain discontinued parts. At least if a company discontinues parts, they should have a cross-reference to equivalent parts.

LOUIS P. FOSHAY
Pomona, NY **R-E**

IN THIS ISSUE

If new electronic circuits turn you on, don't miss the article on the new Magnavox TV remote-control system —it's different, it's digital, it's on page 44.

Now make almost all your replacements with RCA's medium-priced Colorama A's

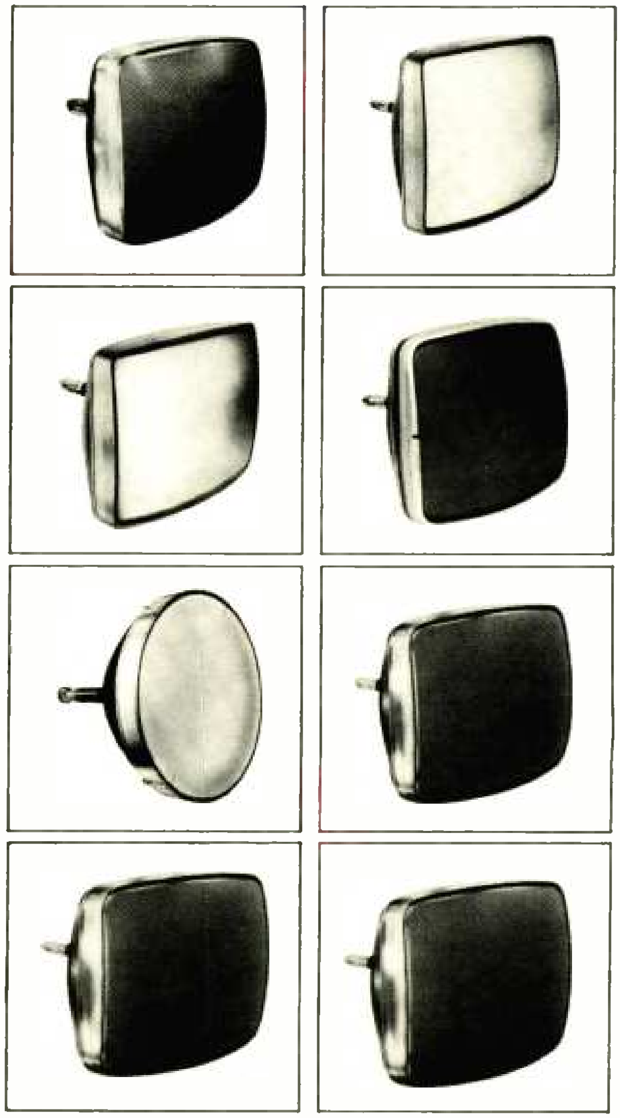
That's the kind of socket coverage you can count on from this popular new "middle line" of RCA replacement color picture tubes. With just eight Colorama A types, you can cover almost all of the replacement market with "Grade A" performance at a price your customers can afford.

Every tube in the RCA Colorama A line is totally remanufactured. That's why they all can carry RCA's 18-month inboarded warranty plus the option for an additional 12 months. Each has a completely new gun and a completely new screen made of the latest all-new rare-earth phosphors. In addition, every "V" type is made of advanced x-ray glass.

The RCA Colorama A line includes three Matrix types: CA-21VAKP22, CA-23VALP22 and CA-25VABP22. These advanced RCA Matrix tubes are as much as 100 percent brighter than any equivalent non-Matrix picture tube in RCA history.

So why not give your customers the "Grade A" choice. Choose Colorama A at your RCA Distributor today.

Remember, RCA is the world-wide leader in picture tubes, with over 65 million produced to date.



RCA

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

equipment report

B & K Model 467 Pix Tube Restorer/Analyzer

Circle 94 on reader service card

MANY MANUFACTURERS HAVE TEST instruments on the market today performing the job they were intended to do, all under the heading of picture tube checkers, rejuvenators or restorers. They range in price from $120 to almost $500.

The 467, a new unit from B & K, essentially combines the desirable features of the popular devices on the market in all price ranges and throws in some new features of its own.

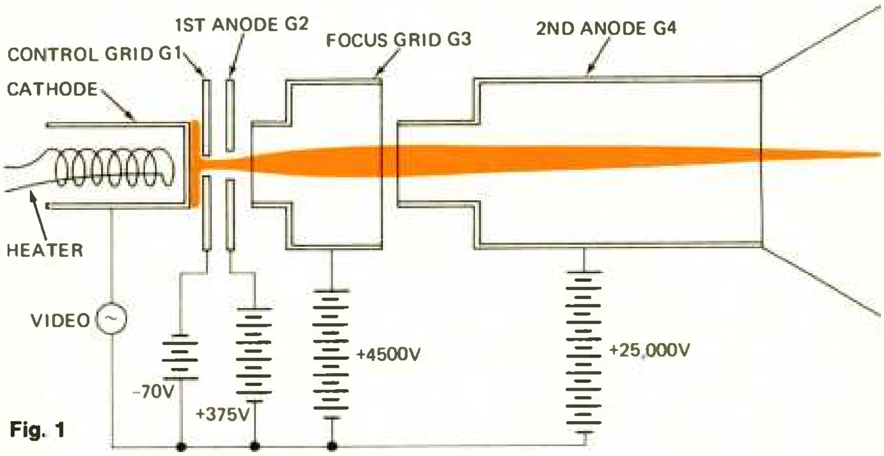


Fig. 1

Present day color TV uses mostly the three-beam tube with a magnetic convergence system. Other types of tubes are available too—the in-line, those with common elements, and the Trinitron.

Figure 1 is a typical electron gun. It is composed of a heater, cathode, control grid (grid No. 1), accelerating anode (gride No. 2), and a focusing anode (grid No. 3). The final anode (grid No. 4) at the end of the gun is electrically connected to the neck coating and to the shadow mask. The mask, coating, and grid No. 4 together form the ultor anode of the tube.

As in any other thermionic emission type device, the heater brings the cathode to its operating temperature to set free electrons in motion about the cathode. The control grid (G1) is biased typically at -70 volts. The video signal is applied between the cathode and the control grid. Once the positive excursion of signal is sufficient to overcome the negative bias potential at G1, beam current flows through the aperture at G1 from the cathode and continues on at an accelerated rate to strike its proper phosphor dot.

The potentials at G2, G3, and G4 are set to assure an accelerated electron beam which is finely pinpointed (focused) when it reaches the surface of the pix tube. Remember that, what is shown in Figure 1 is a simplified version of actual potentials applied to the elements and no consideration is given to signal applications and the grids as in an actual color pix tube.

What makes it tick?

Amazingly enough, regardless of the type of picture tube that's being tested, the procedure is the same. B & K's preliminary instruction book has stated

(continued on page 26)

mitScope

Our 25 lb., $2000.00 four channel scope is handheld, digital, weights 10 ozs. and costs $189.50*

SIZE: 5 3/4" x 3 1/4" x 1 1/4"

The mitScope MS-416 is a valuable tool in analyzing circuits. With the increasing use of digital circuitry in home entertainment equipment (stereo receivers, television sets, etc.), the MS-416 will be indispensable for every electronic service department. Digital circuitry is becoming more and more commonplace, and the mitScope is designed to handle this requirement. The MS-416 can be extremely useful in digital circuit design in electronic research and development situations. With its memory capability the mitScope can outperform oscilloscopes many times its price.
A few of the areas where the mitScope is an excellent tool for diagnosing problems are: electronic calculators; digital clocks and timers; digital automotive electronics; and many more.

DISPLAY: LED Matrix: 4x16 LED Matrix. 4 channels: with 16 divisions per channel useful for determining extensive time relationships.

TIME BASE: Range: from .5 u sec. to .2 sec. Triggering: from channel one input signal; positive or negative edge selection using SYNC switch; also an automatic sweep for checking DC steady-state signals.
Range Selection: using three controls–a potentiometer for initial sweep rate and two switches for X1000 and X20 selection.

MODES: Normal: for most troubleshooting and testing applications. Storage: on all 4 channels stores the information in a 16x4 bit high speed RAM and displays the signal continuously.

PULSE CATCHING: Single-shot storage capability: can catch and store a one-time occuring pulse in the memory and display it for as long as desired.

POWER: Battery: operation using rechargable NiCads. AC: operation using an AC-(Adapter/Charger) for use with normal 110 v.a.c.

* OR, IF YOU REALLY WANT TO SAVE, BUILD YOUR OWN MS-416 FOR JUST $127.50

PRICE: MS-416 (fully assembled) $189.50
MS-416 (kit with easy-to-follow manual) $127.50

Warranty: One year on parts and labor on assembled units. 90 days on parts for kits.

Prices, specifications and delivery subject to change without notice.

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Circle 13 on reader service card

EQUIPMENT REPORT

(continued from page 24)

"after the user has become thoroughly familiar with the instructions and the instrument itself, he will need only to refer to the SET-UP CHART booklet." This is indeed quite true. After only two weeks of use, I found only the need to verify the type of socket to be used for a particular tube and the G1 potential (either –50V or –70V). In most color pix tubes, socket 3 and a G1 potential of –50V are used. The set-up becomes almost second nature.

A tour of the 467 in operation is now in order. Let's assume we are checking a 25AP22A pix tube. The set-up manual says to use test adapter No. 3, the heater voltage is 6.3 volts and the G1 potential is –50 volts. (Anything other than –50V is noted with an * in the manual and the setting for G1 is then –70 volts.) We're ready to go. The TV receiver must be unplugged at all times for any testing!

With the function switch in the OFF position, select the proper heater voltage range. In the case of our 25AP22A we'll use a range of 4 to 7 volts.

Now rotate the function switch to the SET UP position. The G2 switch is

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EQUIPMENT REPORT

(continued from page 26)

in the NORM position (0-350 Vdc. In the SET UP position, a meter will indicate the precise heater voltage as determined by the SET HTR control. Meter 2 displays the G1 potential as determined by the SET G1 control. Meter 3 monitors the line voltage at the duplex outlet of the particular area you are in.

let's proceed to setting the precise cut-off potential of our picture tube.

Rotate the function selector switch to the CUT-OFF position. We now use the meters to set *spot cut-off* of the pix tube to +1 division above zero. *Spot cut-off* is the point at which the pix tube at the threshold of conduction (or *cut-off*) for a fixed G1 potential of −50V and varying G2. To see how this operates let's refer to Fig. 2. Notice that a

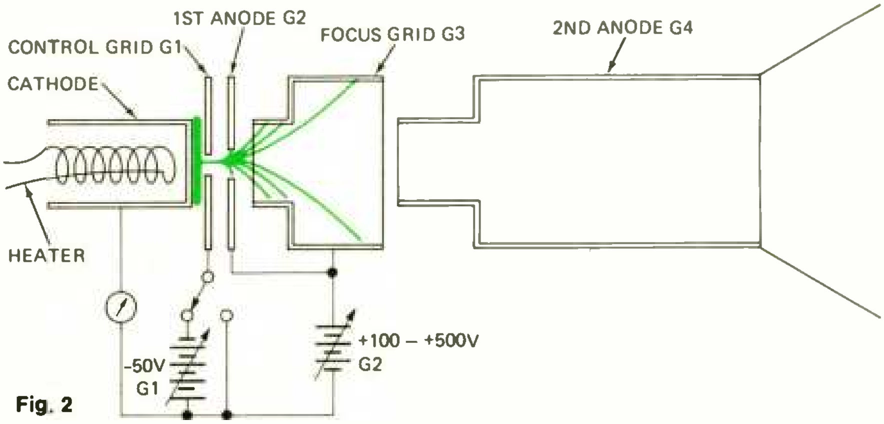


Fig. 2

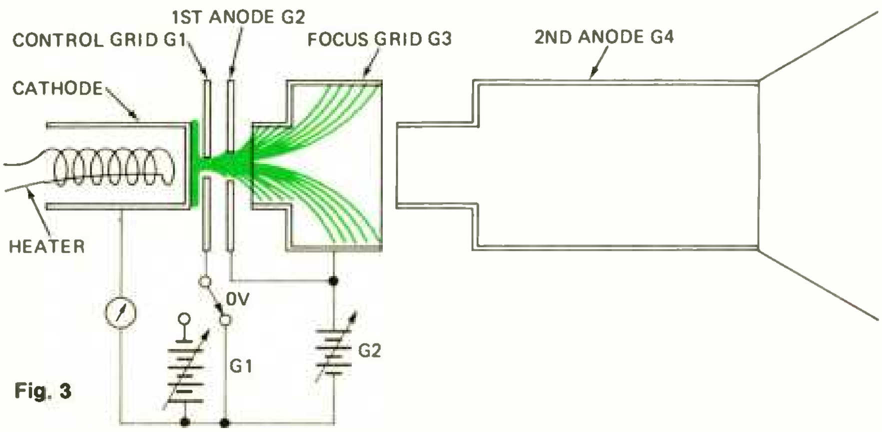


Fig. 3

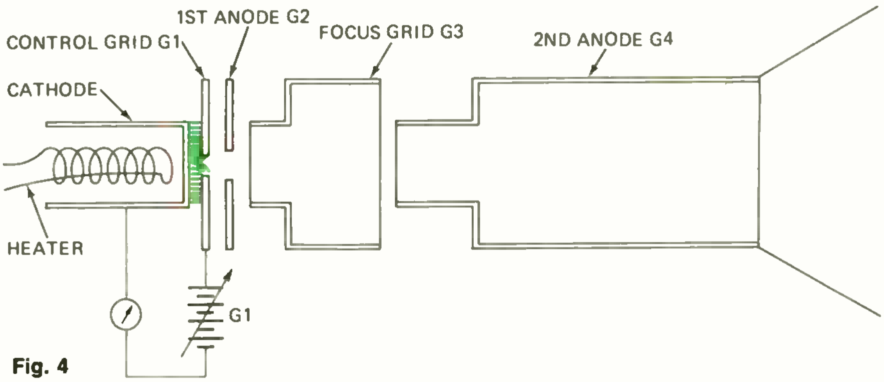


Fig. 4

No variable control is used. It's strictly a means of monitoring. The leakage lamps will automatically indicate any interelement leakage from heater-cathode or from K cathode (R, G, or B) to G1. If there is a heater-cathode short, there can be no repair. Either use a good isolation transformer or replace the tube.

Now that we have selected the proper heater voltage and G1 potential and made note of the line voltage,

single gun is drawn. Now we don't have a general operation but rather we have the actual method by which the Model 467 connects elements of the pix tube under test. Remember, the heater voltage was previously set at 6.3 volts and G1 at −50 volts. Also note that the focus grid (G3) and the accelerating anode (G2) are common. The small amount of current flowing at the cut-off point is monitored by

(continued on page 30)

SOUTHWEST TECHNICAL PRODUCTS CORPORATION

219 W. RHAPSODY

SAN ANTONIO, TEXAS 78216

December, 1974

Dear Radio-Electronics Readers,

It has been some time since I have had a chance to bring you up to date on the latest news here at Southwest Technical Products. This has been a busy and kind of frantic year for us. Until this fall, deliveries on many parts have been long and undependable. It seemed that we would just solve one shortage problem when another would crop up. Happily, we seem to be past the worst of it and most of our kits can again be delivered in a reasonable time.

Early in the summer we installed a "Datapoint 2200" computer system to help us keep track of orders and our inventory. Now I know some of you probably have "hang ups" about computers, but we are very happy with this one. Since about the middle of August all orders have been completely on the system. Not only has it speeded things up in handling your orders, it also makes it possible to confirm all orders and to notify you immediately and automatically if there is to be a delay. Without old Datapoint, doing this would have taken more hours of time than we had available.

We are also once more expanding our warehouse and workspace. Thanks to all our customer friends Southwest Technical Products is continuing to grow. The additional space will make it possible to produce our kits more efficiently and hopefully help us hold our prices. The majority of our board manufacturing, chassis punching and printing work is done right here at the plant to keep costs as low as possible. This combined with our — direct to you — sales method makes our kits a real bargan compared to other similar products.

During this year we have introduced several new kit projects of which we are quite proud. We have several new amplifiers, a keyboard kit, a new guitar preamp, an octave equalizer, a compressor expander and a multimeter plug in for our digital instrument. If you don't have our latest catalog listing all these goodies, circle our number on the reader service card and mail it in, or call us. We will get a new catalog to you as fast as possible. IT'S FREE.

During the coming year we will have several more new kits that I know will interest many of you. We will have a tachometer plug-in for the digital mainframe and possibly others. We will have the improved Digi-Viewer and Microlab kit too. The big one though will be our computer terminal kit. Your enthusiastic response to the "TV Typewritter" (Radio-Electronics Sept. 73) convinced us that many of you would appreciate a real honest to gosh professional quality terminal with all the features available on commercial units. Like the "TV Typewritter" this kit will use any television set for the display, which will consist of 16 lines with 32 characters on each line. The kit will offer two pages of memory as standard equipment—not an optional extra. It will operate from our KBD-2 or any other ASCII input source. For those that want the features; we will have special cursor controls, screen read (off line edit), and a UART system. We are making the kit available in as many forms and with as many options as practical so that you can build anything from a simple TV display to a full feature computer terminal for the least possible cost. Since you use a TV set for the display, you can choose the size that is best suited to your application and it will work with any old set you may have. Would you believe you can have the basic kit with the two pages of semiconductor type memory for $175.00.

See the January 1975 issue of Radio-Electronic for complete details.

Sincerely,

Dan

Daniel Meyer

SOUTHWEST TECHNICAL PRODUCTS CORPORATION
219 W. RHAPSODY DEPT. RE-L
SAN ANTONIO, TEXAS 78216

EQUIPMENT REPORT

(continued from page 28)

the meter. This current will be entirely dependent upon the setting of the G2 potential for each gun. Now we're ready to test.

Rotate the function selector switch to the TEST position. Automatically, the meters will indicate the condition of each gun. In the green area the gun is good. In the red area the gun is bad. You can also use the top scales of the meters for relative current indications if you wish to record data for your customer records. If the individual guns are well into the green area, we can be fairly sure the pix tube is good. Or is it? How will it track? Let's find out. See which gun provides the greatest emission. With this in mind, depress the TRACKING PUSH-BUTTON and set the best gun on the "set tracking" line of its respective meter by rotating the TRACKING control just above the TRACKING PUSH-BUTTON. The two weaker guns should now fall within the yellow wedges on their meters.

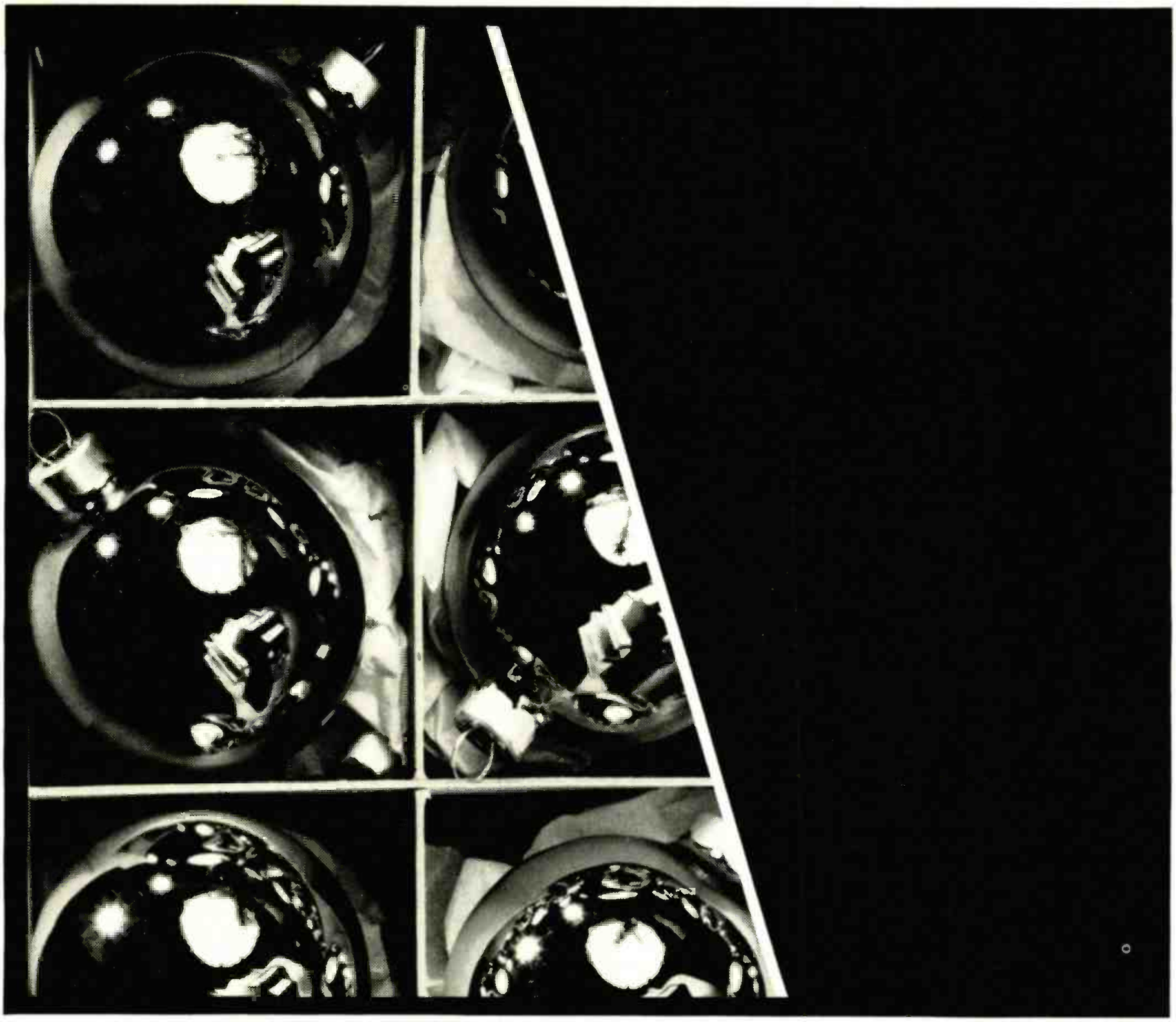
Assume that we have what appear to be three good guns. How good are they? We know that under normal heater voltage the emission is "up" and that it will track. Depress the LIFE pushbutton. This reduces heater voltage by 15% and simulates reduced line voltage. If the drop in emission is negligible you can assume not only good emission but a good life expectancy. Tracking can be checked under this reduced heater condition too. If there is good tracking, then only one other test need be made. Depress the FOCUS pushbutton. If the FOCUS OK lamp lights, the focus element is good.

The quality test that was just performed is one of the most important features of the Model 467. It rapidly tells the technician the emissive condition of each gun at a mere glance of the three meters, and the tube's ability to track (grey scale). Relative life span has been determined.

This is where B & K's claim of "true" beam current measurement and the multiplex system come into the act. Refer to Fig. 3. In the TEST position of the function selector switch, G1 is set to 0 volts. The tube now attempts to conduct at its maximum. Notice that the meter is connected (as before) so it measures the current that flows from K to G2 (G3). This is what B & K calls the *"true" beam current* and (according to B & K) is more meaningful for analysis purposes.

Our pix tube under test is still hooked up in a triode configuration. At the same time each gun is being pulsed 20 times per second. The guns

(continued on page 78)



A cartridge in a pear tree.

A gift of the *Shure* V-15 *Type III* stereo phono cartridge will earn you the eternal endearment of the discriminating audiophile who receives it. What makes the V-15 such a predictable Yuletime success, of course, is its ability to extract the real sound of pipers piping, drummers drumming, rings ringing, et cetera, et cetera. Stereo Review, in a test report that expressed more superlatives than a Christmas dinner, described the performance of the V-15 Type III as "... a virtually flat frequency response ... Its sound is as neutral and uncolored as can be desired." All of which means that if you're the giver, you can make a hi-fi enthusiast deliriously happy. (If you'd like to receive it yourself, keep your fingers crossed!)

Shure Brothers Inc.
222 Hartrey Ave., Evanston, Ill. 60204
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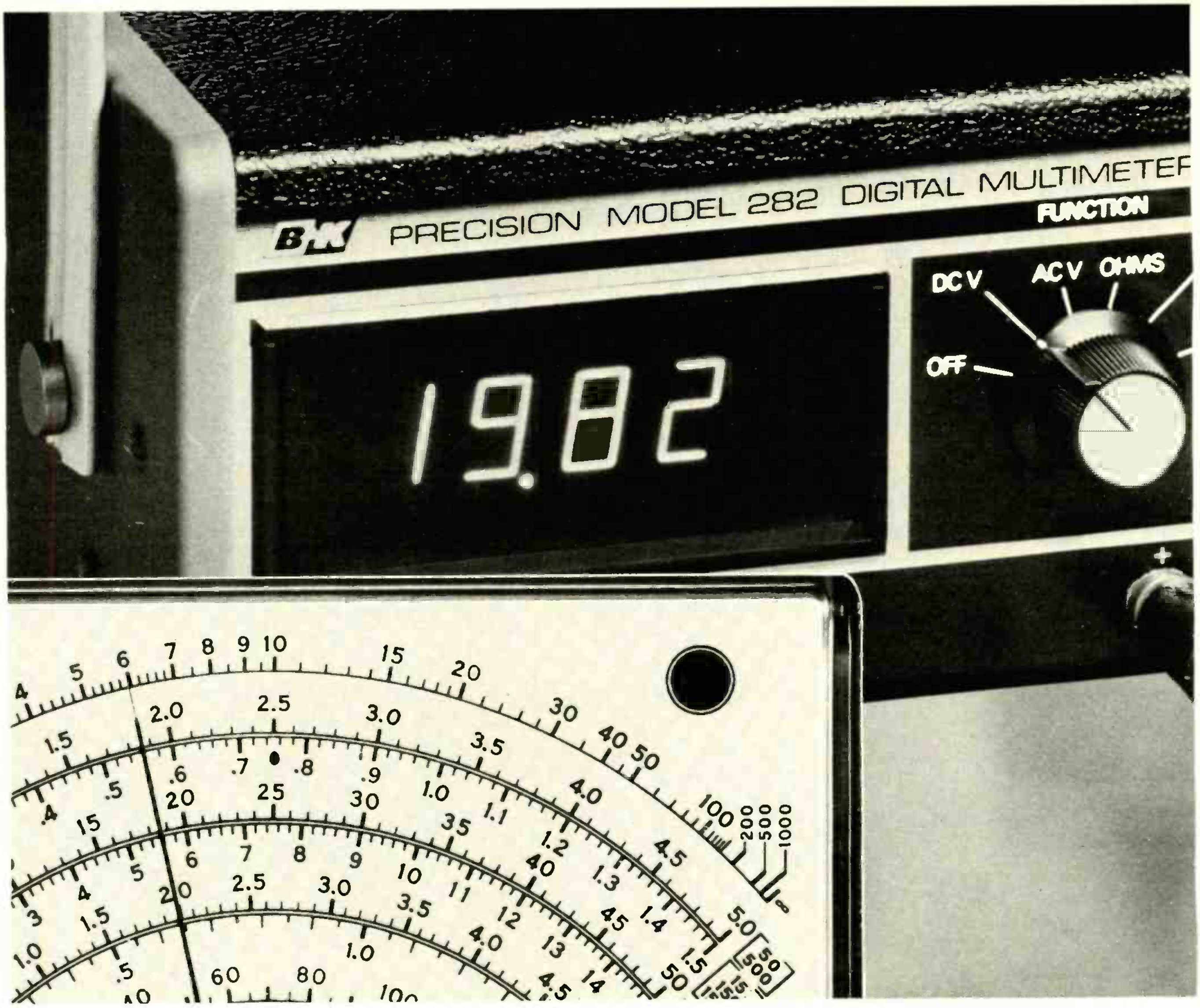
Circle 21 on reader service card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COLOR TV '75

Manufacturer's are incorporating new design innovations into their 1975 color TVs. Here's a rundown of the major manufacturer's new designs.

by KARL SAVON
SEMICONDUCTOR EDITOR

BY NO MEANS HAVE WE SEEN THE END OF technological innovation in television design. But there is a lull in activity this year as the industry works to catch up with itself. Second and third generation solid-state models are on the market. The design bugs of first-generation sets have been ironed out. Refinements brought about by hard earned service experience have been incorporated. Chassis are simpler. The tube color set is just about dead as more and more people realize the consistant long life performance advantages of solid state. My solid-state receiver of two years ago still plays like new, while a tube model of the same year and make looks like it needs a ring and valve job!

Ferroresonant transformers have been adopted by at least one other manufacturer beside Zenith. Instant-on is about finished and is being dropped one by one by the set-makers.

Manufacturers are spending time looking at the subtler problems they didn't have time for before. Lower production items like modern digital remote control and sophisticated varactor tuning systems are getting attention. Touch tuning has made its debut in this country, and the in-line slotted mask picture tube is becoming commonplace. A surface wave i.f. filter is being used by one major producer.

All in all it is a mopping up operation with some bright spots of innovation here and there. What's happening is that new circuits are being developed, many of them IC's with their very long development cycles. In a discrete design, a production problem is often cured by soldering a resistor on the back of a printed circuit board, but try soldering to an IC. The design must be right at the beginning. They are going to show up in the next couple of years and you're not going to be disappointed.

Admiral

About half of Admiral's models are 100% solid state. The two top models have Digital Touch Tuning. Just touching the channel number on the control panel selects one of the vhf or one out of a possible six uhf stations. The channel number lights up on a digital readout next to the screen. Most models use the 100% solid state SS1000 chassis. The SS1000 has plug-in satellite modules on a slide out chassis. Admiral uses their Super-Solarcolor black matrix slotted mask picture tube in most of their 19-inch sets.

THIS SUPER INSTA-MATIC color tuning system controls picture quality automatically. It's used by Quasar.

Color Master Control calls in preset color, tint, brightness and contrast in almost all sets.

Two Sonar remote controls are available in portables and consoles. One is a two function remote for on-off and channel changing. The other 4-function remote includes an additional volume adjust.

Quasar by Matsushita

Quasar is the new name for the Motorola line bought out by Matsushita Electric. It is an interesting situation since Quasar competes with its sister subsidiary Panasonic in some market areas.

QS3000 is the name of the third generation Quasar 100 percent solid-state entry. Simplification contributes to easier servicing. A video peaking control was added to the QS3000 portables to give sharper pictures when signal conditions permit. The control had been previously reserved for consoles only. Module count is down from eight to five on non-remote models. The integrated circuit count was increased from three to four and is given credit for part of the module simplification.

Super Insta-Matic keeps the picture brightness, contrast, and color intensity in balance with changes in room brightness. Similar to Magnavox's approach, Quasar uses a honeycomb lens in front of an LDR (light dependent resistor). An IC responds to the sensor's output and controls the change in picture energy. When Super Insta-Matic is turned off, a manual slide picture control changes the three picture parameters in the same proportion as the automatic system.

Do you use your TV for a nightlight? "Slumber Sentry" added to the "Satellite" remote control system turns off the set when the tuned in station concludes its transmission day.

Speaker jacks and low level audio jacks are found at the back of the QS3000 consoles. A high-quality speaker or amplifier-speaker system can be substituted for the TV's for better sound.

What's new at RCA

Seven new models in four screen sizes round out the XL-100 solid state series for 1975. All of RCA's color models are 100% solid state for 75. They use about 25% less power than the equivalent former tube models. In the lineup is the new 15 inch Model ET535 and the 17 inch ET395. These sets use PST precision static toroid yokes. The yokes are permanently bonded to the picture tube eliminating dynamic color convergence adjustments. The picture tubes are in-line black matrix types. There is a new "E" version of the CTC58 chassis used in 25 inch consoles. A new XL-100 chassis, the CTC76, is used in several models. It is very similar to the CTC71. Single-sided deflection boards are used rather than double-clad boards.

The new PST yoke has one-tenth the impedance of the conventional types. A new vertical module was designed to drive it. Fig. 1 is the schematic of the CTC72 vertical system. At the end of the trace interval switch Q1 is turned on and remains on for retrace. The collector of Q1 is grounded by the device's saturation resistance turning off the Darlington connected grounded emitter amplifier Q9-Q2. As the collectors of Q9 and Q2 rise toward 140 volts through R6, D4, and D5, D1 becomes forward biased when it reaches one junction voltage higher than the 26 volt reference supply.

This pulse feeds the output driver and the vertical yoke windings through C105. Returning R6 to 140 volts gives higher gain since the resistance value can be higher for the same current. The upper driver Q3 and output Q5 are emitter followers. The lower drive pair Q4 and Q6 make a composite pnp transistor. It has the characteristics of a pnp transistor, yet the bulk of the current is carried by the npn device. Current limiter Q10 turns on if the current in R11 products a voltage that reaches the turn-on threshold of the transistor's base to emitter voltage. Q10 drains current through R6 starving Q3 and limiting the output current to a safe value. Grounding the predriver Q9's base by the transistor switch during retrace breaks any possible negative feedback path, and the amplifier operates as an open loop pulse amplifier.

At the end of the retrace period. Q1 is turned off by *positive* feedback through module pin 3. R409 is a current sampling resistor; the voltage across it is proportional to the current through the yoke. This voltage is fed back to the predriver through the integrating capacitor C418 and diodes D2 and D3. The base of Q9 is supplied from 26 volts through the vertical height control which determines the current or the rate at which C418 can charge.

Sync blanker Q7 forms a window or limits the portion of the vertical cycle time the oscillator can be reset or synchronized.

Changes in the CTC68 for 1975 include new audio output and kine driver modules, elimination of standby heater consumption, and an improved tuner.

The two transistor cascode mixer in the old tuner design is replaced by a dual-gate MOS type in the KRK211 tuner as shown in Fig. 2. It has high input impedance, a very good noise figure, and low cross modulation because of its parabolic characteristics. It can withstand stronger signals so the agc can be delayed longer, improving signal to noise on moderately weak signals. The drawing shows the evolution of the design. Gate 2 of the FET has a similar effect as the upper base of the original cascoded transistor pair. R6, R7, and R8 bias the gates for best mixing.

The drain of Q1 is tuned by the shunt fed circuit L30 and C4. L30 connects to the low impedance input of the i.f. module so that looking from the MOSFET, L30 appears to be grounded.

Digital gas-discharge channel indicators are used in some models. Fig. 3 is a simplified drawing of the switching for the units uhf digital readout. Grounds are connected to the necessary cathode elements by the units switch through isolating diodes. The switch is deactivated in the VHF position when a different one takes over. In the UHF position S4002 grounds the cathodes of D6201 and D6202. D6202 conducts current to ground for the uhf display and D6201 lights the uhf indicator lamp. D6003 holds the VHF lamp off by restricting its voltage drop to two diode junction voltages, way below the gas ignition voltage.

Sony has a zinger

The Sony KV-1722 uses a 17-inch 114-degree deflection Trinitron picture tube. It is completely solid state and uses 26 transistors, 33 diodes, 7 integrated circuits, 3 gate controlled switches and 1 FET.

The receiver has a switching mode power supply that is being used in Sony's 20-inch Japanese and other European models.

Fig. 5 is a block diagram of the switching system. Full wave rectification produces 303 volts dc. A switching circuit operating at the horizontal scan rate, 15,734 Hz, generates a non-symmetrical square wave output that has an average value of 103 volts dc. The 130-volt output is compared with a 12-volt Zener diode to pulse width modulate the chopper drive. This is a regulation loop that maintains the 130 volts dc by changing the average value of the switched waveform. It is efficient because the switching device Q603 is either on or off, both minimum dissipation states. The EVP block is an excess voltage protection system.

For some more appreciation of the system look at the schematic diagram in Fig. 4. Sony doesn't cut ocrners in their designs! The switching device Q603 is a

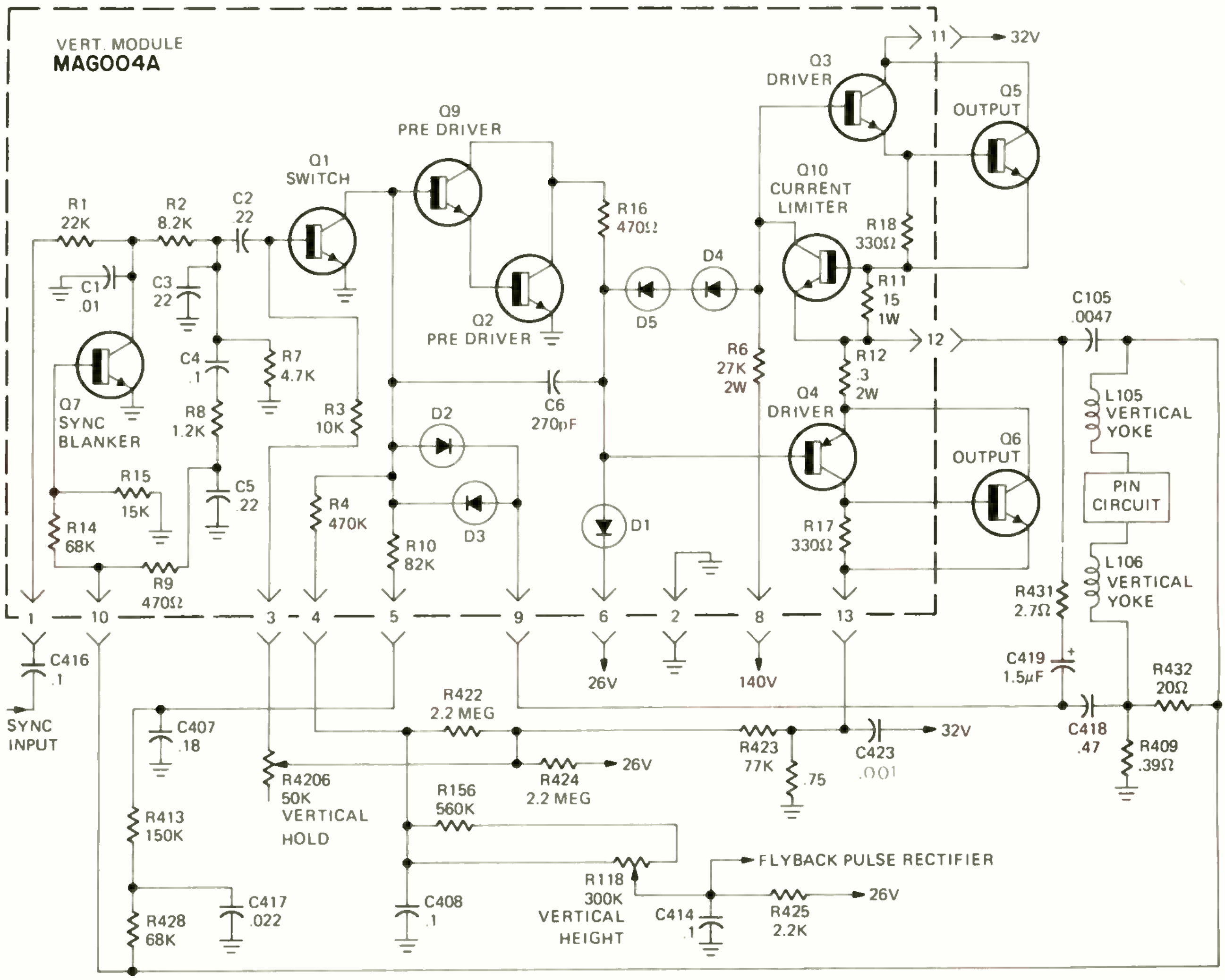

FIG. 1—THE NEW RCA CTA-72 VERTICAL DEFLECTION SYSTEM was designed to work with the new PST yoke.

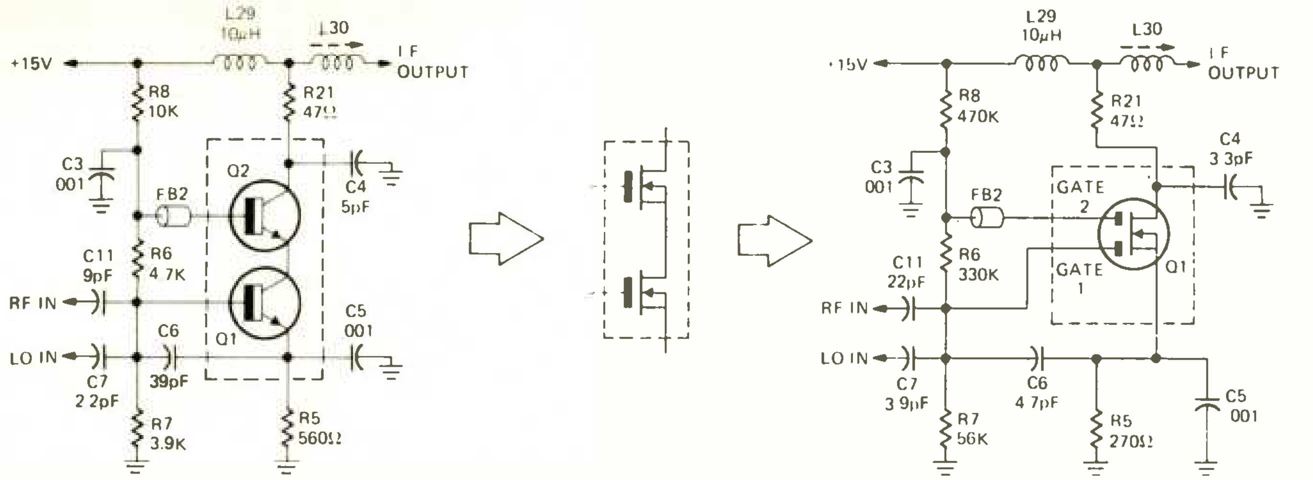

FIG. 2—RCA's NEW KRK-211 TUNER features an improved signal-to-noise ratio with dual-gate MOS-type mixer.

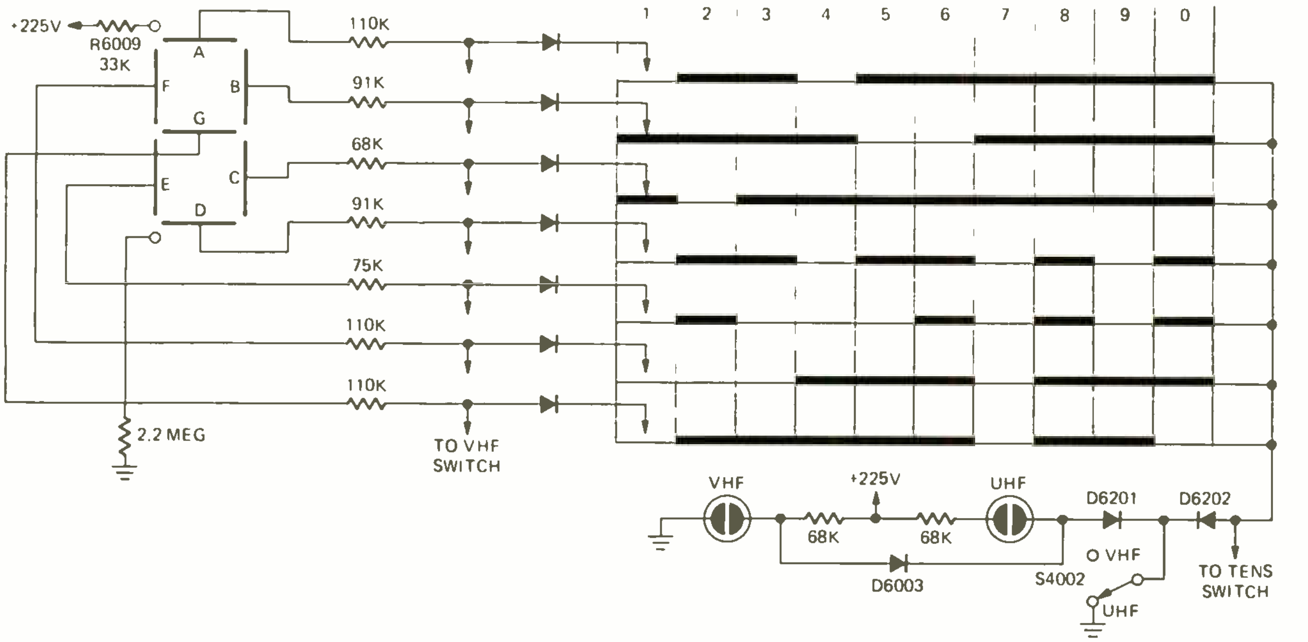

FIG. 3—RCA's DIGITAL GAS-DISCHARGE channel indication. Switching for units UHF readout is shown simplified.

gate controlled switch (GCS). It is a pnpn regenerative device similar to an SCR, but the geometry is such that the gate does not lose control when the transistor is turned on. Applying a negative signal to the gate turns if off. The gate of the GCS is fed from the chopper drive transistor Q604 through transformer T603. Q603's anode is connected to the 303 volt supply through R607. The horizontal rate drive is transmitted through pin 17 from the horizontal oscillator.

Filter L601, C621, L603 removes the 15-kHz switching frequency and its harmonics from the chopped output at the cathode of Q603. Error amplifier transistor Q608 compares a portion of the regulator output with the Zener reference. Current through R632 from the 19-volt dc line biases Zener D610 on through the base-to-emitter junction of Q601. Potentiometer VR601, the regulated supply voltage adjustment, is part of a resistor divider that biases the base of Q608 at 11.9 volts. Q609 is reverse biased and normally does not affect the operation of the circuit.

As the ac line voltage and dc loads on the 130-volt supply fluctuate, the current in Q608 varies, changing the control input to pulse-width modulator Q606-Q607. Like all regulators the feedback must be negative in phase. Loading the output increases the pulse width increasing the average value output of the chopped 303 volts. Starter circuit Q601-Q602 is essential for initial turn-on. Some mechanism is needed to start the oscillator which runs on its self-generated 19 volt supply. There is a path through R642, D604, Q602 and D605 to the 19-volt line. Initial turn-on of the set gates on GCS Q602 to power up the 19-volt line temporarily. The horizontal deflection system is then started by this voltage and takes over the 19-volt supply generation by rectification of horizontal output pulses. Forward bias on Zener regulator D610 will then saturate Q601 pulling down the gate of Q602 and turning it off disabling the initial power flow path.

If you ever run into one of these sets there is a characteristic of the power supply you should be aware of. If the horizontal oscillator fails, the 303 volt dc will pass through the switching circuit without being converted down. That is because it is not being chopped and the average value will equal its now constant peak value. When this happens some transistors and fuses unhappily pop along the way, confusing the unwary.

Zenith for '75

Zenith's Chromacolor II "F" line models are similar to last year's "E" line's vertical chassis. New 23-inch and 25-inch Titan chassis replace last year's horizontal model. The main differences between the larger and smaller sets are in the high-voltage circuits. Only one set in the 52 model 1975 line has tubes.

Power Sentry, the ferroresonant line regulating power transformer introduced last year has been retained to nobody's surprise. It does a fine job of smoothing out the bumps on the power line and gives full scan voltage with reduced

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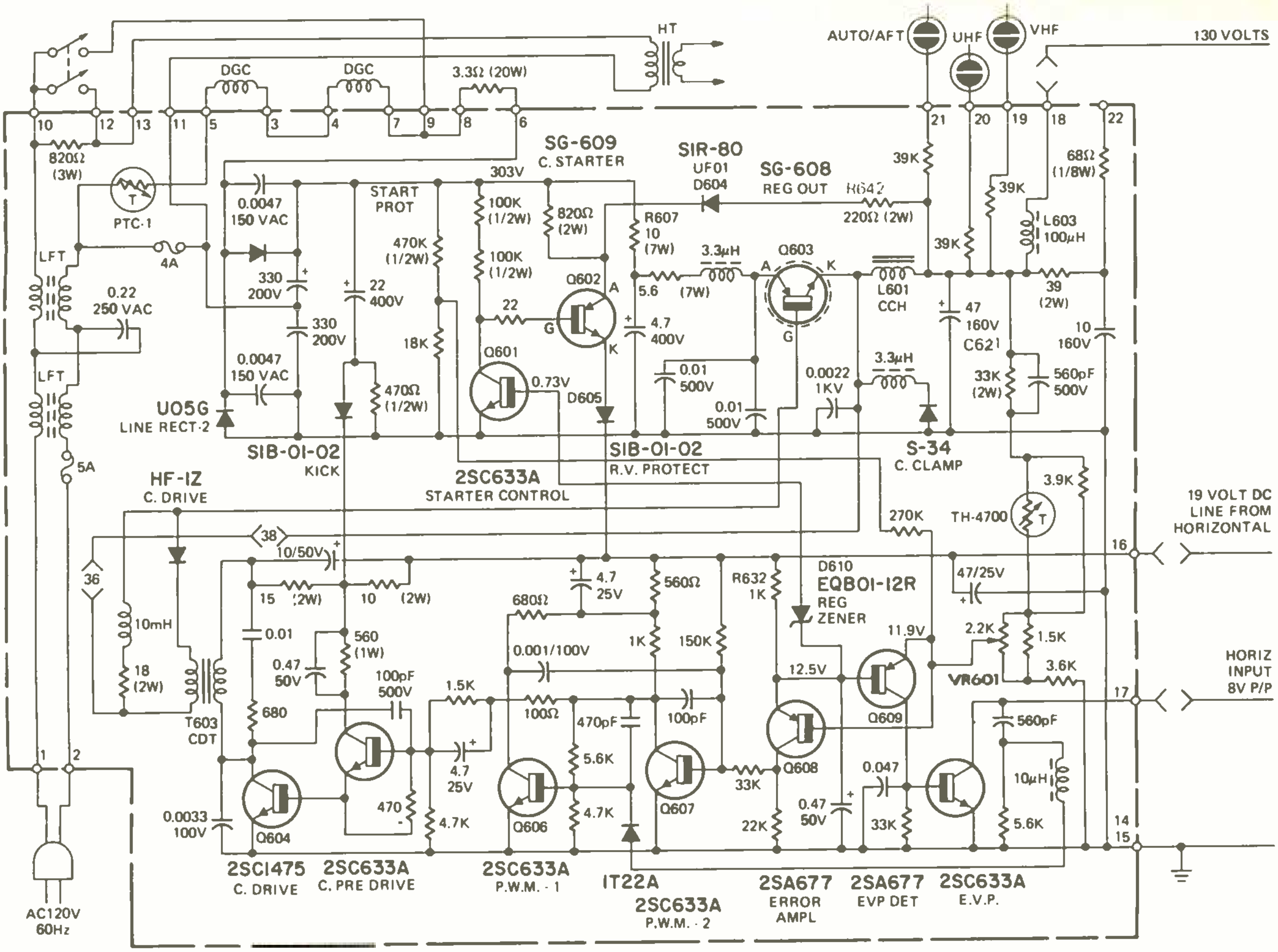

FIG. 4—SCHEMATIC OF SONY's POWER SUPPLY SWITCHING CIRCUIT.

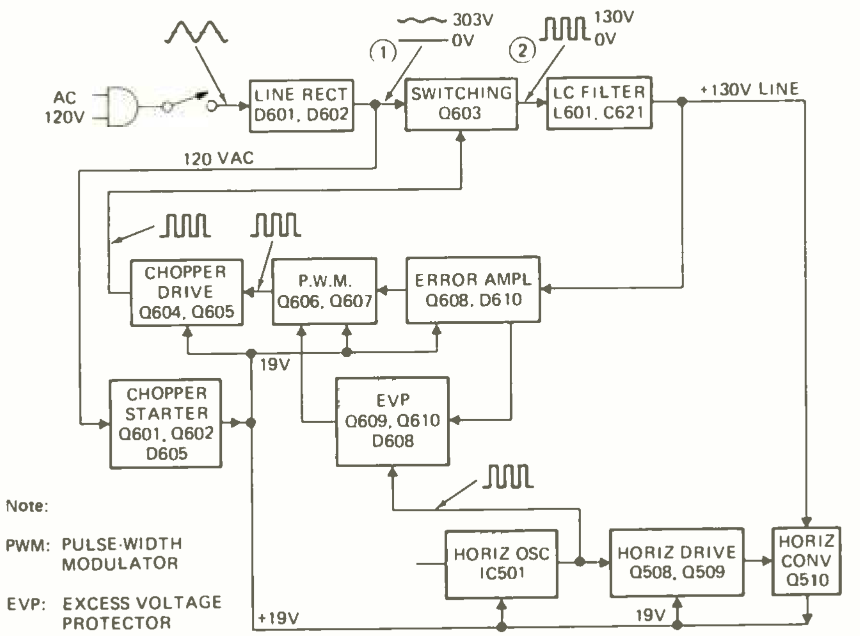

FIG. 5—POWER SUPPLY SWITCHING SYSTEM used on Sony's KV-1722. Switching is done at the horizontal scan rate.

ac supply voltage. A new power saving "quick-on" circuit replaces the older system. The standby filament transformer has been eliminated.

The 150-401 i.f. module uses a surface wave filter built into an IC to simplify i.f. alignment and improve performance. The alignment procedure for this new module is 10 steps compared to the conventional 13-step procedure. There are

ZENITH'S SLIDE-TUNE electronic tuning system lets you select channels in a random sequence.

no 1st or 2nd i.f. coils or 39.75-MHz trap.

Zenith's electronic solid-state tuning system is a varactor diode based setup allowing any sequential mixture of 14 uhf and vhf channels. Six manually tuned receivers have this feature this year. A unique slide type channel selector is built into the tuner control panel. Signal frequency circuits are not switched mechanically, but the system does include two mechanical switches. One is to select the varactor tuning voltage and the other for band switching.

75-ohm antenna connectors are built into some models for master or cable system hook up. *(continued next month)*

HOW IT WORKS

Slotted-mask color picture tube

RCA has come up with an improvement to their famous three-gun shadow mask color picture tube. The new picture tube is part of their Acculine system and it requires no dynamic convergence. Here's how it works

by JACK DARR
SERVICE EDITOR

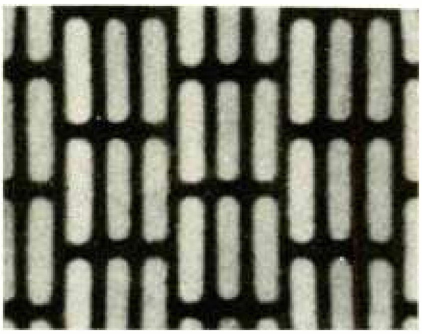

FIG. 1 — PHOTOMICROGRAPH OF THE SCREEN of RCA's new color picture tube.

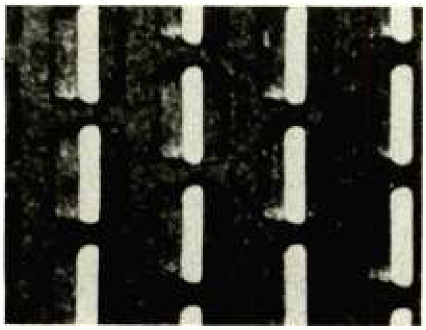

FIG. 2 — PHOTOMICROGRAPH OF THE MASK shows the new slotted apertures.

A LONG TIME AGO, RCA DEVELOPED THE famous three-gun shadow-mask color picture tube. This made all-electronic color TV possible. The original design proved so successful that even the Europeans still use it, without basic changes.

Now, RCA engineers have come up with a decided improvement. First introduced in early 1973, in the 15V and 17V sizes, they proved so successful that the 1974 line includes these two sizes, and a 19V as well. The new picture tube is a type 15VADTC01 (17V—, 19V—, etc.) and is called the "AccuLine" system.

These tubes use 90° deflection angle, with the three guns mounted in-line horizontally. The problems encountered in previous types have been overcome, by very precise design, as well as other things to be covered in a moment. The phosphor screen of the AccuLine tube does not have the familiar triads of dots. Instead, it has *lines*. Fig. 1 shows a photomicrograph of the screen itself, and Fig. 2 shows the slotted apertures of the mask.

This type of pattern gives several advantages. Vertical lines can be "nested" better than dots. The phosphor screen can be completely filled, while dots allow only 91% fill. The effects of geometric-trio distortion at the edges is greatly reduced: this makes edge-convergence a lot simpler. The edges of the screen are also much brighter. Due to the vertical lines and slots, vertical misconvergence is practically non-existent, and horizontal misconvergence is easily compensated. The effects of the earth's magnetic field are reduced. (Wait just a minute, and you'll hear the "really good news"; it'll shake you up!)

No convergence board!

The most unusual thing you'll see when you take the back off of a set with a CTC-62 RCA chassis is the thing you *don't* see! No dynamic convergence board; no dynamic convergence yoke, and no blue lateral magnet on the tube-neck; only one pix tube screen control—these parts are gone. They aren't needed in this system.

The installation setup and convergence procedure is drastically shortened. Most of it is done for you, at the factory—even the purity and grey-scale adjustments. All you'll see on the neck of the picture tube is a rather odd-looking yoke, with only one layer of wire, and a small magnet-ring assembly (Fig. 3). Let's see how they did it.

The good news

Here's the good news. With this system there are *NO DYNAMIC CONVERGENCE* adjustments! Only static convergence is needed. (Don't throw the bar-dot away; we'll still need it.) Because of the precision design of the gun assembly plus the special design of the deflection yoke, it is possible to build a system, consisting of the picture tube and deflection yoke, that makes dynamic convergence unnecessary. All of these adjustments, including purity, can be and are made *at the factory*. The deflection yoke is cemented in place after they're done. The tube and deflection yoke are designed *for each other*. That's why we keep referring to them as a system.

How it works

In a typical delta-gun system, the beams can be statically converged at the center of the screen; however, they will be over-converged at the edges. So dynamic convergence must be used to correct this. In the in-line gun system, the deflection yoke is designed so that there is no trapezoidal distortion at the edges, and the beams are very slightly distorted so that they make a thin vertical line at this point. Fig. 4 shows how this works. The beams can be held to less than 0.51 mm misconvergence at any point on the entire screen.

The gun unit

Let's look at the design of this gun unit. To get an inherently self-converging assembly, the in-line beams must pass through the center of the deflection yoke in a precisely spaced and precisely horizontal array. The grids of the new tube are a single piece, with a triple aperture. In the "RGB" or cathode-drive circuit, the grids are common, making this possible. (Cathodes are separate, of course.)

This construction also eliminates thermal-expansion convergence drift, one of the bugs possible with older types. The beam-to-beam spacing in this gun assembly is only 0.2" (5.08

mm) instead of the 0.45" (11.45 mm) of the delta-gun unit. This very tight spacing is possible because this is a function of tool-die dimensions, rather than mount-assembly. Tool-die dimensions can be held to extremely tight tolerance. This avoids one rare, but possible problem of the past, where tube and deflection yokes could come down on opposite sides of the tolerance, making this setup very hard to converge.

There are the four magnetic rings at the top of the electron-gun assembly. (These are internal; not the outside rings!) They have dual functions; the outer ones, on the B-G guns, reduce the size of the outer-beam rasters slightly, both vertically and horizontally, by shunting a small part of the deflection field. The two smaller ones, above and below the red gun, in the middle, provide a little extra width for this raster. With these built in corrections, the red beam always lands *between* the other two, at all points on the screen. Convergence errors of the red beam are always annoying, since visual fringing of red is more visible (especially to the customer.)

The base connections of this new tube are the same as those of the 110° 29-mm neck tubes. Blue and green grid connections are omitted since the grids are common; only one is needed. The screen is also common, so only one pin is used here. An examination of the base and socket used with this tube shows some new features. Special contacts are used, which look as if they would give much better contact, due to a larger contact area on the pins.

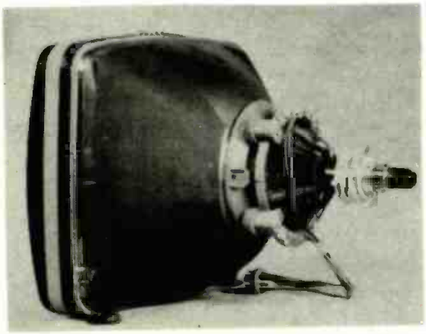

FIG. 3—PICTURE TUBE AND DEFLECTION YOKE comes as one assembly. The dynamic convergence and purity adjustments are done at the factory.

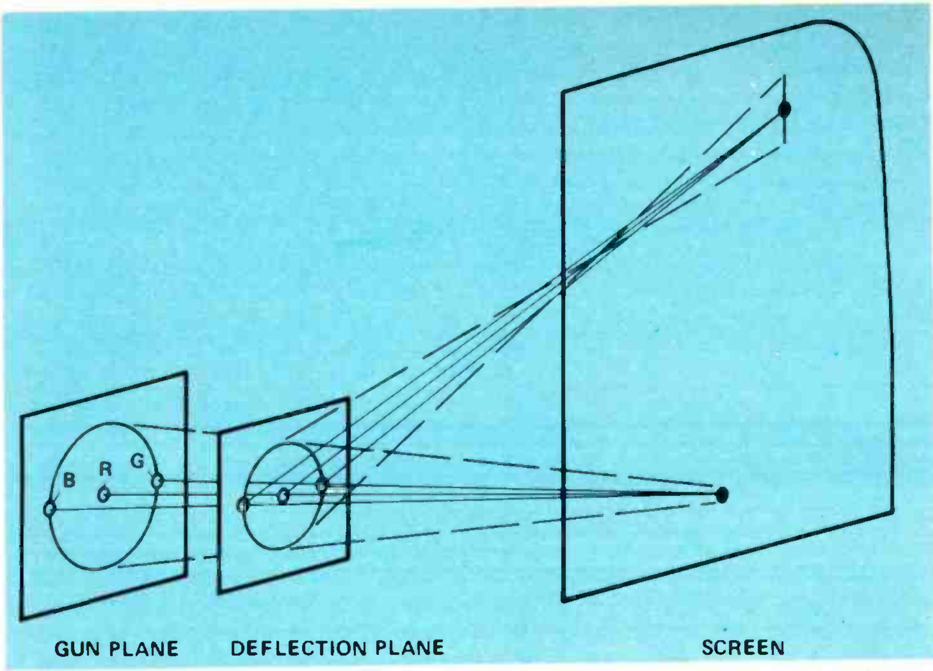

FIG. 4—DEFLECTION SCHEME OF THE IN-LINE SYSTEM. The beams are within 0.51-mm misconvergence over the entire screen.

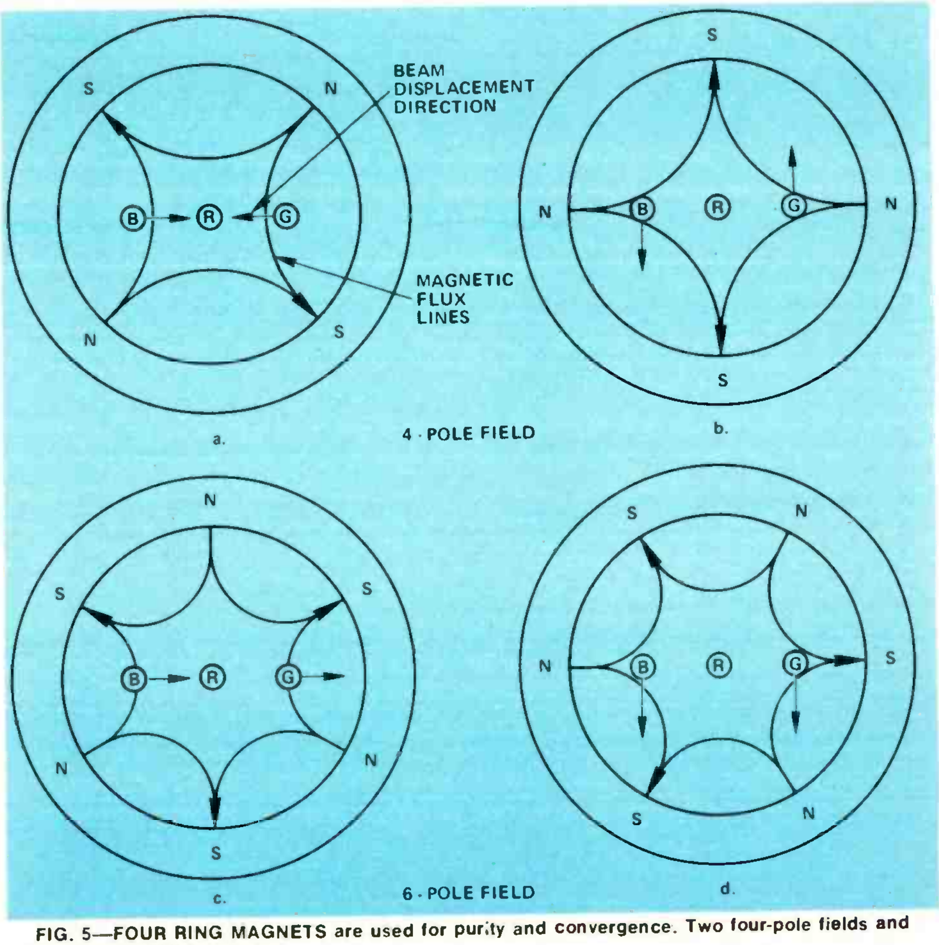

FIG. 5—FOUR RING MAGNETS are used for purity and convergence. Two four-pole fields and two six-pole fields are used.

Convergence

Only a very slight correction is needed for convergence in this system. The purity/convergence device uses what looks like a dual assembly of conventional ring magnets, mounted in a small assembly just behind the deflection yoke. The old convergence yoke is gone. These magnets are of a special type, made of barium ferrite, which has a permeability close to 1 (one). This helps to get rid of any undesired effects from the deflection fields on the convergence.

There are four of these rings, in pairs. Two of them develop four-pole fields, as seen in Fig. 5. These move the outside (B/G) beams equally, in opposite directions (Fig. 5-a, b). The other set develops 6-pole fields which also move the outer beams equally, but in the same direction (Fig. 5-c, d).

So "convergence" boils down to moving only the two outer beams, blue and green. The red beam remains stationary; the gun design is such that the magnetic fields won't affect it. No internal pole-pieces are used. There is practically no interaction between the beams, resulting in very small distortion in the shape of the individual beams.

The deflection yoke

I've mentioned the deflection yoke as being special. It definitely is! We may have to cover its design and construction in a following article; here is a capsule description of it. This is called a PST (*Precision Static Toroid*), and it has only a *single* layer winding. Each wire lies in a winding-groove in the plastic form. This type of construction allows much tighter control of tolerances in the deflection *fields*. These can be "shaped" with such precision that several highly desirable goals are met: much better focus; much more *light* at the edges, due to better control of beam-landing; practically no misconvergence; no trapezoid effects at edges, and on and on. The new yoke design, precisely matched to the characteristics of the new slot-beam tube, makes this into a true "system". It's the perfected matching of tube and yoke that gives these desirable results.

The reduced amount of wire needed, only 20% of that used in saddle yokes, also allows much better matching to solid-state drive circuits. These are inherently low-inductance types; the horizontal windings, in parallel, have only 1.5 mH, and 0.58 mH in series. Vertical windings have only 2.3 ohms resistance, in series.

This type of design makes it possible to mount the deflection yoke *at the tube factory*. In a test jig, convergence, purity, white uniformity, etc. are all set up and tested. The yoke is then firmly cemented to the neck of the tube. This is a thermoplastic cement, which sets quickly. It won't soften at any temperature found in normal operation.

"What if - - - - -?"

The first question that a technician asks, of course, is "What if the yoke goes bad?" The answer to this is that, while it isn't impossible, it's not too likely. With the bigger wire used, plus the wider spacing between turns, plus the improved, heavier insulation (four layers of high-temperature compound), the chances of yoke failure are really small. This includes the most common yoke failures; arcover and insulation breakdown. With only one layer of wire, the turn-to-turn voltage stress is much reduced. If the yoke should fail, it can be taken off the tube-neck, with a heat gun, and replaced.

This new system should offer several advantages to the technicians. Picture tube replacement is about as easy as B/W replacement. Only minor static adjustments are needed. (And, when you come right down to it, I know of *very* few technicians who really *like* to do dynamic convergence!) So, this should go over big with them, as well as the consumer. This system has been in use since early this year, and field experience has been very good. **R-E**

computer modifications

THE ORIGINAL MARK-8 MINICOMPUTER (see **Radio Electronics,** July 1974) can have up to eight output port latches to output data to experiments, readouts or the TV-Typewriter. Output port 0 is used for the display register on the front panel. Only two input ports have been provided on the Mark-8 for data input. The modifications described here, show how to increase the input capability up to eight input ports and how to use an additional sixteen output commands to generate pulses for control.

Increasing output flexibility

The original construction booklet shows how decoders and gates can be added to an output port to control external devices, but this requires us to load an instruction into the *A* register and then output it to the output port where it is then decoded. Each time the computer executes an OUT instruction, a pulse is generated to activate one of the eight selected ports. Actually, sixteen additional ports could be added to the Mark-8 to output data, with only a few modifications or additions to the existing hardware. While the additional ports could be used to output data to other devices, the output pulses may be used alone to activate devices such as flip-flops, gates, solenoids or even a calculator. We now have our original eight output ports plus sixteen pulses for external control.

The instructions used to activate the output ports are 01 01M MM1, where the binary MMM bits are decoded to signify the particular output port. The sixteen additional ports or pulses come from instructions 01 10M MM1 and 01 11M MM1 which are also OUT type instructions. Some examples are shown in the following chart:

OUT0 = 121 OUT1 = 123 . . . . OUT7 = 137	Latch Outputs
OUT8 = 141 OUT9 = 143 . . . . OUT15 = 157	Pulse Outputs
OUT16 = 161 . . . . . . OUT23 = 177	Pulse Outputs

To add these additional pulse outputs to your Mark-8 computer:

1) Run a jumper (insulated) from the spare connection point, No. 17, on the CPU PC board, to the through-the-board connection just to the lower left of pin 1 on IC13. Be sure to solder the jumper on both sides of the board. This jumper connects to pins 4 and 5 on IC13 and pin 8 on IC18. The signal is called OUTPUT and it indicates when the computer is executing any of the twenty four OUT type instructions listed above.

2) Make the other labeled connections to an SN74154 four-to-sixteen decoder as shown in Fig. 1. Connect the new OUTPUT signal as shown.

Logic zero pulses are now produced at the appropriate outputs of the decoder when the new output instructions are executed. You can obtain positive pulses by adding an inverter to the decoder output. This increased flexibility allows us to perform external operations without a great deal of additional software.

For example, to pulse a flip-flop under program control we connect the clock input of the flip-flop to the decoder output labeled OUT12. Each time the computer executes an OUT12 instruction, a pulse is generated at the OUT12 position on the decoder, clocking the flip-flop. The other decoder outputs could be used for other purposes to control relays, to start a process or to enter data to a calculator. The addition of this decoder replaces the two SN7442 decoders shown in the example in the construction booklet as

(continued on page 85)

STAR-New Kind of TV Remote Control

Now you can switch from any TV channel to any other TV channel in less than a second without tuning through unnecessary or unwanted channels. How's it done? There's a rather special IC that works like a computer and . . .

by **LARRY STECKLER**
EDITOR

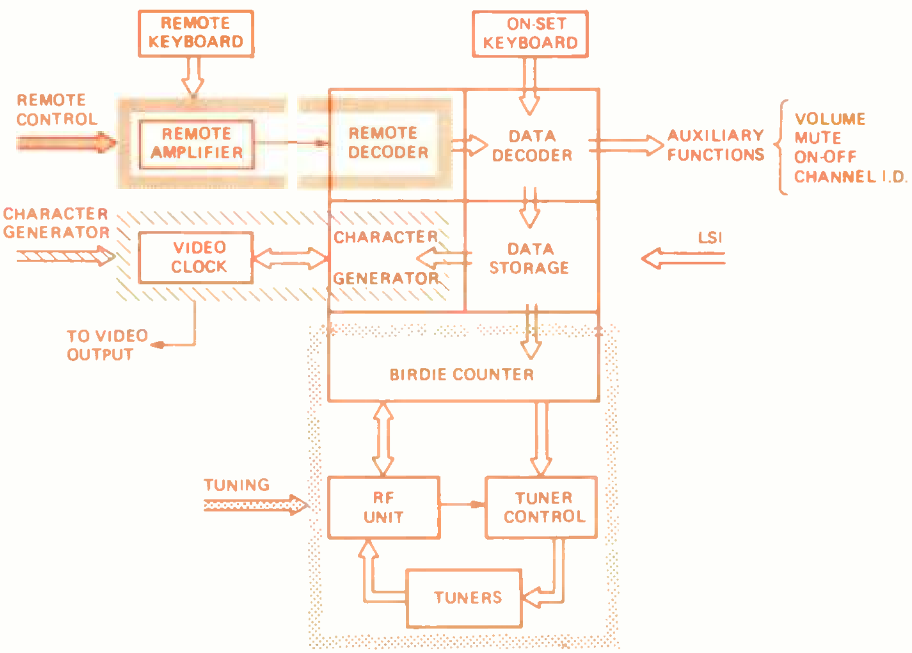

FIG. 1—BLOCK DIAGRAM OF THE MOSTEK LSI that makes the STAR system work. Data enters the system from the keyboard on the remote or from the one on the set.

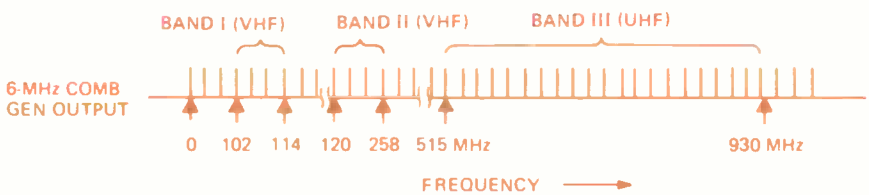

FIG. 2—THE COMB GENERATOR produces a waveform like the one shown here. Note that there is a harmonic every 6 MHz.

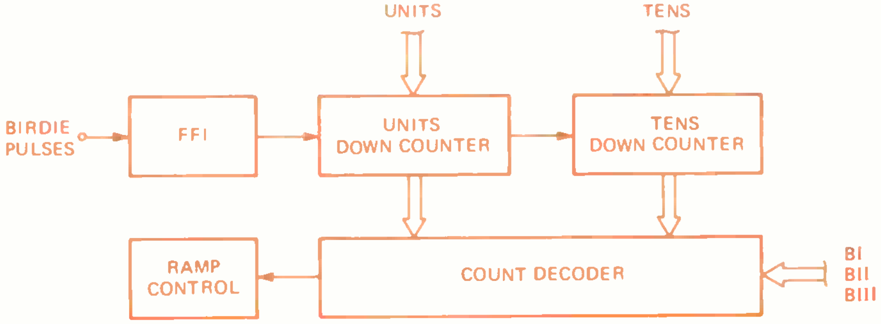

FIG. 4—THE BIRDIES ARE SHAPED INTO PULSES that toggle flip-flop 1 (FF1). FF1 delivers a positive transition for each channel as the counter sweeps the channels.

WANT TO WATCH THE NINE O'CLOCK MOVIE on channel four? Just pick up your STAR remote control, punch out . . . 0 . . . 4 . . . on the calculator-like keyboard; and the station appears on the screen. The channel number is there too, right on the screen, in the upper left hand corner, for a few seconds, and then it fades away while you continue to watch the program you selected.

This new Magnavox innovation may spell the end to all the older electro-mechanical remotes. It puts an end to channel-by-channel switching to reach the one you want to see. Instead, you directly go from any channel to any other channel, in less than a second, without any other unwanted channels in the way. And it all works thanks to a new electronic marvel named STAR—an anacronym for *S*ilent *T*uning *A*t *R*andom.

The total system turns the set on and off; switches channels; selects channel identification; controls volume and sound muting. A calculator-type keyboard mounted in a small wireless ultrasonic remote controls all of these functions.

Advantages of the system

There is no set up for the TV tuner—all 91 channels have feedback networks that let the computer circuitry of the STAR system find the desired station. The tuner is then locked to an internal crystal oscillator by an afc loop. As a result the solid-state tuner can be easily replaced if necessary with only i.f. alignment required.

There is no fine-tuning adjustment on the set, and for that matter, no moving parts at all, even for volume control.

A switch on the TV itself, permits scanning the channels in either direction to cover all channels, if assigned active channels in an area are not known.

The number of the last channel viewed and the volume setting used are stored in the system memory when the set is turned off. When the set is switched on again, that channel and volume setting are selected. However, the memory is volatile, and if the set is disconnected while it is off, the memory is destroyed. Now, when the set comes on a channel will have to be selected; and the volume will automatically reset at minimum.

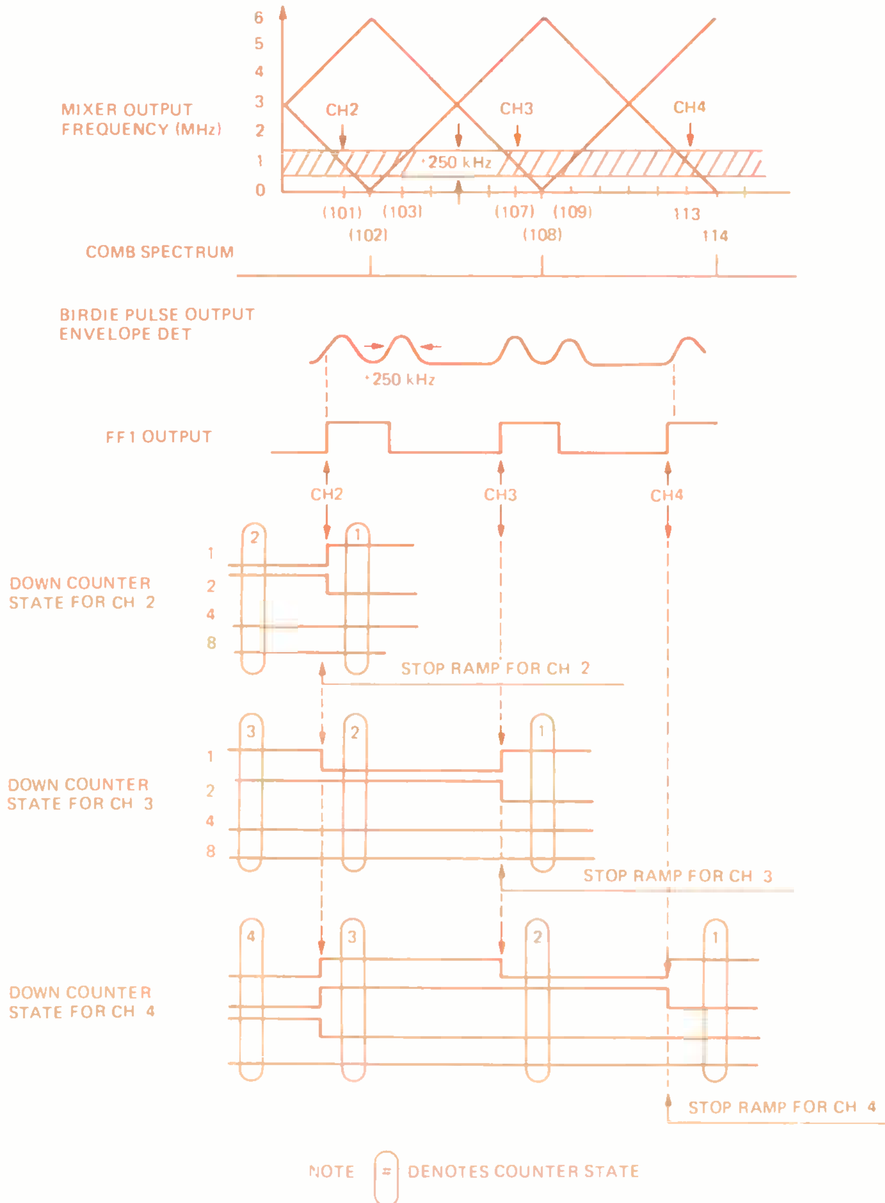

FIG. 3—THE HARMONIC SPECTRUM OF FIGURE 2 is mixed with the output of the local oscillator (L.O.) as shown in this diagram.

How it works

Before we go into great detail let's take a brief look at how the system operates. When any switch on the remote unit is depressed, battery power in the hand-held remote is on and an ultrasonic pulse is generated. (Each of the 15 switch functions on the remote generates a different ultrasonic pulse. These pulses are 720-Hz apart in frequency.)

The receiving unit in the TV counts the incoming frequency to decode and identify the function. The logic section in the receiver then determines whether the signal controls power, volume or channel selection or recall.

If the received signal is a channel selection signal, the first entry goes into memory (where it is retained until the second signal is received—0.1-second or 1-week later). When this second signal is received it becomes, in addition, the execute signal. So as soon as it is received the STAR circuitry generates the channel number and puts it on the TV screen, and the tuner switches to the proper channel.

The tuner switching procedure is a bit more complicated. When the second signal is received the circuitry determines whether it is a Band I, II, or III channel that has been selected (see STAR Frequency Chart) and actuates the appropriate tuner switches. Then the tuner scans to its starting point and the counter is preloaded for the band that is in use. Next the tuner scans through the band while the counter compares the channel count until it matches the command signal. When this happens the scan is stopped and afc is activated to lock the tuner oscillator to the crystal reference oscillator and the selected channel appears on the screen. All this takes place in less than one second.

The channel selector uses a special circuit to convert the energy of a 6-MHz crystal-controlled signal into every harmonic that comes within the television band (101 MHz to 931 MHz). The tuner's local oscillator is referenced to the closest harmonic. For instance, the 17th harmonic for channel 2 or the 86th harmonic for channel 14. Other channels are selected by causing the tuner to sweep through the appropriate band—Ch. 15, 16, 17, etc. for the uhf band. Pulses of energy are generated for each channel, continuing until the logic senses the correct pulse count for the desired channel. At this point, the tuner oscillator is located by an afc channel to the desired harmonic until a new command is received. The command is also placed into a memory

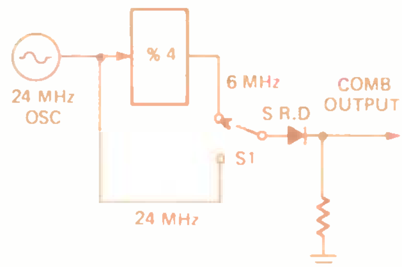

FIG. 5—THE COMB GENERATOR uses a step-recovery-diode driven from a 24- or a 6-MHz signal.

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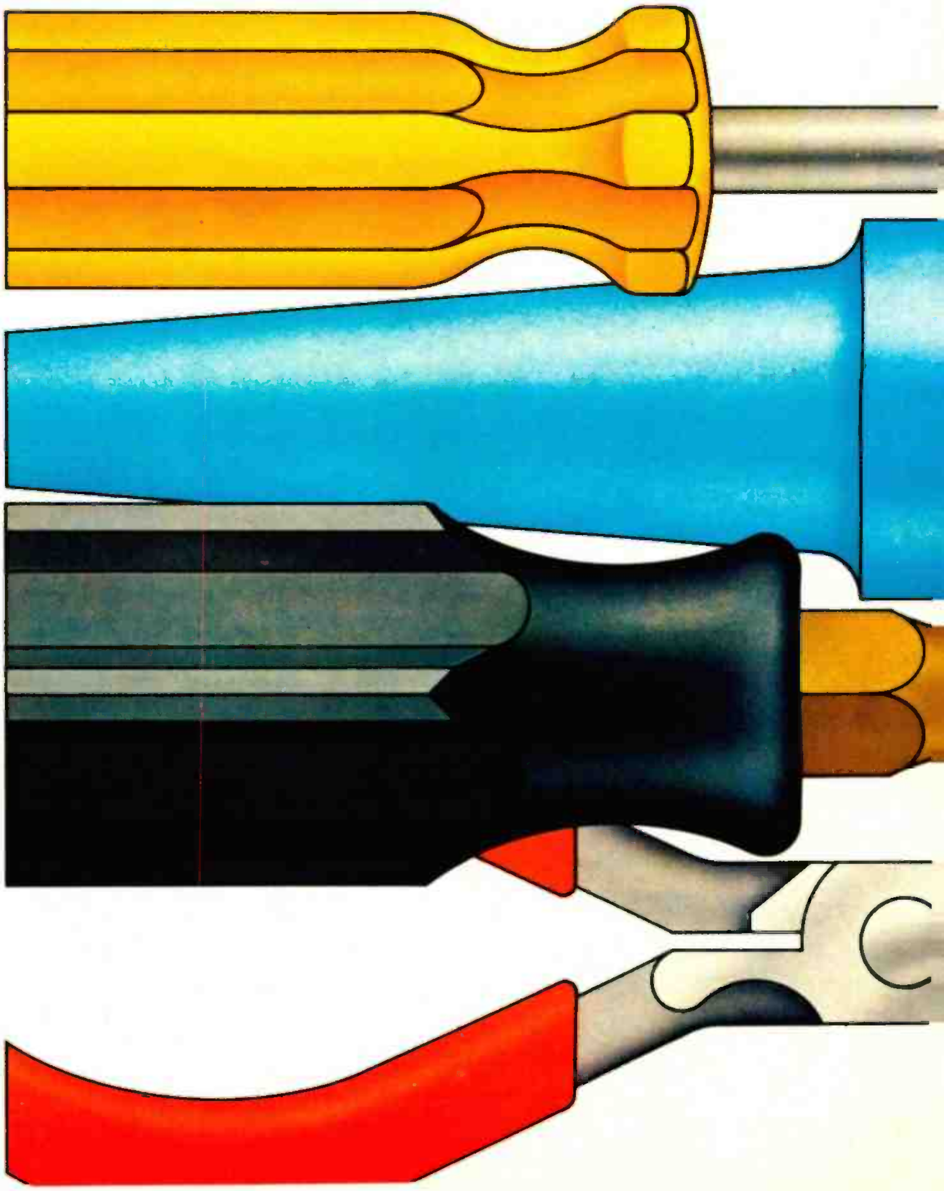

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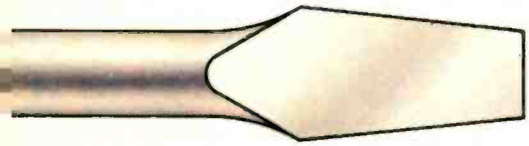

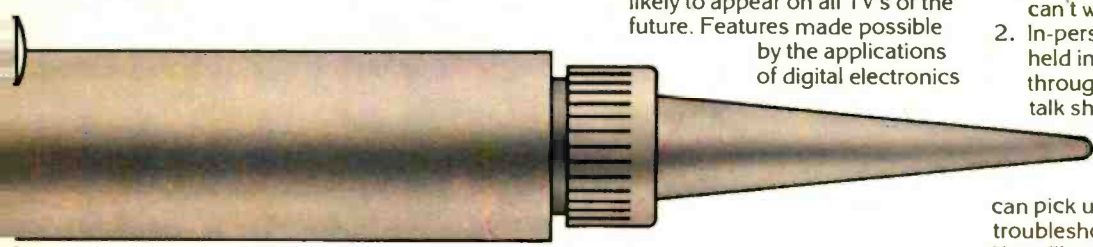

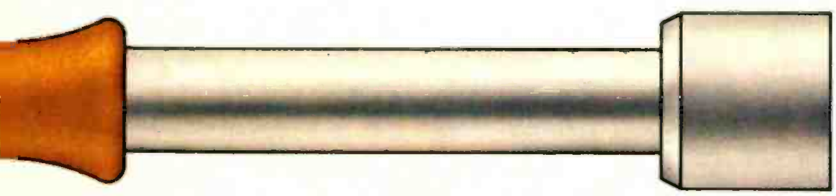

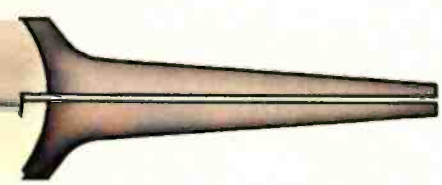

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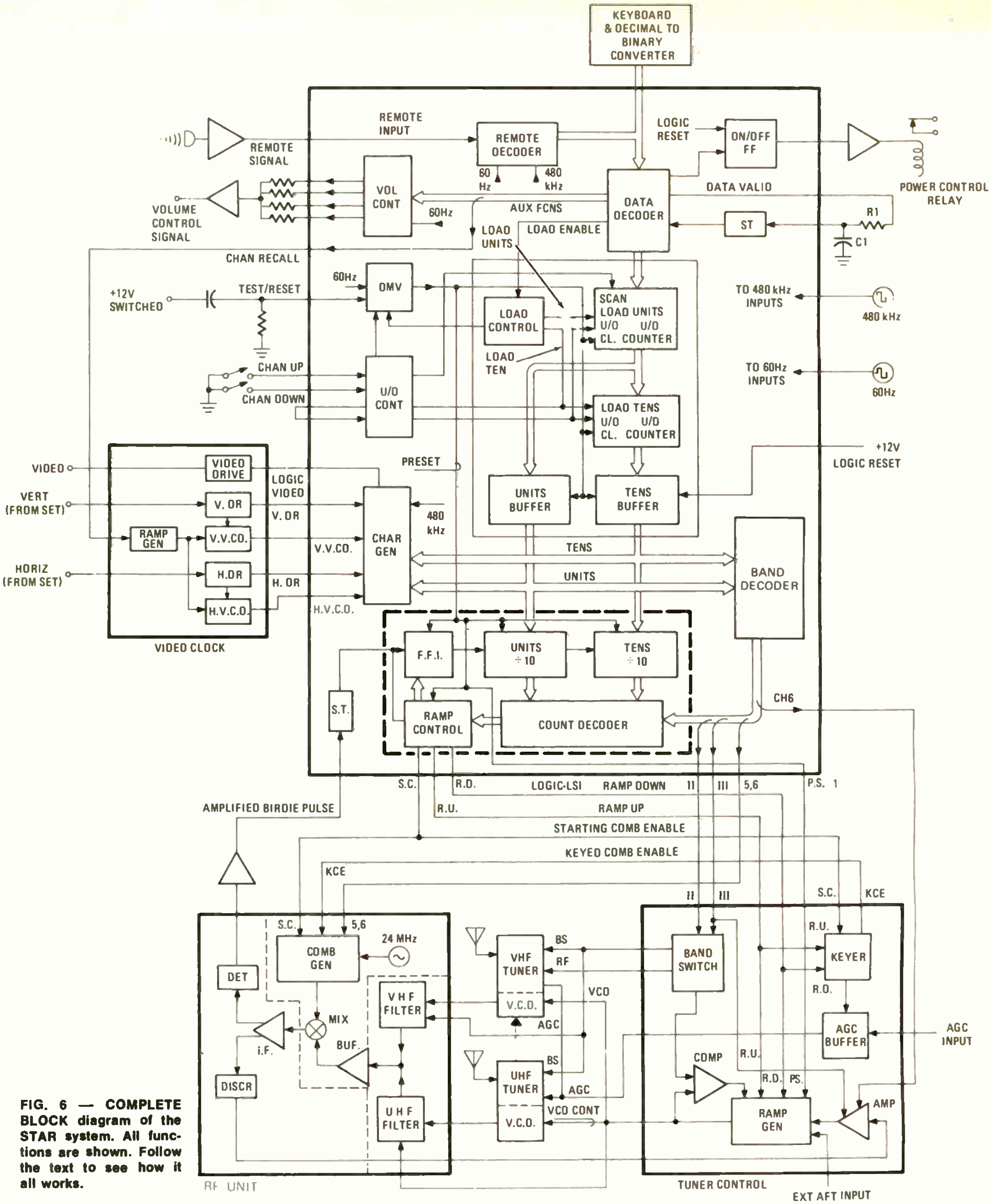

FIG. 6 — COMPLETE BLOCK diagram of the STAR system. All functions are shown. Follow the text to see how it all works.

bank, available immediately whenever the TV set is turned off and later turned on again.

In addition to channel selection, the remote system controls volume, on-off, channel recall and sound mute.

The remote keyboard is complimented by an "on set" keyboard that contains additional keys for bidirectional channel scanning.

When a channel is selected, it is identified by an "on screen" display which presents the channel number in the upper left hand corner of the screen. This fades within a few seconds but may be recalled at any time by depressing the recall button.

The STAR system incorporates three principal subsystems to provide these functions: one for tuning; a second for remote control; and the third for character generation. These share a single LSI chip (you can see it in the cover photo) containing the digital portions of all three of these subsystems. The analog portions are provided by a set of modules connecting with the LSI chip as shown in Fig. 1. The LSI chip used in the STAR system was developed by Mostek for Magnavox.

STAR SYSTEM FREQUENCY CHART

CHANNEL	TUNER OSC	REF SIGNAL	HARMONIC OF REF
BAND I			
2 lo band vhf	101	101	17th
3	107	108	18
4	113	114	19
5	123	124	31*
6	129	128	32*
BAND II			
7 hi band vhf	221	222	37
8	227	228	38
9	233	234	39
10	239	240	40
11	245	246	41
12	251	252	42
13	257	258	43
84 cable chan	173	174	29
85	179	180	30
86	185	186	31
87	191	192	32
88	197	198	33
89	203	204	34
90	209	210	35
91	215	216	36
BAND III			
14 uhf	517	516	86
15	523	522	87
↓	↓	↓	↓
82	925	924	154
83	931	930	155

*Special reference frequency (4MHz)

System operation

Data enters the system (see Fig. 1) from the keyboard on the set or the remote control. It is then separated into channel select or auxiliary functions by the data decoder. Channel-selection data is held in storage. It will program the character generator and the tuning system to the selected channel. Auxiliary functions do not enter data storage, but are diverted by the data decoder to the auxiliary function outputs.

In the STAR system a varactor tuner is used. Here, voltage variable capacitors (Varicaps) make possible the use of the voltage tuning in place of mechanical tuning. This tuning voltage is generated by a frequency synthesizer.

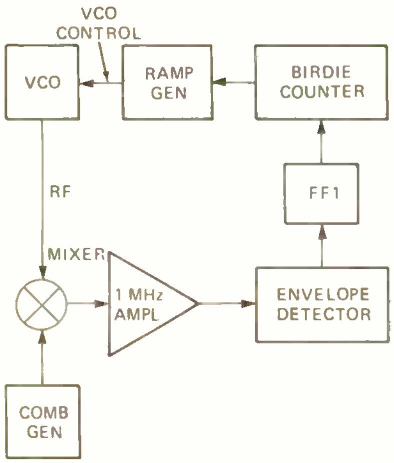

FIG. 7 — FREQUENCY SYNTHESIZER is shown in block diagram form. This circuit develops the tuning voltage.

This synthesizer, (see Fig. 7) uses a harmonic comb generator to produce spectral components spaced at 6-MHz intervals throughout the vhf and uhf bands (see Fig. 2) (a 4-MHz comb is used when tuning channels 5 and 6). The system takes advantage of the fact that these harmonics fall 1-MHz above the vhf and 1-MHz below the uhf oscillator frequencies. (see Table). This harmonic spectrum is mixed with the output of the local oscillator (L.O.) (see Fig. 3).

A ramp voltage sweeps the oscillator across the band of interest. As the L.O. frequency passes 1-MHz *below* and *above* each marker, a 1-MHz beat (or birdie) is developed at the amplifier output (see Fig. 4) A detector shapes these birdies into pulses that toggle flip-flop 1 (FF1). Therefore, FF1 delivers a positive transition each time the L.O. passes through a frequency that corresponds to a TV channel.

By starting the oscillator from a given reference frequency and counting transitions, it is possible to locate the oscillator at any desired channel. This number is controlled by programming a counter to stop the sweep when the required number of pulses have been counted.

Birdie counting is handled by a programmable down counter that is initially set to the channel number (see Fig. 4). FF1 decrements this counter as the L.O. sweeps across the harmonic comb. A decoder that monitors the counter contents, stops the sweep when the count drops to a predetermined number. This sequence is shown for Channels 2, 3 & 4 in Fig. 3.

Let's assume that channel 4 has been selected. The counter is preset to "4" and the L.O. positioned at a reference frequency located below the 102-MHz marker. Next the L.O. is swept upwards, past the 102 and 108-MHz markers. As these markers are passed, the resulting birdie pulses toggle FF1. It, in turn, steps the down counter down. When this counter state reach "1", the decoder signals the ramp control logic to "stop the ramp". The L.O. is now positioned at 113 MHz, the L.O. frequency for Channel 4.

A similar sequence is used for Channels 2 and 3. Common to all of these are the following steps.

1. The down counter is always preset to the channel number.

2. The count decoder is programmed to stop the ramp when the counter contents reach "1".

3. Flip-flop 1 (FF1) is preset so that positive output transitions occur only when the L.O. is 1-MHz below a harmonic marker.

4. The local oscillator (LO) is initially positioned at a reference frequency at the bottom of the band. This frequency acts as the starting point for that band. From this point all channels in this band are acquired.

To align the birdie count with the desired channel, the L.O. must be positioned at the proper reference frequency before counting starts. Since each band has a difference, these frequencies could be generated by three independent oscillators, one for each band. However, there is a simpler solution. It calls for only one oscillator and we use the harmonics of that oscillator for reference. This way we use a 24-MHz signal as the prime signal. The fourth harmonic, 96 MHz, is used for Band I (Channels 2, 3 & 4). (Channels 5 & 6 are also in Band I, but are a special case and are described later.) For Band II (Channels 7 thru 13 and 84 thru 91) the seventh harmonic is used. For Band III the 22nd harmonic, 528 MHz, is the reference (Channels 14 to 83). These harmonics, as well as the 6-MHz harmonics used for birdie counting, are all derived from the comb generator.

Comb generator

This circuit uses (see Fig. 5) a step recovery diode (SRD) that is driven from either a 24- or 6-MHz signal. The SRD enriches the harmonic content of these signals, to create the harmonic comb. The 6-MHz signal, derived by dividing 24-MHz by 4, drives the SRD during birdie counting. Prior to counting, the SRD is driven from the 24-MHz signal to produce the starting comb. The SRD is connected to the 6- or 24-MHz source through electronic switch S1. this switch is controlled by a signal called the starting comb enable (SC). When SC is high, S1 connects the SRD to the 24-MHz source to generate the starting comb. When SC is low, S1 connects the SRD to the divider output to generate the 6-MHz comb used for counting.

The various processes just described are elements of the channel acquisition sequence which is initiated whenever a new channel is selected.

To start this sequence, a 24-MHz comb is initially generated and the VCO is programmed to a frequency midway between the comb harmonics. This is done by a comparator which servos the ramp into the starting position. Having established this position, the VCO ramp then sweeps downwards until the first 24-MHz comb is reached. Upon contacting this comb, the ramp is reversed and the 24-MHz comb is replaced by a 6-MHz comb.

(continued on page 88)

40 PROJECTS

Using COSMOS Digital IC's

Here are 9 more COSMOS projects for you to look over. By building these simple circuits yourself, you can learn about COSMOS solid-state technology. The projects are also useful as well as educational.

by R. M. MARSTON

IN THE FIRST THREE PARTS OF THIS SERIES we looked at the basic operating principles of COSMOS digital IC's, and went on to explore a variety of ways of using the CD4001 quad 2-input NOR gate logic, inverter, gate and multivibrator applications. In this fourth part of the series we look at ways of using the CD4001 in lamp flasher, time-delay, oscillator and alarm projects.

Lamp-flasher circuits

Figure 32 shows how one half of a CD4001 IC can be used in conjunction with a couple of transistors to make a simple lamp-flasher circuit that drives a low-power lamp on and off for equal periods at a rate of roughly 1.5 seconds per cycle.

Here, one half of the CD4001 is wired as a gated astable multivrator, with its output feeding to the lamp via Q1 and Q2. When S1 is open, the astable circuit is disabled and its output is high, so zero base drive is applied to Q1, which is thus cut off: Since Q1 is cut off, zero base drive is applied to Q2, which is also cut off: There is no current flow in lamp LP1 under this condition. Note that the circuit draws virtually zero current in this state, so the supply does not need to be disconnected when the circuit is in this 'standby' mode.

When S1 is closed, the astable circuit is enabled, and its output switches alternately between zero and the full positive supply voltage at a rate of roughly 1.5 seconds per cycle. When the output is high, Q1—Q2 and the lamp are off. When the output is low, Q1—Q2 and the lamp are driven fully on. Thus, the lamp flashes on and off once every 1.5 seconds. The flashing rate is proportional to the R1 value, so the period can be increased to 15 seconds per cycle by simply increasing the R1 value to 10 megohms. The R1 value can in fact be varied from a few thousand ohms to thousands of megohms, to give any required flashing period.

This lamp-flasher circuit has a duty cycle or mark-space ratio of approximately 1:1, so the lamp turns on and off for approximately equal times.

Figure 33 shows how the circuit can be modified to give a programmed duty cycle so that, for example, the lamp turns on for a single period of only 0.75 seconds in each 8.25 second cycle, thus giving a 1:10 duty cycle and giving considerable current economy as an emergency lamp flasher. The ON time of the lamp is controlled by R1 and D1, and is fixed at about 0.75 seconds, but the OFF time is controlled by R2 and D2, and can be varied over a wide range. When R2 is given a value of 1 megohm, the lamp has an OFF time of 0.75 seconds, and when R2 has a value of 10 megohms, the OFF time is about 7.5 seconds. The value

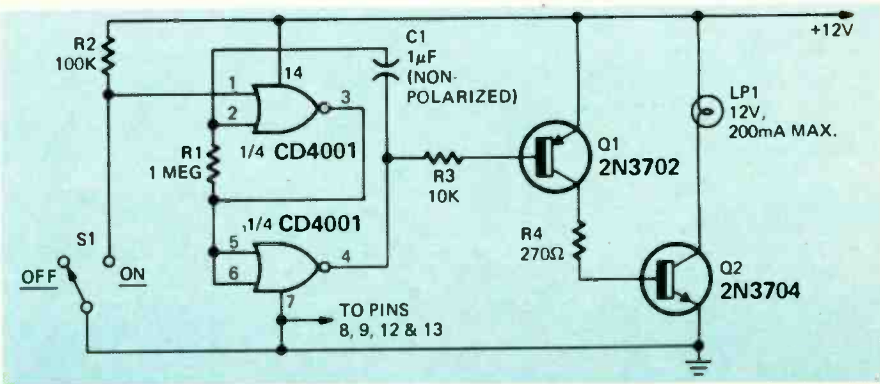

FIG. 32—SIMPLE LAMP FLASHER. One IC and a couple of transistors are the active components.

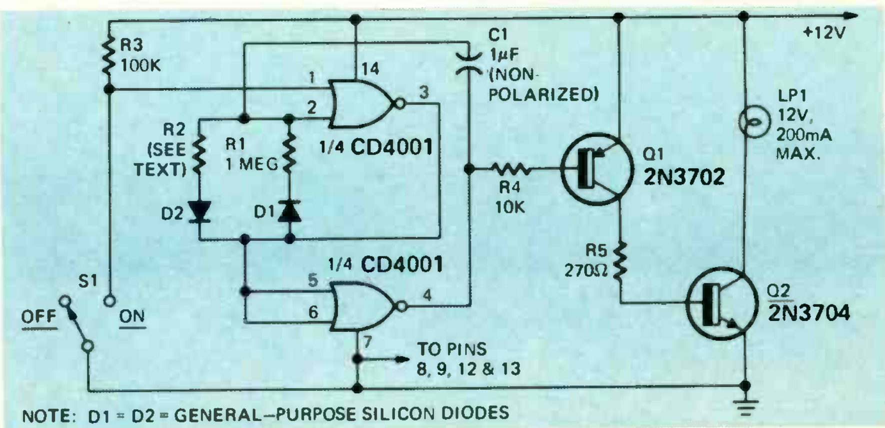

FIG. 33—PROGRAMMED-DUTY-CYCLE lamp flasher.

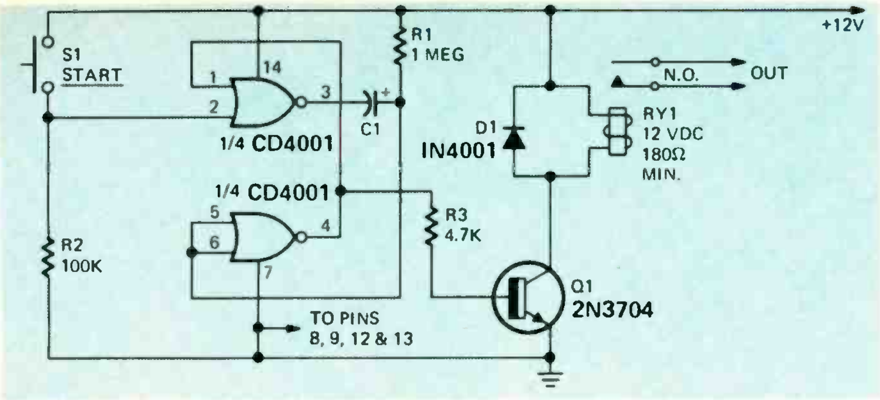

FIG. 34—AUTO-TURN-OFF RELAY time switch.

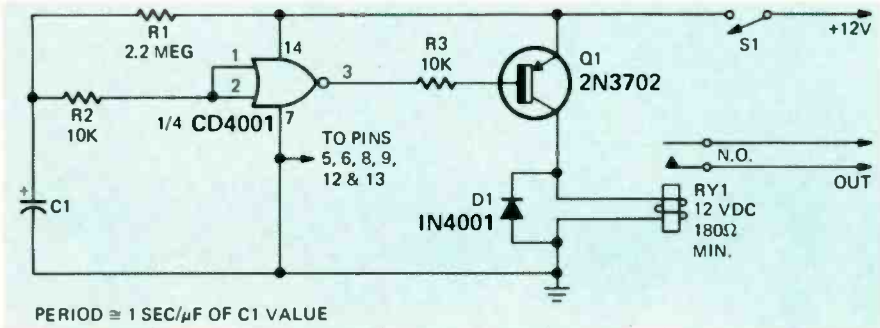

FIG. 35—DELAYED-TURN-ON relay time switch.

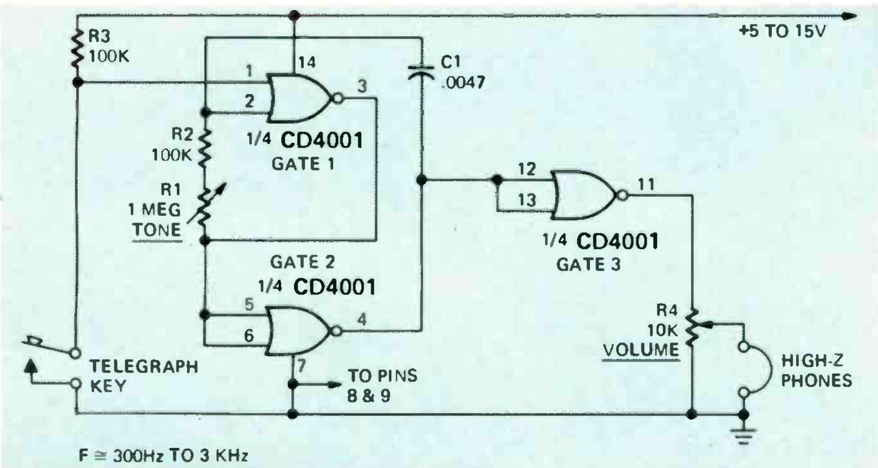

FIG. 36—CODE PRACTICE OSCILLATOR.

of R2 can be varied from a few thousand ohms to thousands of megohms, as required, to give any desired OFF time.

Note that the circuits in Figs. 32 and 33 are both designed to work from a 12-volt supply, and that lamp LP1 can be any 12-volt type with a current rating up to 200 mA. Lamps with higher current ratings can be used if a suitably rated power transistor is used for Q2.

Time-delay circuits

COSMOS digital IC's are ideally suited for use in relay-driving time-delay applications, since they draw virtually zero standby current and have near-infinite input impedances. Figure 34 shows the practical circuit of a COSMOS auto-turn-off relay time switch, in which the relay turns on as soon as START button S1 is momentarily closed, but turns off again automatically after a pre-set period. The delay period can readily be varied from a fraction of a second to about fifteen minutes by selecting the value of C1.

The operation of the circuit is quite simple. One half of the IC is wired as a gated monostable multivibrator, with its output feeding to the relay via Q1. When the circuit is in its quiescent state, the output of the monostable is low, so zero base drive is applied to Q1, and Q1 and the relay are off. The circuit draws virtually zero current under this condition. When S1 is momentarily closed, the monostable fires, and its output goes high and drives Q1 and the relay fully on: After a pre-set period, the monostable completes its period and its output automatically goes low again, so Q1 and the relay turn off and the circuit current falls to near-zero again.

The circuit gives a period of roughly 1 second per µF of C1 value. Thus, if C1 has a value of 10 µF, the delay is 10 seconds, and if C1 has a value of 1000 µF, the delay is in excess of 15 minutes.

Figure 35 shows how one of the four gates of a CD4001 IC can be used to make a delayed-turn-on relay time switch, in which the relay does not turn on until a pre-set time after S1 is closed. Note that the gate is connected as a simple inverter. Circuit operation is as follows.

When S1 is first closed, C1 is fully discharged, so at this moment the R1—R2 junction is effectively shorted to ground. Consequently, the output of the inverter-connected gate is at full positive supply voltage under this condition, and Q1 and the relay are cut off. Shortly after S1 closes, C1 starts to charge up via R1, and an exponential rising voltage is applied to the input of the gate.

Eventually, after a pre-set period, this voltage rises to the transfer voltage value of the gate, and at this point the output of the gate switches into the low or grounded state and drives Q1 and the relay on. The relay then remains on until S1 is opened again, at which point C1 discharges rapidly via R2 and built-in input protection diode D1 (see Fig. 7-b in the September 1974 issue) of the gate. The operating sequence is then complete.

Precise delay period circuit depends on the values of R1 and C1, and on the value of transfer voltage of the particular CD4001 IC that is used. When R1 is 2.2 megohms, as in the diagram, a delay of roughly 1 second is available per µF of C1. A delay or roughly 10 seconds can thus be obtained by giving C1 a value of 10 µF, and a delay in excess of 15 minutes can be obtained by giving C1 a value of 1000 µF.

Note that the circuits of both Figs. 34 and 35 are designed to operate from 12-volt supplies, and that the relays used can be any 12 volt types having coil resistances of 180 ohms or greater.

Finally, note that the timing capacitors (C1) used in these two circuits must have leakage impedances greater than 5 megohms if the circuits are to operate correctly.

Oscillator and alarm generator

The CD4001 IC can be used in a variety of audible-output oscillator and alarm-call generator circuits. Figure 36, for example, shows how the IC can be used as an efficient Morse-code practice oscillator. Here, gates 1 and 2 are wired as a variable-frequency gated astable multivibrator, which can be turned on and off via the Morse key. The output of the astable is taken to a set of high-impedance phones via gate 3, which is connected as a simple inverter. R4 resistor is a volume control.

Normally, when the key is open, the oscillator is disabled and the output of gate 3 is at ground potential, so virtually zero current flows through the circuit under this condition. In fact, the standby current is typically of the order of .004 µA, which is less than the normal leakage current of a supply battery, so there is no need to wire an ON-OFF switch into the supply leads.

When the key is closed, the astable circuit is enabled, and a square-wave sig-

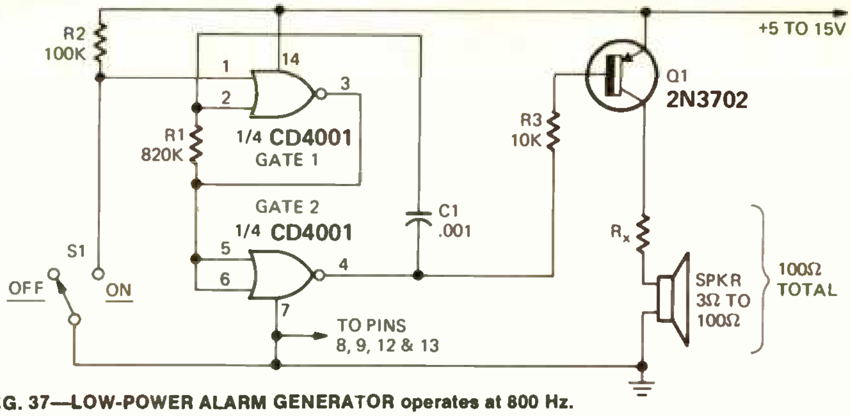

FIG. 37—LOW-POWER ALARM GENERATOR operates at 800 Hz.

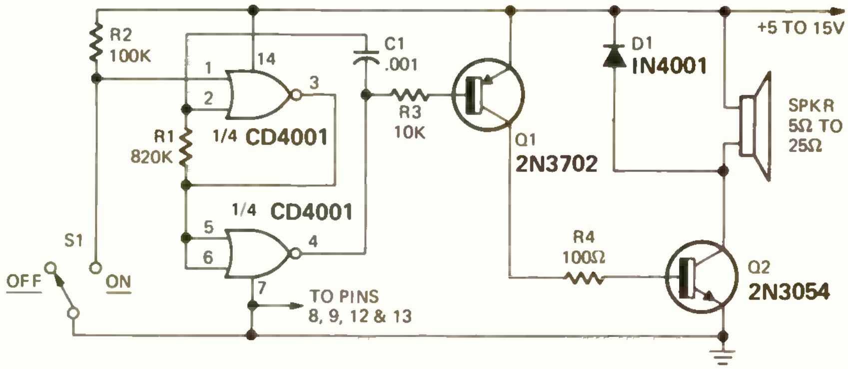

FIG. 38—MEDIUM-POWER (0.25W to 11.25W) alarm generator.

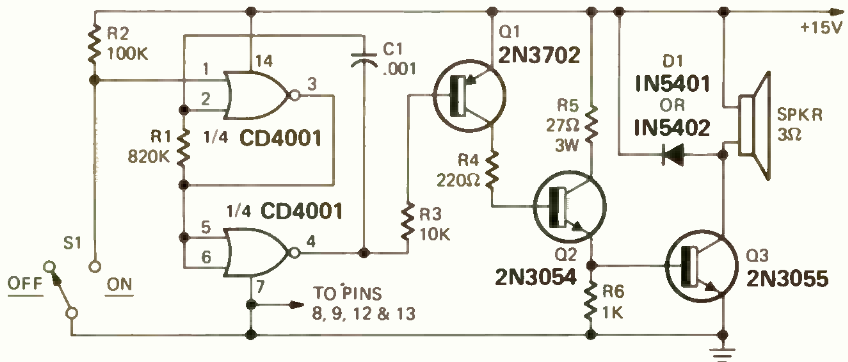

FIG. 39—HIGH POWER (18W) alarm generator.

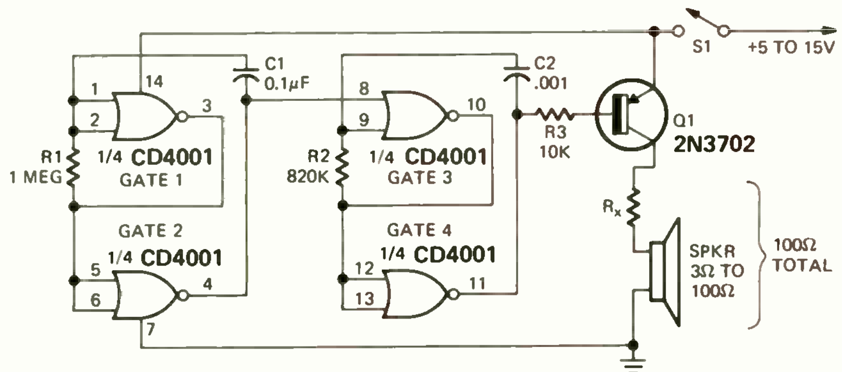

FIG. 40—PULSED LOW-POWER alarm generator.

nal is applied to the phones via R4. The frequency of oscillation can be varied between 300 Hz and 3 kHz via R1, which acts as a TONE control, and the peak amplitude of the phones signal can be varied between zero and the full supply voltage via R4. Note that a short circuit can be placed directly across the output of the device without causing damage to the I.C. The circuit can operate from any supply in the range of 5 to 15 volts.

Figure 37 shows how the CD4001 can be connected for use as a low-level fixed-frequency alarm-call generator circuit. Here, gates 1 and 2 are wired as a gated astable multivibrator that operates at approximately 800 Hz, and the output of the astable is connected to switching transistor Q1 via R3. Q1 uses the speaker and limiting resistor R_x as its collector load.

The action of the circuit is such that Q1 is driven alternately on and off at a frequency of 800 Hz when S1 is closed, so drive current is pulsed into the speaker under this condition. The speaker and limiting resistor R_x should have a total series resistance of 100 ohms. The available acoustic output power of the circuit depends on the value of supply voltage used, and on the impedance of the speaker. Using a 9-volt supply, the mean output current is fixed at about 40 mA, so the output power to a 15-ohm speaker is about 25 mW, and to a 100-ohm speaker is about 160 mW.

The output power of the circuit can be boosted to a higher level by modifying the design as shown in Fig. 38. Here, the output of Q1 is used to provide base current drive to output power transistors Q2, which uses the speaker as its collector load. The speaker can have any impedance in the range 5 to 25 ohms, and the supply can have any voltage in the range 5 to 15 volts. The actual output power of the circuit depends on the combination of supply voltage and speaker impedance that is used, and ranges from 250 mW when a 25-ohm speaker is used with a 5-volt supply, to 11.25 watts when a 5-ohm speaker is used with a 15-volt supply.

The output power can be boosted to about 18 watts by further modifying the circuit as shown in Fig. 39. Here, transistors Q2 and Q3 are super-alpha connected to give high gain, and the circuit is designed to operate from a fixed 15-volt supply and to use a 3-ohm speaker.

Note that protection diodes are wired across the speakers in Figs. 38 and 39. These diodes are used to prevent the collector voltages of the output transistors from swinging above the supply voltage as the inductive speaker loads are pulsed with current. The diodes must have current ratings of at least 1 amp in the Fig. 38 circuit, and of at least 3 amps in the circuit in Fig. 39. Also note that the Fig. 38 circuit passes a typical standby current of about 10 μA, and the Fig. 39 circuit passes a standby current of about 30 μA, due to the leakage currents of the transistors used.

The three alarm-generator circuits that we have looked at so far each produce a fixed or monotone output which is, by definition, monotonous to listen to. A more attractive and attention-catching sound is made by the basic pulsed low-power alarm generator circuit of Fig. 40.

Here, gates 1 and 2 are wired as a fixed-frequency astable multivibrator that operates at a frequency of about 6 Hz, and gates 3 and 4 are wired as a gated 800-Hz fixed-frequency oscillator. The 800-Hz oscillator is gated on and off via the 6-Hz oscillator, and its output feeds to the speaker via Q1 and R_x. The circuit can be operated from any supply in the range 5 to15 volts, and can be turned on and off via switch S1.

In this fourth part of the series, we have looked at different ways of using the CD4001 in lamp flasher, time-delay, oscillator and alarm projects.

Next month we will conclude the alarm projects and show you different electronic alarm control circuits. **R-E**

HOW IT WORKS
IC MOS shift registers

Do you know what a MOS shift register is? Do you know how it works? Here are the answers plus how to interface them with other logic families and different applications

by DON LANCASTER

A SHIFT REGISTER IS A DIGITAL DATA STORAGE device. The data can be the letters to be displayed on a TV screen, numbers in a computer or calculator, intermediate values in a digital filter, or part of an elaborate code or sequence. Shift registers are made up of individual *stages*. Each stage can store one *bit* of information, called a binary 1 or a 0, and usually corresponding to a "yes" or "no" or else perhaps a "present" or "absent" command. Four bits together can represent a decimal number, while six bits together can handle one ASCII character, and so on. In a shift register, the contents can be moved or *shifted* so that the contained information is marched one and only one stage at a time through the device. The shifting process is called *clocking* and one or more clocks are involved in completing the shifting operation.

Figure 1 shows how we might make a shift register out of either a JK or type-D flip-flop. While TTL (Transistor-Transistor logic) devices are shown, we could use any logic family we like. Input data corresponding to a "1" or "0" is presented to the first stage. When the system is clocked, the first bit of data is *entered* and then stored in the *first* stage. On the second clocking, the contents of the first stage get passed on to the second, and the first stage then accepts a new bit of information from the input. The next clocking passes the output of stage 2 on to stage 3, and the output of stage 1 on to stage 2. Finally, stage 1 accepts a new bit of input information.

One more clocking *fills* the register in Fig. 1 as it is only four bits long, and all four stages now have information in them. If we do no more clocking, the register will *keep* the information we sent it. Four more clocking pulses and we can march the data out and use it somewhere else.

So what good is a shift register? We can use it to *store* information. It is a digital *memory*. We can use it to *delay* information. We can use it to *format* information, either in a *buffer* mode where the enter and readout clock rates may be different, or in a *variable-access* mode where we can enter and leave individual stages with data. With certain types of shift registers, we can convert *serial* data to *parallel* form or parallel data (all at once) to serial (one at a time in sequence) form. We can also build counters and sequencers with shift registers. Two popular types are called the *walking ring* computer and the *pseudo random sequence* generator.

Organization

The *organization* of a shift register is decided by how many stages it has and how you can get at the individual stages.

A serial-in-serial-out register gives you the input only to the first stage and the final output of the last stage. it is sometimes called a *serial* register or a SISO (Serial-in-Serial-Out) register. There is no intermediate access.

A SIPO register gives you the outputs of all stages including the last one. The eight-bit 74164 is a typical TTL example. A parallel-in-serial-out or PISO register lets you simultaneously load all the stages but then marches the contents out as a serial-bit string. The TTL 74165 is an eight-bit example of this type.

The most versatile type of shift register would be a PIPO (Parallel-In-Parallel-out) version. Here, you could load data either serially one bit at a time or "broadside" parallel. You could also get all the data out either in broadside parallel all-at-once form, or one bit at a time in serial form. The 74195 is a four-bit TTL package that does this.

You might think that since you could use the PIPO register for everything else anyway that it would be the only way to go. The problem is that you can easily put 2048 shift register stages on a single small chip of silicon. For a 2048-bit PIPO register, you'd need a minimum of 4099 leads for inputs, outputs, clocks, and power supplies. This is a most unwieldy package to say the least, even if we don't worry about the extra circuitry needed for each parallel input. Now the same register can be done SISO in as little as 5 leads.

So, for *short* shift register applications, we have a choice of the four formats. For *long* shift register uses, the only economical way to go is the SISO route. We'll consider everything longer than 24 bits a *long* shift register here. This is often a changeover point. 24 bits or less and you usually use the more flexible and faster TTL registers, often at four or eight stages per package. Above 25 bits, you go to the long serial MOS registers and pick up as many as 2048 bits of storage in a single package.

The majority of registers shift only towards the output and are called *shift right* registers. A very few can also shift back towards the input and are called *bidirectional* or *shift-right-shift-left* devices. These are expensive and not normally available in long lengths. One trick you can do with a *recirculating* register (more on this in a bit) is clock it rapidly ahead one stage less than its length, making it *appear* to back up one, rather than go forward *all but one* of its stages.

Two more things may enter into our register organization. We may have more than one shift register in a single package. One, two, and six registers per package are common. Usually, they have common clocking, but not always. For instance, the Signetics 2518 is a hex 32-bit shift register; the 2519 is a hex 40-bit version. Both have common clocking and a common enter/recirculate control.

You often use several shift registers in parallel. For instance, you might use four shift registers to individually handle each bit of a four-bit BCD or binary-coded-decimal digit. Thus each clocking of the register array gets you a whole new decimal number, rather than only ¼ of it The four bits is sometimes called a *word* and sometimes a *byte*. Likewise, an alphanumeric character can be represented by a six bit ASCII character code. Here, we use six registers at once to give us one whole new character on each clocking. Of course, we have to make sure all the registers get clocked exactly alike, for if they didn't, all the data bits would be hopelessly scrambled. This is usually very easy to prevent.

A final feature of a shift register's organization is its *recirculatibility*. Sometimes we might like to look at the contents of a shift register a bit at a time, and then *return* the information back into the same relative slots in the shift register for later use. This is called *recirculation*. Some sort of switching or selection must be provided if you are sometimes going to *enter* new data as opposed to recirculating old data. Some of the long MOS shift registers have an *internal* recirculate logic and are normally used if you need recirculation. We'll see in a minute that recirculation is essential for the *dynamic* registers if you are going to keep the data more than a fraction of a second. Figure 2 shows the logic needed to add an external recirculate to a shift register.

Long MOS shift registers

There's an incredible variety of long shift registers available using several different MOS (Metal-Oxide-Semiconductor)

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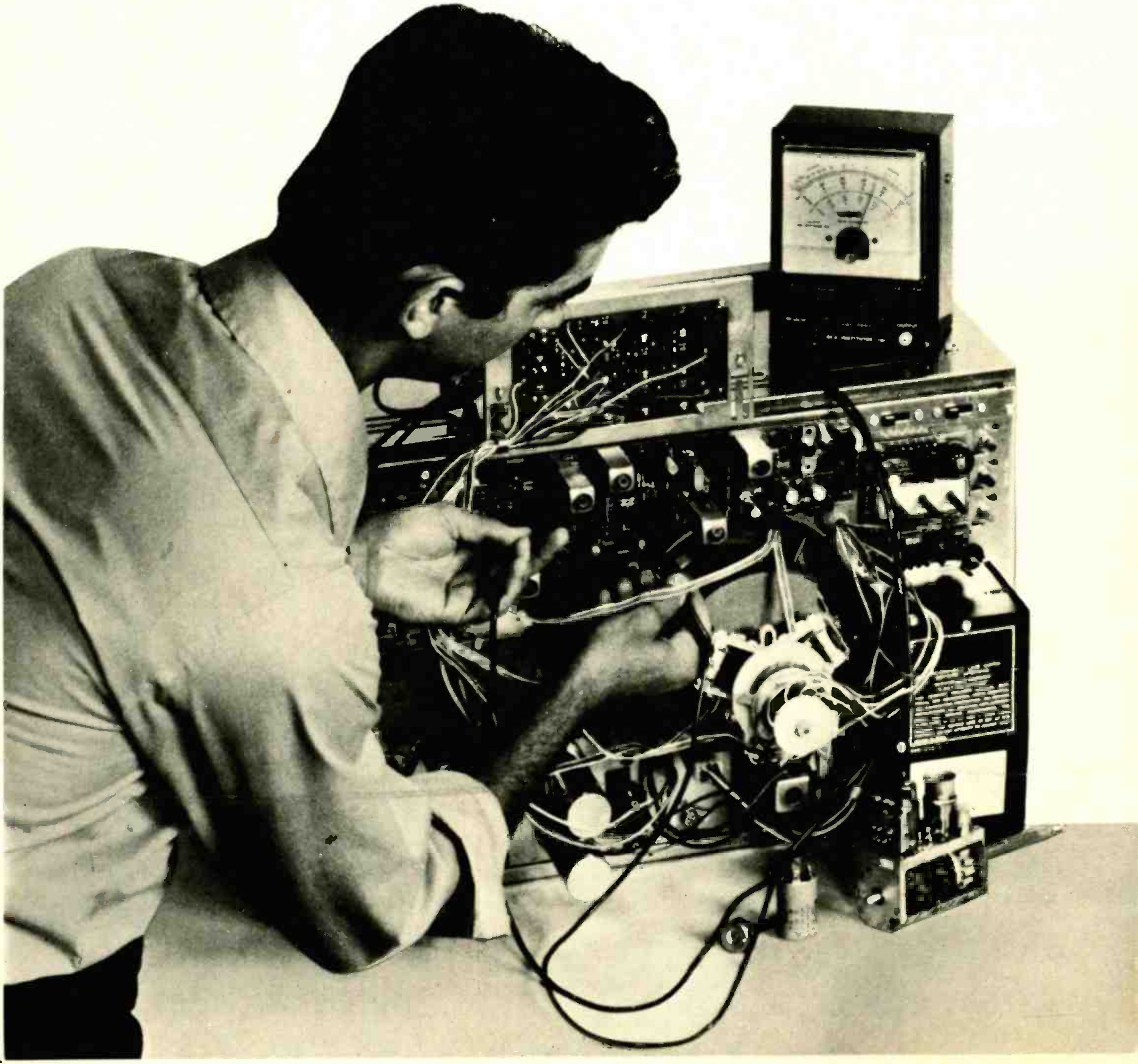

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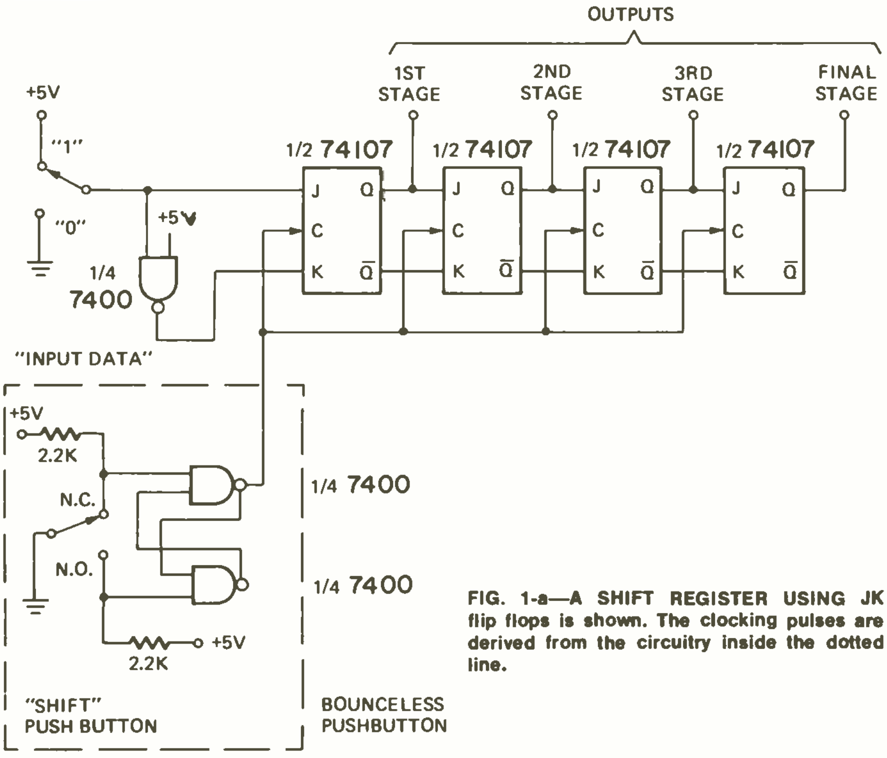


FIG. 1-a—A SHIFT REGISTER USING JK flip flops is shown. The clocking pulses are derived from the circuitry inside the dotted line.

(*a*) USING "JK" FLIP FLOPS

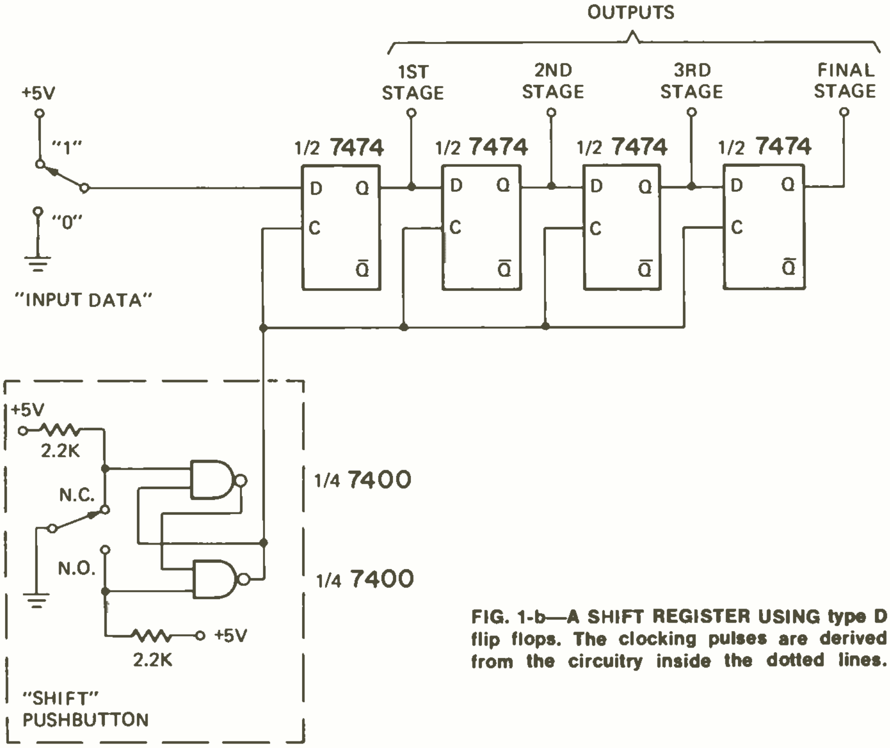


FIG. 1-b—A SHIFT REGISTER USING type D flip flops. The clocking pulses are derived from the circuitry inside the dotted lines.

(*b*) USING "D" FLIP FLOPS

technologies. These range from small 16- and 21-bit versions up to 2048-bit ones in a single package. A brief and more or less random listing is given in Table I, while some of the more prominent manufacturers are listed in Table II. The typical single-unit price varies from around $3 to around $15 per unit and typically runs well under a penny per bit for the longer versions. Some of these have shown up surplus (see back ads of **Radio-Electronics)** for as little as a quarter each for manufacturers seconds. Some of the seconds we tested from the back ads run around a 45% "completely useful" yield. All of these devices are serial-in-serial-out. Typical maximum frequency of operation is 2 or 3 megahertz, although you get much better behavior at a 500 kHz or so rate.

Before you can use any long MOS shift register, you have to ask the following questions:

1. Is the register *static* or *dynamic?*
2. How do you *interface* it with TTL or other logic?
3. What kind of *clock* signals are needed and how many of them?
4. Can it recirculate by itself?
5. Does it have write or read *enables* that lets you combine it with more registers?

Let's take a look at these important concepts in a bit more detail.

Static versus dynamic

Figure 3 shows three different types of shift registers. Our registers of Figs. 1 and 3-a used two flip-flops for storage. They will keep data so long as we apply supply power and are called *static* registers, or sometimes *fully static* registers.

Transformation of information in *any* shift register *has* to be a *two-stage* process or a *two-phase* process. On the beginning of a shift, information is transferred into some form of temporary storage. At the completion of a shift, the information is then sent to a *final* storage. In the case of Fig. 1-a, we have a master (temporary) and a slave (final) storage *within* each JK flip-flop's logic block. The reason for the *necessity* of *two* storage phases per shift is simple—try it with only one, and you get a wild, unchecked race through several stages instead of an orderly progression of one and only one complete stage per clocking.

We don't need a full flip-flop for some applications. Instead, we can use the temporary storage of a capacitor. So, Fig. 3-b shows us a *dynamic* shift register. The capacitor will hold information for us for a reasonably short time, but eventually the leakage will get to us and destroy the information in the cell. Capacitor storage is much simpler and more economical than flip-flops as it usually uses the "free" capacitance found in normay strays. Most dynamic MOS shift registers will hold their information for UP TO one-tenth of a second. Should you fail to clock them in that time, the information is lost.

So, if you are only going to keep your information in your shift register for under a fraction of a second before finally using it, it doesn't matter whether you use a static or a dynamic register. The trouble is that most applications call for data to be reused or held longer than a fraction of a second. So, if you are to use the cheaper, denser dynamic shift registers, you have to move or *refresh* the data a minimum of several dozen times a second. One way to handle the moving of data is to march the information completely once around at least several dozen times per second. In a computer terminal or TV Typewriter, recirculation at the 60 hertz vertical rate is one good approach.

Figure 3-c shows an interesting compromise between static and dynamic registers. Here, we use a capacitor for the temporary storage and a flip-flop for the final storage. This is a compromise that gives us static performance at slightly over half the normal cost. Strictly speaking, this is called a *quasi-static* operation, but practically all the "static" MOS reg-

isters use this technique. There is only one restriction, the clock line must remain in a specified level during the static part of the operation, and there is a *maximum* allowable clock pulse width during the dynamic transfer process.

Interface

Most of the long MOS registers will interface with TTL, DTL, and RTL, but most often a few resistors are needed. You have to read the data sheets very carefully. Unless the data sheet specifically states otherwise, the clock lines are NOT compatible with TTL and take special drive circuitry. More on this in just a bit. Remember that the inputs, enables, recirculates, and output pins can be made TTL compatible, but the clock almost always takes special circuitry.

There are lots of different MOS technologies, and each takes one of the interface circuits shown in Fig. 4. You can usually tell the technology by the supply voltage used or recommended.

If the supplies are ±15 volts, chances are it is a *metal gate* or *high threshold P channel device*. These are the oldest MOS integrated circuits and the hardest to interface. To drive them, you need an *open circuit* TTL logic block that can withstand 15 volts. Suitable devices are the 7406 and 7416. A pull-up resistor is provided to produce the ground and ±15-volt logic inputs. Two resistors are normally used in going from the MOS to TTL, one down to −15 to provide the −1.6 mA needed for a TTL "0", and one series resistor to limit the positive swing to 5 volts or less.

Silicon gate circuits are presently the most common. They have a +5 and −12-volt supply. Usually a 2.2K pull-up resistor is recommended when they are driven by TTL, and their output drive capability depends on the particular output structure used. Often a single 6.8K resistor to −12 volts does the trick.

N-channel circuits often work with a single +5-volt supply and are directly TTL compatible without resistors on output and input. *CMOS* integrated circuits also work off a single +5- to +15-volt supply. At +5 volts, they are directly TTL compatible on an input, but may not have enough output drive current for regular TTL, so low-power TTL is often used as an output sense amplifier.

Its usually tricky to simultaneously drive another MOS stage along with TTL as the voltage and current swings don't usually work out too well. To get around this, you usually run through a single TTL inverter and use its output to drive the MOS following.

Clocks

More problems happen with long shift registers over clocks and clocking than over any other single difficulty. First and foremost, consult the individual data sheets for the device you are going to use. Unless it specifically says so otherwise (boldly and in large print!), the clock lines are not compatible with TTL. Usually the clock lines need almost the entire supply swing, such as a 16- or 17-volt swing for a silicon gate circuit on +5-, −12-volt power supplies. Further, what-

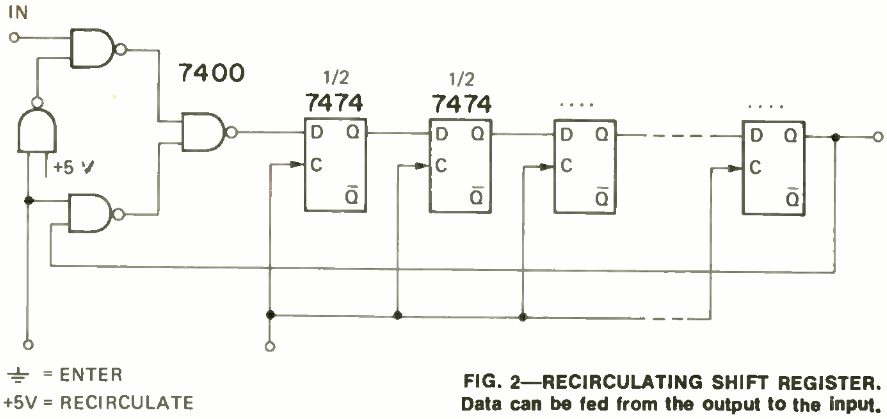


FIG. 2—RECIRCULATING SHIFT REGISTER. Data can be fed from the output to the input.

TABLE I
A FEW OF THE MORE POPULAR LONG MOS SHIFT REGISTERS

ELECTRONIC ARRAYS:

EA1003 Dual 32, static, rec.
EA1004 Dual 100, static
EA1007 Dual 32, static
EA1200 Quad 32, dynamic
EA1203 Variable 1-64 dynamic
EA1210 Dual 526 dynamic
EA1212 Single 512 Dynamic

FAIRCHILD:

3325 Quad 64, Dynamic
3330 480 Bit, Dynamic
3342 Quad 64, Static
3343 Dual 128, Static
3346 Dual 144, Static
3383 Single 256, Dynamic

INTEL:

1402 Quad 256, Dyn, Mpx.
1403 Dual 512, Dyn, Mpx.
1404 Single 1024, Dyn, Mpx.
1405 Single 512, Dyn, Recirc.
1506 Dual 100 dynamic
2401 2048 dynamic, recirc.
2405 1024 dynamic, recirc.

MOSTEK:

MK1002 Dual 128, Static
MK1007 4 x 80, dynamic

MOTOROLA

MC1141G Triple 66 dynamic
MC1142G Single 200 dynamic
MC1160G dual 100 dynamic
MC1161G Dual 50 bit static
MC2360G Dual 100 Static
MC2361G Dual 128 Static
MC2362G Dual 250 Static
MC2363G Dual 256 Static
MC2380G Dual 100 dynamic

NATIONAL:

MM400 Dual 25 Dynamic
MM402 Dual 50 Dynamic
MM406 Dual 100 Dynamic
MM4001 Dual 64 Dynamic
MM4006 Dual 100 Dynamic
MM4012 Dual 256 Dynamic
MM4013 Single 512, dyn, rec.
MM4105 Quad 64, static
MM5054 Dual 64/72/80 static

SIGNETICS:

2505 Single 512 dyn, rec.
2506 Dual 100, dynamic
2509 Dual 50 Static
2510 Dual 100 Static
2511 Dual 200 Static
2512 Single 1024, dyn, rec.
2518 Hex 32, static, rec.
2519 Hex 40, static, rec.
2521 Dual 128, static
2522 Dual 128, static
2524 Single 512, dyn, rec.
2525 Single 1024, dyn, rec.
2527 Dual 256 static
2528 Dual 250 Static
2529 Dual 240 Static
2532 Quad 80 static
2533 1024 static, rec.

TEXAS INSTRUMENTS:

TMS3000 Dual 25 static
TMS3001 Dual 32 static
TMS3002 Dual 50 static
TMS3012 Dual 128, stat, rec.
TMS3102 Dual 80, static
TMS3112 Hex 32, static, rec.
TMS3113 Dual 133 static, rec.
TMS3304 Triple 66, dynamic
TMS3309 Dual 512, dynamic
TMS3314 Triple 60+4 dynamic
TMS3412 Single 1024 Dynamic

TABLE II
SOME LONG MOS SHIFT REGISTER SOURCES

ELECTRONIC ARRAYS INC.
501 Ellis Street
Mountain View, California 94040

FAIRCHILD SEMICONDUCTOR
464 Ellis Street
Mountain View, California 94040

INTEL CORPORATION
3065 Bowers Avenue
Santa Clara, California 95051

MOSTEK
1215 West Crosby Road
Carrolton, Texas 75006

MOTOROLA SEMICONDUCTOR
Box 20912
Phoenix, Arizona 85036

NATIONAL SEMICONDUCTOR
2900 Semiconductor Drive
Santa Clara, California 95051

SIGNETICS
811 East Arques Avenue
Sunnyvale, California 94086

TEXAS INSTRUMENTS
Box 5012
Dallas, Texas 75222

ever is driving the clock has to drive a bunch of internal switches in a long register, so the clock line capacitance may be several hundred picofarads. Since you need sharp rise and fall times on the clock, it usually takes a special circuit called a *clock driver* to get the job done, as the peak currents involved in charging and discharging the clock line capacitances may be several hundred milliamperes or more. Except for the simplest circuits, a push-pull "totem pole" drive circuit is needed, and a small current limiting resistor (usually 10 ohms) must be provided between the registers and clock lines to prevent short circuit damages and risetimes that raise havoc with the supply lines and decoupling. The clocks must NEVER be allowed to "overshoot" and exceed the positive supply voltage, even briefly for this will destroy or selectively change the information in the register. Clocks must be the proper widths and must not overlap. Where two clocks are used, the "daylight" or space between them is just as important as their widths.

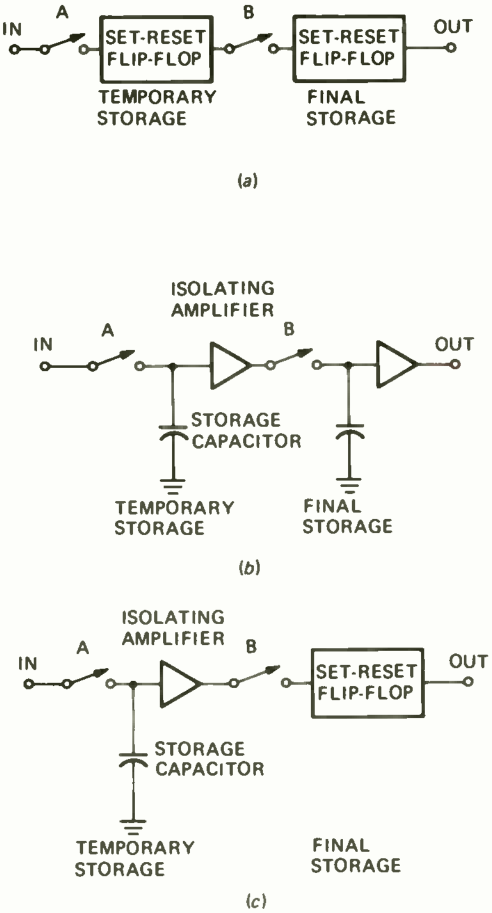
As a general rule, always use clock widths near the *minimum* called for on the data sheets. With most registers, the wider the clock pulses, the more the supply current, and the hotter the IC runs, leading to potential temperature and bit pattern sensitivity problems. Clock widths should be precisely derived from system timing instead of randomly adjusted through monostables or half-monostable pulse shapers, since the position and widths can be quite critical.

On your first design with a new long MOS register, you also have to watch for the number of clocks needed per cycle. Generally static registers need a single clock and each clock pulse advances the information one stage. Static registers are also usually much easier to drive on their clock lines.

Most dynamic registers have two clock lines and need two clock drivers. One clock is the *input* clock; one is the *output* clock. A *pair* of clock pulses is needed to advance the information one stage.

Finally, there are a few dynamic *multiplexed* registers such as the *Intel* 1402, 1403, and 1404. These are tricky and hard to use. They contain *two* internal shift registers with a *common* input and output. What is an input clock for one side is the output clock for the other half and vice versa. The data *externally* appears to travel one stage *per* clock pulse, although a *pair* of clock pulses is needed to *complete* each transfer operation. If you are not very careful, you can end up one clock pulse short or long of what you really need, and change the effective register length.

Note that any of these devices can have the clocks spaced out in time. They need not be continuous. They can be in bursts or random, so long as you don't exceed the minimum clock width and "daylight" spacing, and so long as you don't wait



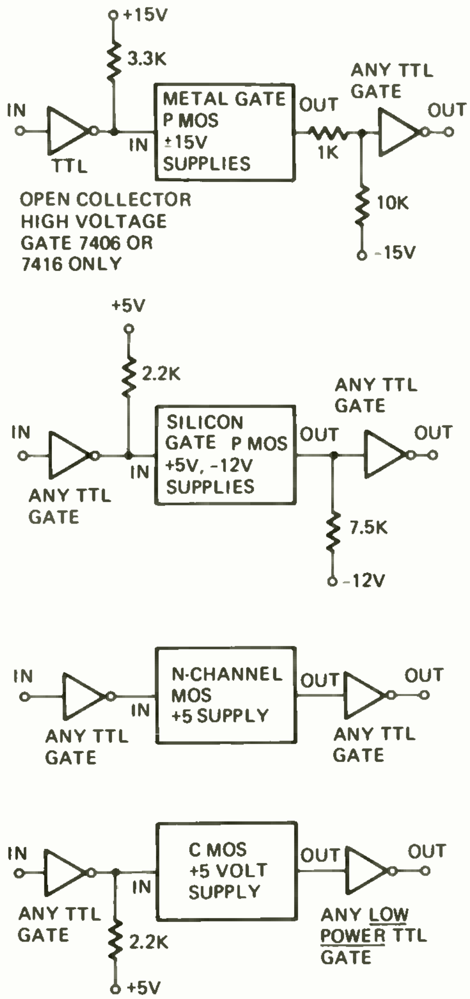


FIG. 3 (top of page)—STATIC shift register. b) DYNAMIC shift register. c) QUASI-STATIC shift register.

FIG. 4 (bottom of page)—INTERFACING DIFFERENT MOS logic with TTL gates. The type of MOS logic can be identified by the supply requirements.

longer than the dropout time on a dynamic register. Outside of the capacitance you may have to charge and discharge rapidly, *all* of the inputs on any MOS integrated circuit are essentially open circuits and neither source nor sink current.

Enables

An *enable* pin lets you combine either the outputs or inputs of a shift register group without using any fancy selector switches or external logic. Output enables are sometimes called *read enables.* You can combine memories simply by shorting all the outputs together provided you enable only one circuit at a time. Two common types of enables are the *open collector* and the *tri-state*. The latter provides a "1", a "0", or a high-impedance open circuit on command. Write enables also exist, but only on a few of the long registers.

Applications

We only have enough room to quickly run down some obvious applications of long shift registers. Two important ones were shown in the TV Typewriter story (**Radio-Electronics**, September 1973). Six recirculating 512-bit registers were used as a main memory character store and a final hex 32-bit shift register was used as a line register needed for formatting the dot matrix characters.

Pocket calculators and computers use long shift registers for number and program storage. Often, they are combined with internal multiplexing, calculation, and control circuitry into a single package.

Some music synthesizers use long shift registers as tune computers or composer storage. Several far out tricks that can be done with them is the separation of pitch and tempo, and the ability to play an upside down scale, or a reversed or backwards score. To reverse a shift register, you simply run it ahead N-1 clock pulses as fast as you can go. For instance, a 512-bit shift register can be clocked ahead 511 bits in well under a millisecond, and it appears to have backed up one slot at the end of the burst.

Long shift registers are ideal for sequence generation of noise that repeats for cryptography, computer security, music, and audio testing applications.

Long shift registers make good *buffers* or *data concentrators.* Input information can be loaded into a shift register at a random, slow, or asynchronous outside-world rate and then transferred to the rest of your circuit later on synchronously at high speed.

You can build an electrically variable delay line out of long shift registers. The clocking controls the delay time independently of the input data frequencies. You can get a delay to risetime ratio of 500:1 out of a 1024-bit register, something that's hard to do with analog delay lines. Speech compression (for talking book tapes and records), vibrato (for music synthesizers), and spectrum translation are three typical use examples.

In fancier circuits, shift registers are used as the key element in digital filters,

(continued on page 97)

New Concepts In FM Tuner Designs

New innovations in tuner design have come to light in recent years. These innovations include new frequency synthesis techniques, tuning indicators, noise blanking circuits and phase-locked-loop arrangements. Here's what these innovations can mean to you.

by LEN FELDMAN
CONTRIBUTING HIGH-FIDELITY EDITOR

THE PERFORMANCE LEVEL OF THE TYPical all-in-one stereo hi-fi component receiver has improved remarkably over the last few years. Circuit refinements have been applied to both the amplifier sections and the FM tuner sections of the one-piece receiver, so that each of these sections now outperforms some of the better separate tuners and amplifiers of earlier years. There are receivers which boast continuous power outputs of 100 watts per channel and more at less than 0.1% total harmonic distortion—specifications previously associated only with separate integrated amplifiers or even separate basic power amplifiers. As for FM performance, it is not unusual to find integrated stereo FM receivers which offer ultimate signal-to-noise ratios well above 70 dB, distortion levels (even at 100% modulation) of below 0.25%, and stereo separation capabilities of well over 40-dB at mid-frequencies and better than 30-dB over the entire audio range.

To "justify" the continued existence of the "separate" FM tuner, manufacturers of these relatively high-priced components have had to seek and develop improvements which extend beyond the commonly reported performance specifications and which offer operating convenience and simplicity to the prospective buyer that are not available in the popular all-in-one receiver component format. Typical of this new breed of FM tuner is Kenwood's new Model 700-T Frequency Synthesizing Tuner, shown in Fig. 1.

FIG. 1—THE KENWOOD 700-T frequency synthesizing tuner.

Tuning accuracy and distortion

Even the very best FM tuner which boasts low, low distortion can deliver its lowest THD figures only when the tuned circuits in the front end are precisely tuned to the center frequency of the desired station signal. Typical values of distortion introduced by even minimal mis-tuning of frequency are illustrated in the graph of Fig. 2. As this graph illustrates, a mis-tuning of as little as 50 kHz can increase distortion in the output from 0.13% to 0.45% for monophonic signals. In stereo FM, the degradation of audio purity can be even greater.

Conventional tuners and receivers generally use center-of-channel tuning meters or other idicators as tuning aids. Often, such indicators are simply dc voltmeters hooked up to the take-off point of the FM ratio detector. In a properly aligned FM tuner. proper tuning should result in zero dc voltage at this point and the meter pointer is then centered. Even slight misalignment of the ratio detector or other tuned circuits in the i.f. section of the tuner can cause the meter pointer to swing left or right of center and the user, relying upon this indication, would then deliberately mistune the set until the pointer returned to its mid-point. Even in a perfecly aligned system, detector bandwidth on modern tuners is so great that the tuning meter's range, from end to end, must extend over several hundred kHz, making the exact "center point" rather difficult to determine visually.

Frequency synthesizing

The idea of using a frequency synthesizing circuit for accurate FM tuning is not new. It first appeared in a consumer type tuner a few years ago when the Heath AJ-1510 tuner was introduced. That tuner was tuned with keyboard push-buttons and, therefore, required a great amount of digital circuitry beyond the relatively simple requirements of frequency synthesis. In addition, the AJ-1510 tuner displayed tuned frequencies on digital read-out tubes, which also required a fair amount of digital drive circuitry.

Kenwood engineers, in designing the new 700-T decided that audiophiles

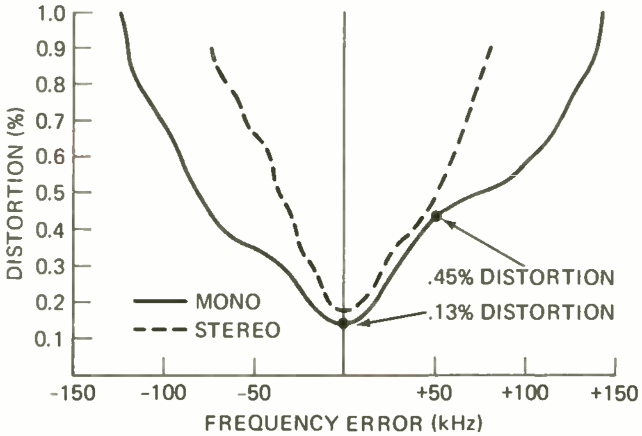


FIG. 2 — DISTORTION INCREASES RAPIDLY as FM station is detuned from exact center frequency.

prefer to select frequencies with a conventional tuning knob and to read those frequencies on a printed dial scale, and so the front panel layout of the new tuner is not unlike that of conventional tuners which use multi-section variable capacitors. What goes on behind the dial scale is quite different, however.

The block diagram of Fig. 3 shows the circuit elements of the rf front-end and the frequency synthesizer section. The front-end is quite conventional in that it includes two stages of tuned rf amplification, a mixer stage and a local oscillator. The local oscillator is tuned by varactor diodes, rather than the conventional variable capacitor. The dc voltage applied to the varactors determines their effective capacitance which, in turn, determines the frequency of the local oscillator.

The lower cluster of blocks in Fig. 3 represent the frequency synthesizer. First, the frequency of the local oscillator is divided by four through a 4:1 divider circuit. Thus, possible frequencies available at the output of the divider will range from 24.68 MHz to 29.68 MHz. (Local oscillators in FM sets are tuned to 10.7 MHz above the incoming frequency, so that the range of an FM local oscillator extends from 98.7 MHz to 118.7 MHz.)

The output of a crystal-controlled oscillator, tuned to 2 MHz, is divided in an 80:1 divider circuit to produce an accurate and constant output at 25 kHz. The outputs of both dividers are translated to narrow digital pulses. Both sets of pulses are applied to the two inputs of a comparator circuit. So long as there are exactly the prescribed number of pulses of divided-down local oscillator signal compared to a single 25-kHz pulse from the divided down 2-MHz signal source, a prescribed value of dc voltage appears at the output of the phase comparator. If mistuning occurs, and the frequency or phase relationship changes between the two sets of pulses, the dc output of the comparator changes—not linearly, but in finite steps, as illustrated in Fig. 4.

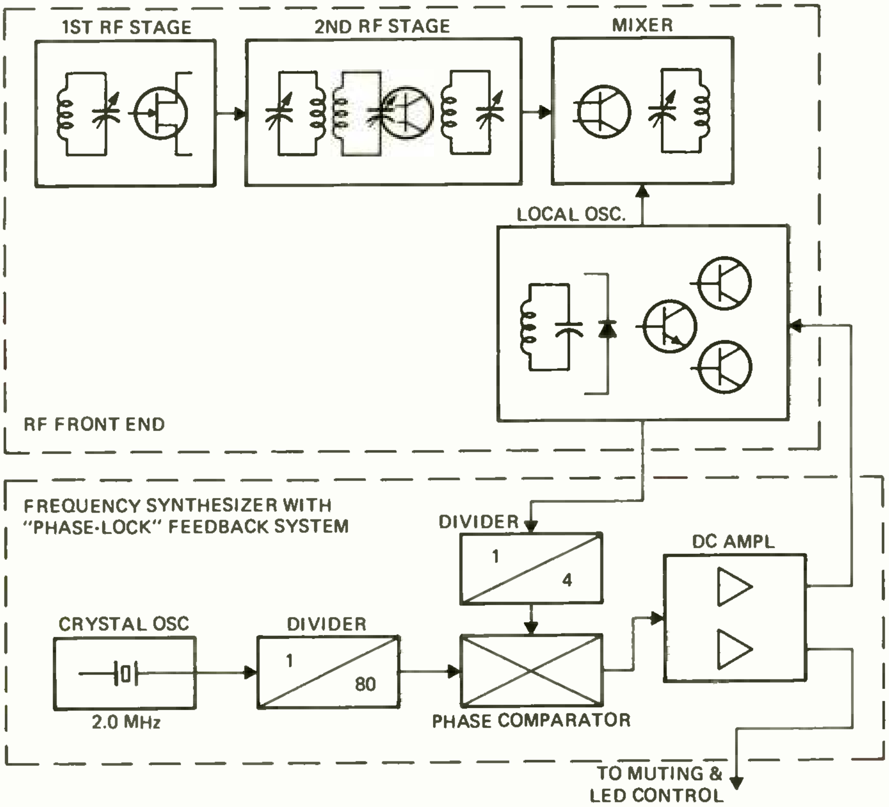


FIG. 3—BLOCK DIAGRAM OF FRONT END and frequency synthesizer section of Kenwood 700-T tuner.

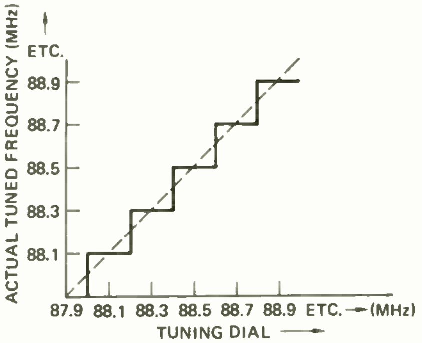


FIG. 4—CONVENTIONAL TUNING is continuous, as shown by dotted linear scale. In Kenwood 700-T, tuning occurs in fixed, 200 kHz increments as tuning knob is rotated.

The dc output of the comparator is amplified by a dc amplifier and the resulting dc voltage is used to "tune" the local oscillator in the front end. This concept of discrete steps of voltage rather than continuously variable tuning voltage is what makes this electronically tuned system different from other varactor-tuned FM sets. It is very much analogous to the "phase-lock-loop" concept used in the multiplex sections of this and other tuners, in that there is a finite "lock-in" range of the system. Essentially, if the local oscillator is tuned to less than ±100 kHz of the desired frequency, the system pulls the oscillator to exact desired center frequency. Once tuned beyond 100 kHz to either side of center, the stepped dc voltage forces the oscillator to jump in frequency to the next, discrete, FM channel frequency. Accuracy of tuning is dependent only upon the accuracy of the 2-MHz crystal oscillator which is used to create the 25-kHz reference pulses. That crystal is accurate enough to provide an overall tuning accuracy of 0.0024%. At a desired tuning frequency of 100 MHz, that means that the maximum error of tuning possible is 2.4 kHz, hardly enough to alter the distortion of the audio output signal by a measurable amount.

Tuning indicators

To provide the user with a positive indication of tuning accuracy, the 700-T is equipped with a two-step muting and LED control unit (not shown in the block diagram of Fig. 3). This circuit receives inputs from the frequency synthesizer as well as from a special noise-sensing circuit in the i.f. section of the tuner. Muting threshold is, therefore, dependent not only on signal strength (determined by signal noise content), but on accuracy of tuning as well. The three LED indicators seen at the right of the signal strength meter in Fig. 1 light when a station signal is received, with the outermost, red colored ones denoting a mistuning of 100 kHz and the center green indicator denoting perfect, on-center tuning.

Noise blanking circuit

Another novel circuit designed into the 700-T tuner is called PNBS (Pulse Noise Blanking System). Its purpose is to substantially reduce the audible effects of noise pulses which might be generated by man-made interference such as motor ignition noises. A block diagram illustrating the operation of this circuit is in Fig. 5. The noise amplifier and first comparator stage at the left of the diagram are fed a detected i.f. signal from the i.f. section of the tuner. The output of this first comparator is arranged to drive the other elements of the system so that in the presence of a weak signal (which might otherwise be interpreted as "noise pulses"), the main gating circuit in the audio amplifier stages permits the audio to come through.

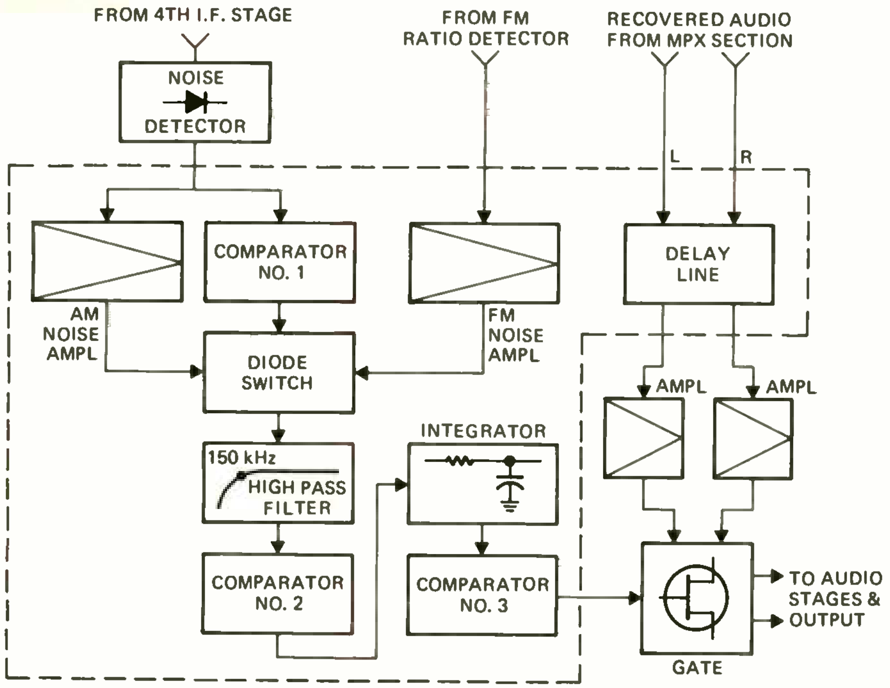


FIG. 5—BLOCK DIAGRAM OF PULSE NOISE BLANKING system.

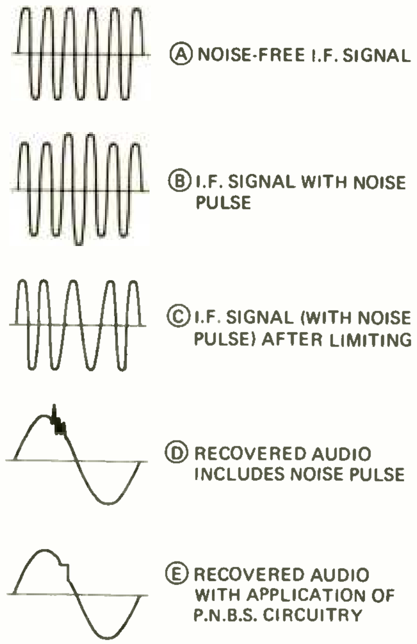


FIG. 6—APPEARANCE OF I.F. SIGNALS with and without pulse noise (a, b and c) and appearance of recovered audio without (d) and with (e) PBNS circuitry.

At stronger signal levels, the real operation of the PNBS system comes into play. The FM noise amplifier feeds a diode switch which is now set to pass inputs from this source. The output of the switch is fed to a high-pass filter which has a cutoff frequency of 150 kHz. The noise pulses contain frequency components beyond 150 kHz and are, therefore, amplified and sent on to the second comparator which is in reality a form of pulse detector. The resulting pulses are passed through an integrator where they are shaped into lower-frequency square shaped dc pulses. These pulses are then applied to the final comparator and on to a dual gating circuit which is positioned between stages of the audio amplifier section of the tuner. When a shaped pulse is applied to this gating circuit, it effectively interrupts the passage of the audio signals for a very short time, thereby blocking the otherwise audible noise pulse.

The series of waveforms shown in Fig. 6 illustrates the appearance of the i.f. signal and the resultant audio. An i.f. signal without noise is represented by the upper waveform. Pulse noise alters the waveform so that it appears as in the second diagram. Even though the limiter stages of the i.f. system remove the AM variations caused by the noise pulse, the constant-amplitude i.f. signal at the output of the limiters now contains frequency variations which correspond to the noise and which would ordinarily be detected by the ratio-detector as audible noise, as represented by the single sine wave (recovered audio) shown next. The PNBS circuit has a "smoothing" effect on the audio waveform and, while it does not eliminate the "break" in the normal audio sinewave, the audible effects of this kind of smooth disparity in the waveform are far less annoying to the listener.

The various circuits involved in the PNBS section (and especially the high-pass filter) introduce a time delay of a few microseconds. Thus, the gating voltage which finally "turns off" the gate circuit in the audio amplifier section arrives a small fraction of a second after the noise pulse arriving from the two outputs of the stereo decoder section. If this were not compensated for, the audible noise pulse would "sneak through" before the gating circuit was turned off. Accordingly, a time-delay circuit is introduced ahead of the audio amplifier section so that the arrival of the gate pulse coincides exactly with the arrival of the noise pulse from the audio amplifier inputs to the gating circuit.

Other advanced features

Like other state-of-the-art FM tuners currently available, the 700-T uses a phase-lock-loop circuit in its multiplex stereo section. In addition, the 38-kHz switching circuitry used to demodulate the composite stereo signal into separate left and right outputs consists of two, 180° phase displaced switching circuits, each fed with appropriately phased audio composite signals. This arrangement tends to maintain better phase accuracy (and therefore better separation) at high audio frequencies and also reduces or cancels residual carrier products at the audio outputs of the system. Kenwood has been using this circuit in a variety of its products in the past, but this represents its first use in combination with a phase-lock-loop arrangement for maintaining the critical phase relationship between the 19-kHz pilot signal and the audio sub-carrier sidebands of the stereo composite signal.

The signal strength meter on the 700-T serves a second function. By depressing a front panel button it is transformed into a multipath indicator meter, facilitating proper orientation of an FM antenna for least interference from signal reflections. A pair of jacks at the back of the tuner permit connection of an oscilloscope for visual observation (and correction) of multipath effects, thus permitting greater antenna orientation accuracy.

As for more familiar performance specifications, the 700-T attributes these to its unique circuit innovations. Harmonic distortion is stated as 0.15% in mono and 0.25% in stereo. Quieting slope is so steep that with a signal input of only 1.8 μV, S/N (signal-to-noise) ratio is 40 dB while with only 200 μV of signal applied, S/N ratio is at least 73 dB. The elaborate stereo decoder section provides 45 dB of channel separation at 1 kHz and maintains separation capability of at least 35 dB at 10 kHz.

Obviously, one could buy a pretty good receiver for the $700.00 selling price of the FM/AM tuner. But the hi-fi audience is such that there will always be those willing to pay a premium price for that last bit of perfection and for the unique features built into a product such as Kenwood's 700-T. **R-E**

DESIGNING AUDIO

Feedback serves many useful purposes
circuits it can be used to reduce
frequency equalization. See how to

IN AUDIO CIRCUITS, FEEDBACK IS USED in a variety of applications. It is applied around power amplifiers to reduce distortion while minimizing the output impedance to improve loudspeaker damping. Preamplifiers use feedback in tone control circuits to maintain proper equalization for tape and phono reproduction. It is these preamplifier applications that we will discuss here*.

Feedback equalization

Records and tapes are not recorded with a flat frequency response characteristic, that is, not all frequencies are recorded with equal amplitude. The amplitudes at the high-frequency end of the audio spectrum are recorded with a rising characteristic so that the recorded signal can override any noise present in the medium. Playback curves at this end of the audio spectrum must provide roll-off to compensate for the emphasis in the recording process. This roll-off characteristic is called de-emphasis and it further improves the signal-to-noise ratio.

At the other end of the audio spectrum, the low-frequency signals are reduced in amplitude with respect to the mid-frequencies during the recording process, so the width of the record groove can be maintained within reasonable limits. The playback curve must emphasize the low frequencies.

The final factor affecting the frequency characteristics of the reproduced record or tape, is the playback cartridge or head. The widely used magnetic type of cartridge does not have an output with a linear relationship to the amplitude of the signal being reproduced. It is a velocity-sensitive device in which the output voltage is proportional to the *frequency* of the signal.

Taking all these factors into account, the preamplifier must have the frequency response which is shown by curve A in Fig. 1. The overall output of the complete system, from record through playback will be linear only if the response is as shown. A straight line approximation to curve A has been drawn as curve B in Fig. 1.

Note that the curve has three distinct sections — two 6dB/octave roll-offs starting at 50 and 2000 Hz, and a flat response between 500 and 2000 Hz. The total frequency response of curve B can be produced by the summation of three separate curves. One curve will have a 6 dB/octave rolloff starting at 50 Hz. The second curve will be a 6 dB/octave rise starting at 500 Hz. Finally, the third curve will be a 6 dB/octave roll-off starting at 2000 Hz. The algebraic addition of these three curves will produce the frequency response shown in curve B of Fig. 1.

Designing a circuit

The design procedure can proceed in several logical steps. First, there must be a minimum of about 40 dB of feedback applied around the circuit. This allows for 0 dB of feedback at 30 Hz and for more than the required 36 dB of feedback at 15 kHz. Since 40 dB is a voltage ratio of 100:1, the gain of the circuit without feedback must be greater than 100. This is easily done with the two transistors shown in Fig. 2.

The next step is to design the R-C networks in the feedback loop. The voltage gain (A_{vf}) of the circuit shown in Fig. 2 is approximately equal to Z_f/R_{e1}, because the forward gain is sizeable. Z_f is the impedance of the feedback loop. Substituting the actual impedance of the feedback loop for Z_f in the voltage gain equation yields:

$$A_{vf} = \frac{Z_f}{R_{e1}} = \frac{1 + j\,6.28\,f\,R\,(C1 + C2)}{j\,6.28\,f\,C1\,R_{e1}\,[1 + j\,6.28\,f\,C2R]} \quad \text{Eq. 1.}$$

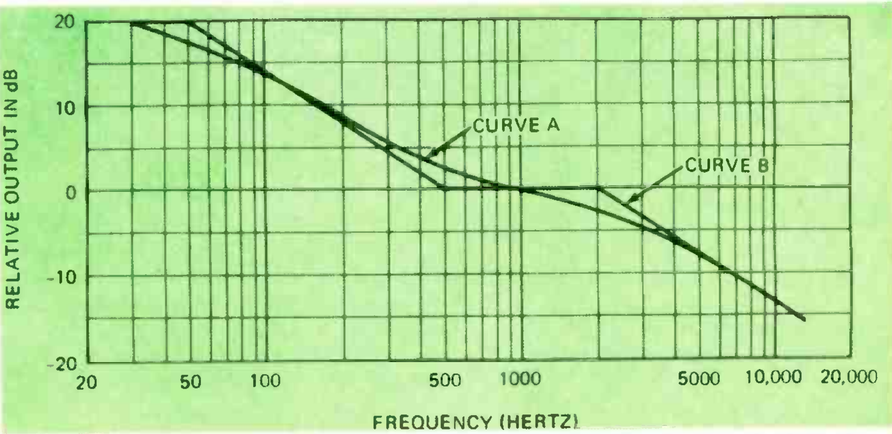


FIG. 1—PHONOGRAPH PLAYBACK CURVES when using a magnetic cartridge. Curve A shows the exact frequency response, while curve B is a straight line approximation of curve A.

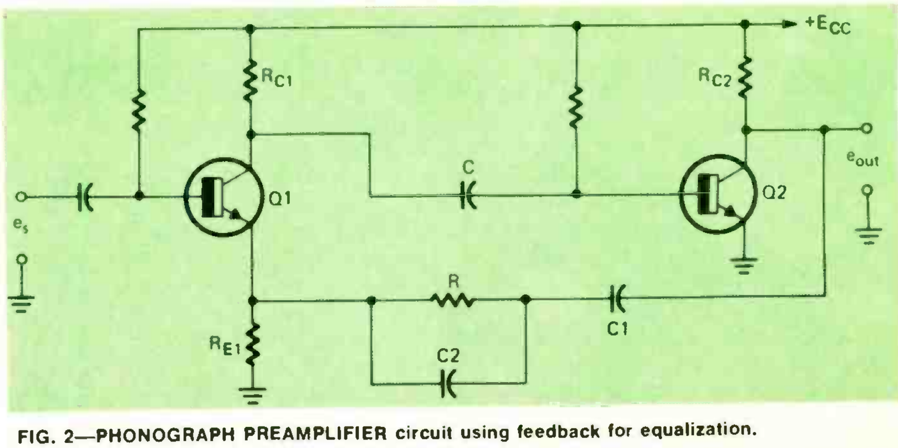


FIG. 2—PHONOGRAPH PREAMPLIFIER circuit using feedback for equalization.

*This article is included in the TAB book "How To Build Solid State Audio Circuits".

FEEDBACK CIRCUITS

in electronic devices. In audio distortion or provide proper design practical feedback circuits yourself

by MANNIE HOROWITZ

This follows from the fact that Z_f is equal to the reactance of C1 or 1/j6.28fC1 in addition to the impedance of the parallel combination of R and C2 or R/(1+j6.28fC2R). In the equation, j indicates a 90° phase shift.

Equations in the form of Equation 1 can easily be analyzed to determine corner frequencies. (The corner frequencies are those frequencies on the response curve where two straight line segments join. ie., the corner frequencies in Fig. 1 are 50, 500, and 2000 Hz). To analyze Equation 1, all factors in the form of (1+jx) are set equal to (1+j). All other factors including those terms in the form of jx are set equal to zero. Thus for the numerator;

$$1+j6.28fR\,(C1+C2) = 1+j$$

Therefore; $6.28fR(C1+C2) = 1$. Solving for f yields;

$$f_{o1} = 1/6.28R(C1+C2) \quad \text{Eq. 2.}$$

f_{o1} is one corner frequency. Similarly, the (1+j) term in the denominator yields the second corner frequency, f_{o2};

$$f_{o2} = 1/6.28RC2 \quad \text{Eq. 3.}$$

The third corner frequency, f_{o3}, is found by setting the $j6.28fC1R_{e1}$ term equal to zero;

$$f_{o3} = 0 \quad \text{Eq. 4.}$$

Now, substitute the actual corner frequencies noted in Fig. 1 for f_{o1}, f_{o2} and f_{o3}. Curves roll-off at a 6dB/oct. rate, beginning at the corner frequencies determined from the factors in the denominator of Equation 1. They rise at a 6dB/oct. rate, beginning at frequencies determined from the numerator.

Rolloff starts at f_{o3} = 0-Hz from Equation 4 and continues to 500-Hz as determined from f_{o1} in Equation 2. It begins to roll-off again at f_{o2} = 2000 Hz, as determined from Equation 3. The three equations can be solved simultaneously to determine the value of the various components.

You may justifiably ask why the rolloff begins at 0-Hz rather than 50 Hz. The basic design is simplified if this approximation is made. Actually, the coupling capacitor between stages in the forward circuit can be adjusted to move the corner frequency from 0 Hz to 50 Hz. A more accurate circuit includes a resistor across C1 to readjust the corner frequency to its proper location at 50 Hz.

Tape equalization

A similar response curve may be derived for a tape playback preamplifier. A very rough approximation of the 7½-ips playback curve is shown in Fig. 3. There are two corner frequencies—one at 50 Hz and a second one at 3000 Hz. Once again, the basic amplifier circuit in Fig. 2 can be used. However, we must substitute the series R-C circuit shown in Fig. 4 for the feedback network of C1, C2 and R in Fig. 2. In the analysis, we let Z_f be the impedance of the R-C circuit; $Z_f = R+1/j6.28fC = (j6.28fRC+1)/j6.28fC$. Since the voltage gain with feedback is approximately Z_f/R_{e1};

$$A_{vf} = (j6.28fRC + 1) / j6.28R_{e1}fC \quad \text{Eq.5.}$$

The roll-off in the response curve begins at the frequency where the denominator is equal to zero. This occurs at;

$$f_{o1} = 0 \text{ Hz} \quad \text{Eq. 6.}$$

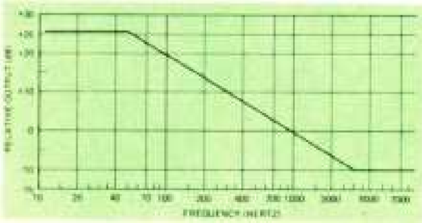


FIG. 3—TAPE PLAYBACK CURVE showing a rough approximation of the equalization for 7½ ips.

FIG. 4—FEEDBACK NETWORK used for tape playback equalization. This network is used in place of R1, C1, and C2 in Fig. 2.

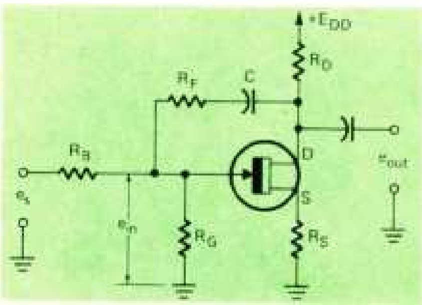


FIG. 5—"OPERATIONAL" AMPLIFIER circuit using an FET.

The rise begins at 3000-Hz or wherever the numerator is equal to j+1. This frequency is;

$$f_{o2} = 3000 \text{ Hz} = 1/6.28RC \quad \text{Eq. 7.}$$

Once again, the 50-Hz roll-off point must be treated as in the previous discussion of phono feedback equalization.

Now, for the final and most important step in the design. Check the actual circuit in the laboratory and adjust the response curve using physical components. Too many stray factors are usually omitted in a "paper" design for the calculated components to be sufficiently accurate.

Bipolar devices were used in this example, but JFET's can serve as equally well in these applications. In both instances, the first transistor stage must be designed so that there is a sufficient voltage swing at its output during the peaks in the music to prevent clipping. A phonograph preamplifier with about 3 or 4 mV input sensitivity for an average size signal, and that will accommodate 60 or 70 mV input signal before the output distorts, is satisfactory. A similar ratio of maximum to minimum input signal is required for the tape preamplifier, but the minimum input sensitivity in this case should be about 1 mV.

"Operational" amplifier

The "operational" amplifier is usually associated with computer electronics. Actually, the circuit known as an "operational" amplifier has been in use for many years as tone control circuits in high quality amplifiers. Because they are no more expensive or complex than the "lossier" type of base and treble, boost and cut controls, the feedback control is used almost exclusively in all audio equipment. Analysis of the feedback control requires some knowledge of the characteristics of the "operational" amplifier.

An "operational" amplifier using an FET is shown in Fig. 5. The dc gate bias for this stage is developed across R_s and applied to the gate through R_G. Resistor R_G is made as large as practical so as not to affect any other parameters in the circuit. It is assumed that *no* ac-signal current flows through this resistor.

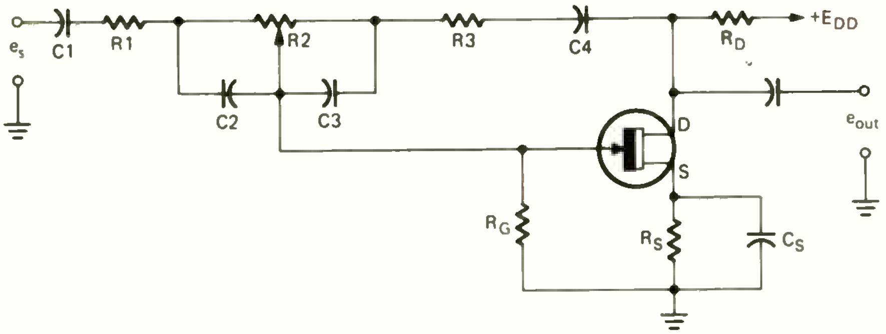


FIG. 6—BASS TONE CONTROL circuit using an operational amplifier and feedback.

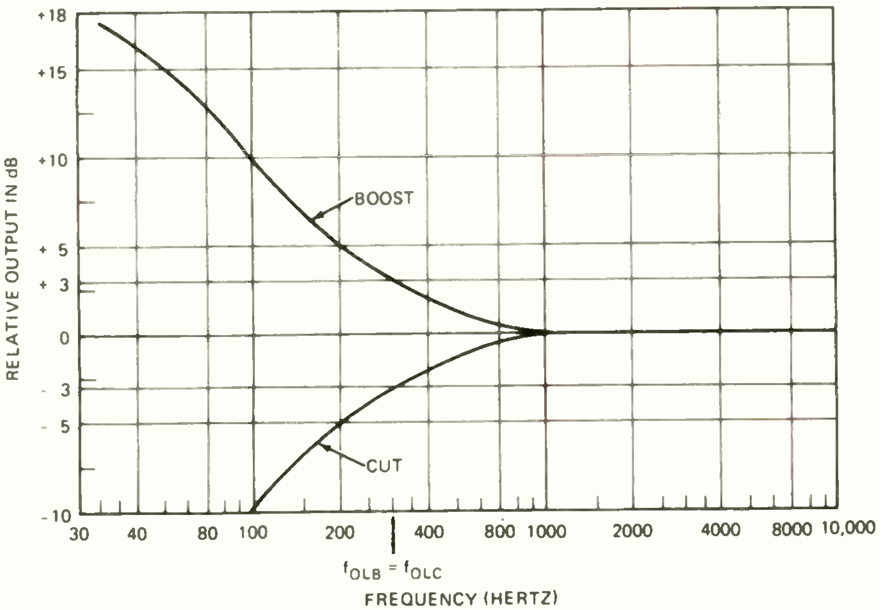


FIG. 7—BASS CUT AND BOOST curves for circuit shown in Fig. 6 with tone control set at maximum positions.

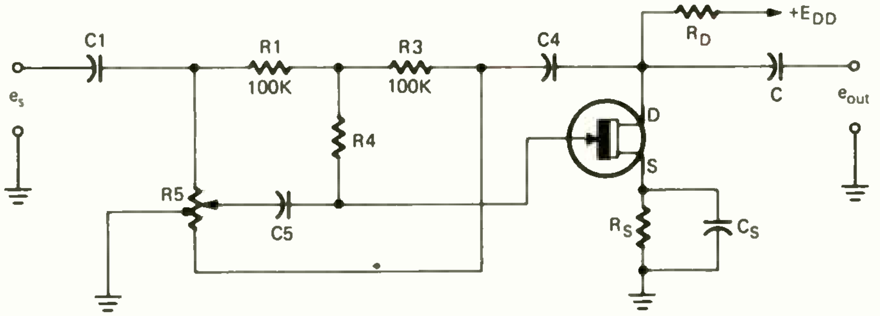


FIG. 8—TREBLE TONE CONTROL circuit using an operational amplifier and feedback.

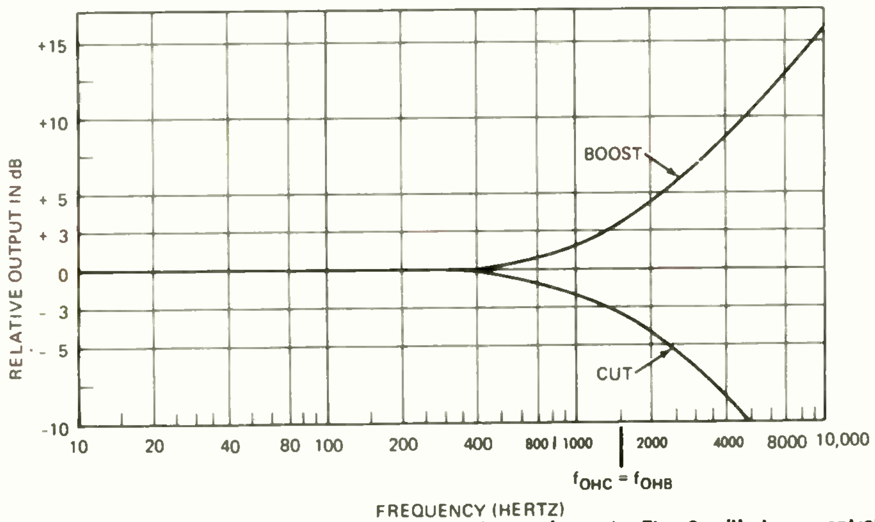


FIG. 9—TREBLE CUT AND BOOST curves for circuit shown in Fig. 8 with tone control set at maximum positions.

The FET stage is an ordinary amplifier where the input signal will be amplified to produce an output voltage across R_D. However, the actual signal generated, e_s, is applied through R_B to the amplifier. R_F feeds the output signal back to the gate in a feedback circuit. In this circuit, C is considered to be a short circuit for audio signals and is designed into the circuit with the sole purpose of preventing the dc voltage at the drain from affecting the gate bias.

The signal current flowing through R_B is equal to $(e_s - e_{in})/R_B$. This current divides between R_G and R_F. Since the current through R_G and the gate circuit are negligible (due to their high impedance) when compared to the current flowing through R_F, we can with reasonable accuracy, assume that all the current flowing through R_B also flows through R_F. The current in R_F is equal to $(e_{out} - e_{in})/R_F$. Equating the current through R_B with the current through R_F, we have

$(e_s - e_{in})/R_B = (e_{out} - e_{in})/R_F$ Eq. 8.

We can now write a second equation which considers the gain, A_v, of the amplifier stage itself.

$$e_{out} = e_{in} A_v;$$

$$e_{in} = e_{out}/A_v \qquad \text{Eq. 9.}$$

The gain is usually extremely high and is often assumed to be infinite. When this assumption is made, e_{in} approaches zero. Although e_{in} is *practically* zero, the gate is not at ground potential. This point is referred to as a *virtual ground.*

Substituting $e_{in} = 0$ into equation 9, we get the well known relationship

$$e_{out}/e_s = R_F/R_B \quad \text{Eq. 10.}$$

The *ideal* operational amplifier has six primary characteristics: 1. Infinite input impedance. 2. Zero output impedance. 3. Infinite gain. 4. Zero offset —zero output level when the input is zero. 5. Zero response time—instant response at the output when the input signal is applied. 6. Infinite bandwidth.

Obviously, no amplifier will fully meet any of these requirements. However, the closer the actual circuit approaches the ideal, the more accurate the calculations below will be.

Feedback tone controls

Let us now analyze a practical feedback tone control which is, in its completed form, known as the Baxendall tone control circuit. Start with the bass control section in Fig. 6. C1 and C4 are short circuits for the audio signals and are used only to prevent dc from entering the gate circuit. R1 is made equal to R3, C2 is equal to C3 and R2 is a linear potentiometer set at the center of rotation.

Compare Fig. 6 with Fig. 5. R1 plus the parallel combination of C2 and the

(continued on page 80)

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JANUARY 1974—DECEMBER 1974

Abbreviations: (AC) Appliance Clinic; (C) Construction; (D) Department; (ER) Equipment Report; (GE) Guest Editorial; (F) Filler; (SC) Service Clinic

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RE's Service Clinic

The orphan amplifier

How do you service without service data

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.

ONE PROBLEM WE RUN INTO TOO OFTEN is the little solid-state amplifier with the output transistors blown out. The tough part is the complete lack of any information; no schematic, no numbers, just nothing. So the only thing we can do is get in there and dig out the answers.

Before we start, let me make one thing perfectly clear. Due to the utter and complete lack of even rudimentary standardization in these amplifiers—transistor types, numbers and even circuits—the methods suggested here will definitely NOT apply to ALL of these amplifiers! About all we can do is point out a few "trends" that seem to show up more often. Certain types seem to use certain circuits. We'll do our best to point these out.

If you have even a small, postage stamp size schematic, this will help. However, the ones we'll be talking about will be the little "Orphan Imports". Small record players, mono or stereo, no recognizable name or numbers. The amplifier(s) are often tucked away under the motorboard. They can be hard to find; I've found a few by following the leads from the pickup. They're on PC boards, about 2 inches square.

For economy reasons, the vast majority of these use an output transformerless (OTL) circuit. They use two transistors, in Class B, with the speaker connected to the mid-point through a big electrolytic capacitor. (Big in capacitance, not physical size!) Note: In the Far Eastern imports, the speaker is usually connected from the midpoint to common or ground. In European imports, particularly German, French and a few British, you may find the speaker hooked from midpoint to B+. (Actually, this term should be B±, since the power supply can be of either polarity. However, the circuit works in exactly the same way.

There are two basic circuits. They work in exactly the same way; only the polarity of the transistors is different. One is called a "stacked" or totem-pole circuit, as shown in Fig. 1-a. The other is a "complementary-symmetry" circuit, as in Fig. 1-b. The stack circuit uses two identical transistors, while the complementary-symmetry circuit uses transistors of opposite polarity. As far as we're concerned, the only difference is in the driver stage.

Just to help keep things straight, let's define the transistors. From now on, the "top" transistor in the output pair is the one connected to the dc power supply, it can be of either polarity, depending on which type of transistor is used in the circuit. The bottom transistor is the one with its collector or emitter returned to common or ground. The driver may be connected to the base of either one,

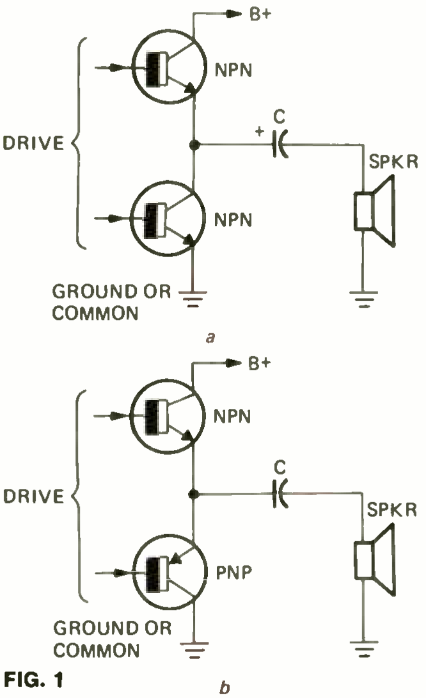

FIG. 1

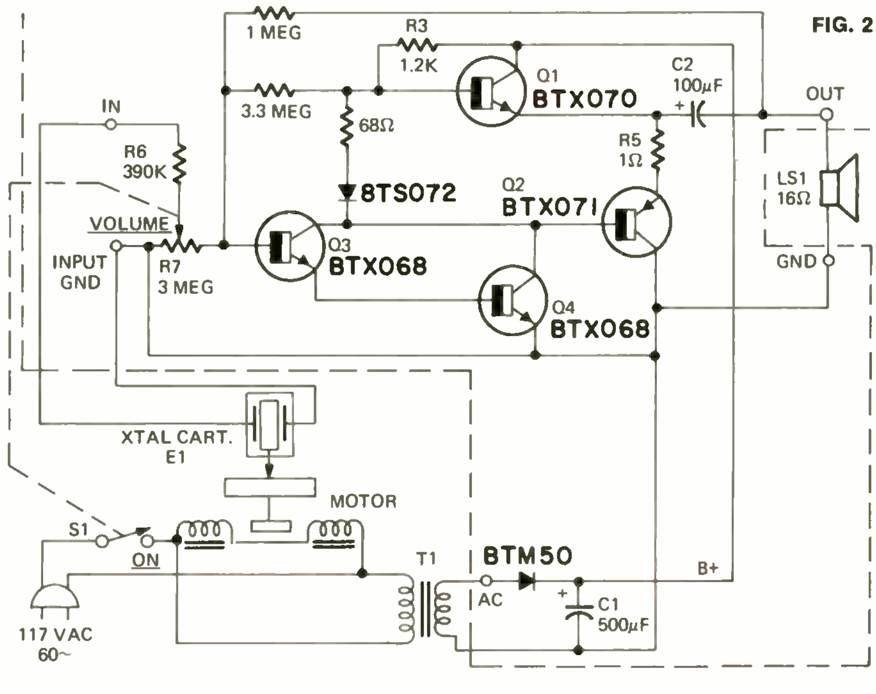

FIG. 2

it depends upon the manufacturer of the amplifier.

Questions, questions

We have a lot of questions to answer. Start with "What type of transistors are (were!) these? npn or pnp?" Make an ohmmeter check of the output transistors. This tells you which one is shorted or open. In many cases, you'll find that only one of the output pair has blown. This helps. Take the good one out and check it. Your ohmmeter will tell you its polarity (see Table). Take the bad one out, too. With a huge magnifying glass, see if there are any numbers on them. If these are the same, the chances are this is a stack circuit. If they differ, say by one digit (i.e. "1439" and "1440"), the chances are that this is a complementary-symmetry circuit. If only one transistor is bad, you can tell which one goes where.

In either type of circuit, the collector of the top transistor goes directly to the power supply. To find the polarity of the voltage, take the shorted transistor out, turn on the amplifier, and read the voltage (maximum). This determines the polarity of the top transistor. If the dc voltage is positive, it's an npn transistor. If the dc voltage is negative, its a pnp. Write down your two facts, dc voltage

TABLE OF OHMMETER TESTS TO DETERMINE TRANSISTOR TYPE

Ohmmeter Probe Connections To Transistor		Resistance Reading	Transistor Type
Positive Probe	Negative Probe		
collector	base	Low High	PNP NPN
base	collector	Low High	NPN PNP
emitter	base	Low High	PNP NPN
base	emitter	Low High	NPN PNP

maximum and polarity. We're off and running.

You can obtain some data about the connections from the top transistor. The collector is the lead with the dc voltage (positive or negative). The emitter probably goes to a very small resistor, then to a capacitor coupled to the speaker. The remaining lead has to be the base lead. If the two transistors are the same type, you have the connections. If they're different, as in the complementary-symmetry circuit, the connections can still be the same; ohmmeter check to make sure. A handy quick-check for the common or ground is to look for the end of the *filter* capacitor that is *not* connected to the rectifier diode. This is usually the largest electrolytic on the board. *(continued next month)*


Advanced
Electronics

EQUIPMENT REPORT

(continued from page 30)

are pulsed sequentially so that only one gun at a time is conducting. During the conduction interval, the G2 voltage is automatically adjusted by a programmable shunt regulator controlled from a multiplex generator. They have very conveniently used the line frequency to trigger their multiplex generator. The generator itself is a TTL chip consisting of two JK flip-flops. The clock driver is essentially ½ of a TTL 7400 Quad NAND gate. What we have is a signal-driven (digital) pix tube providing a dynamic emission test as opposed to the more widely used "Static Emission Test." Figure 4 shows the basic test set-up for measuring emission with the pix tube hooked-up as a 2-element device.

We are still in the TEST position of the function switch. Let's assume that our 25AP22A has low emission on all three guns. Proceed to the next step.

Rotate the function switch to the RESTORE position. There are three restoration functions that can be performed in this position: remove shorts, clean-balance, rejuvenate.

At this time the pix tube we are testing has no shorts or leakage indications—just very low emission (in the red). Put the REJUVENATE/CLEAN-BALANCE switch into the REJUVENATE position. With the function switch in the restore position, the heater voltage will be increased by 58% from the initial setting of 6.3 volts to 10 volts. There will be a 30-second wait until the proper operating temperature is reached. At this time we depress the RED REJUVENATE pushbutton. The heater voltage automatically decreases to zero. At the same time the meter directly above the pushbutton should show a marked rise in current that drops off toward the meter's red region.

When the current has decreased to the red region and is approaching zero, release the pushbutton. This is an automatic timing feature for the process and leaves very little chance for stripping the cathode. Immediately return the function selector switch to the TEST position. All things being normal, the gun usually comes up to a very good emission reading. Repeat the process with the green and blue guns, using the GREEN and BLUE REJUVENATE pushbuttons. Now recheck the TRACKING and LIFE tests. The results should be remarkable.

Let's assume that in the SET-UP position of the function selector switch that LEAKAGE was indicated from G1 to the blue cathode. This immediately suggests that a current path exists between these two elements that is below 2 megohms. However, in the RESTORE position the G1-cathode short lamp is *not* lit. This means that the leakage path is greater than 20,000 ohms. We then attempt a CLEAN-BALANCE operation for the gun in question. Simply put the function switch in the RESTORE position and the REJUVENATE/CLEAN-BALANCE switch in the CLEAN-BALANCE position. Wait the required 30 seconds and depress the BLUE REJUVENATE pushbutton and watch its respective meter drop toward zero. Then release when the pointer reaches 0.2.

Let's set up a third (and final) condition with our 25AP22A. Assume that in the SET-UP position the G1 and K BLUE lamps were again lit. This still indicates a leakage path between the elements of less than 2 megohms. However, when the function switch is rotated to the RESTORE position the G1-K short lamp is lit. This now indicates that the leakage path is *less than* 20K and possibly a dead short. Merely depress the REMOVE SHORTS pushbutton and (unless the elements are welded together) the short should disappear.

We can now faithfully draw definitive conclusions about the model 467 and comment on the equipment based on real field experience. I have had approximately one month of use of the 467 for analysis of good tubes and bad tubes. The restoration process has had successes and failures. The results and conclusions were immediate. No tube during this period was ever "destroyed" by the equipment. I would like to qualify what I mean by "success" or "failure."

- In all cases thus far, the instrument accurately analyzed any given defect in picture tubes tested;
- The 467 would not restore tubes which had had a booster installed for a prolonged period of time;
- The 467 would not restore tubes which had previously been "rejuvenated" by another process.
- In all cases, when the picture tubes were "virgin," that is to say had not had a booster on it or no other restoration process applied, the 467 *did the job* and did it well.

Conclusion

From the *analysis standpoint*, the B & K Model 467 does a total job in determining that any given pix tube is good, bad, or marginal. It has performed its functions rapidly and has added only 3-4 minutes total diagnosis time (including set-up and restoration) to the in-home service call. Based upon this alone, it would be a welcome addition to any technician's list of valuable test equipment.

In many instances it has outshone it's own predecessor, the B & K Model 466. The new unit costs $279. **R-E**

AUDIO FEEDBACK CIRCUITS

(continued from page 68)

left hand half of R2 are the equivalent of R_B in Fig. 5, while R3 plus the parallel combination of C3 and the right hand half of R2 are the equivalent of R_F in Fig. 5. Because $R_F = R_B$ at all frequencies (since it has been specified that R1 = R3, C2 = C3 and R_2 is linear so that the right hand half is equal to the left hand half), the voltage gain of the circuit is $e_{out}/e_s = 1$ (See Equation 10) at all frequencies. The curve relating gain to frequency is theoretically flat from 0 Hz to ∞ Hz.

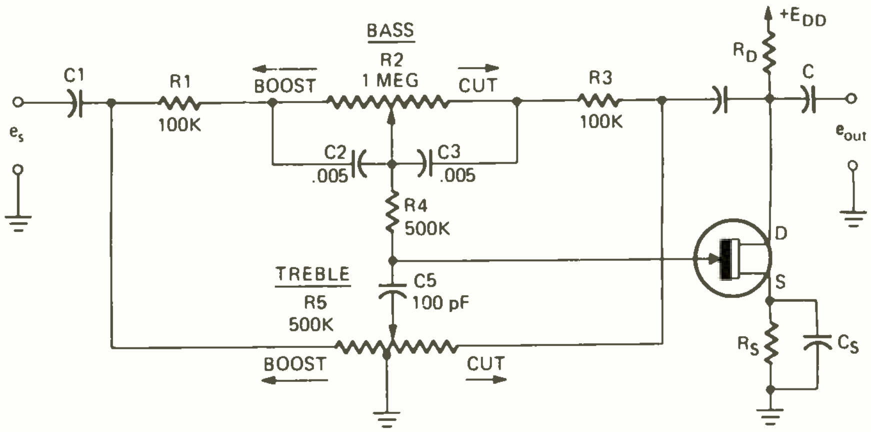

FIG. 10—COMPLETE TONE CONTROL circuit using the operational amplifier and feedback.

Now move the wiper arm of potentiometer R2 to the extreme left. C2 is shorted while C3 is placed across the entire resistance of R2. In this position, R_B of Fig. 5 becomes R1 while R_F is effectively R3 in series with C3. The impedance of R_F is R3+1/j6.28fC3 = (j6.28fC3R3+1)/j6.28fC3. Applying Equation 10, the output becomes;

$$e_{out} = e_s\left(\frac{j6.28fC3R3+1}{j6.28fC3R1}\right) \quad \text{Eq. 11.}$$

The response curve will begin to rise at the frequency where the numerator is equal to (j+1) or $f_{o1.B} = 1/6.28$ C3R3 Hz. It should level off at the frequency where the denominator is zero or f = 0 Hz. Equation 11 defines the maximum bass boost curve shown in Fig. 7.

The maximum bass cut occurs when the wiper arm of potentiometer R2 is at maximum right hand setting. Here,

Circle 30 on reader service card

R_B of Equation 10 becomes $R1 + 1/j6.28fC2 = (j6.28fC2R1+1)/j6.28fC2$, while R_F is simply R3. Sustituting this into equation 10 yields

$$e_{out} = e_s\left(\frac{j6.28fC2C3}{j6.28fC2R1+1}\right) \quad \text{Eq. 12.}$$

The curve will begin to roll off at the frequency where the denominator is equal to j+1 or $f_{oLC} = 1/6.28C2R1$ Hz. It should level off at f = 0 Hz, the frequency when the numerator is equal to zero. This bass cut curve is also illustrated in Fig. 7.

We can now choose the components for this circuit. It is desirable to make the value of R2 as large as practical. A 1-megohm potentiometer was the component originally chosen by the inventor.

We can expect about 15 dB of actual boost and cut at the extreme settings of the control if we overdesign for a maximum cut and boost of 20 dB. 20 dB is a voltage ratio of 10:1. Again applying Equation 10, $e_{out}/e_s = 10/1 = R_F/R_B$. Since $R_B = R_F/10$, R1 is made equal to about 1/10 of R2, or about 100,000 ohms. For symmetry of the boost and cut modes, R3 is set equal to R1.

Fifteen dB of boost is required at 50 Hz. The curve should have an eventual 6dB/octave boost or roll-off. This

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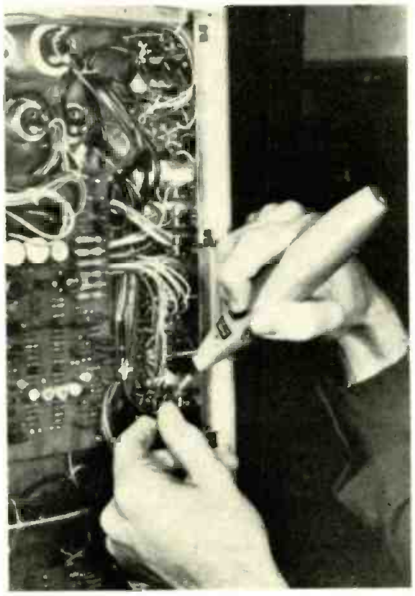
new products

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.

CORDLESS SOLDERING IRON, *Quick Charge model 7700.* Decrease in recharging time is due to long-life nickel cadmium batteries. Lower base stand (with slot for spare tip) will return a partially discharged battery to full capacity in an hour or two. A completely discharged battery can be fully recharged and used again in about four hours, giving tip performance equivalent to up to 50 watts and over 700° temperature. Same low voltage and isolated-tip construction as original *Iso-Tip* which eliminates electrical leakage and need for grounding, reducing risk of heat damage to sensitive components. Tip is easily replaceable with any of the four completely different tip sizes from heavy duty to fine (manufacturer does caution against interchanging standard *Iso-Tip* with a *Quick Charge* stand as units are not interchangeable.



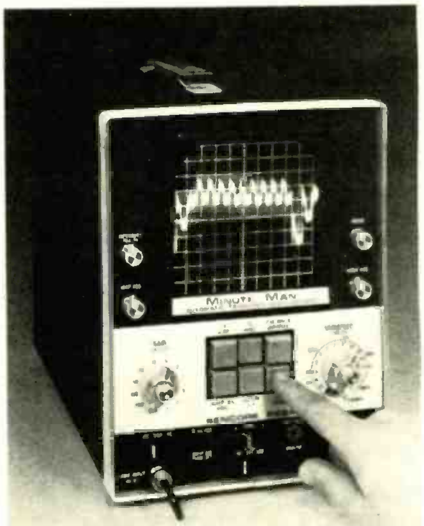
Pressing the button gives you soldering heat in five seconds plus a built-in work light on working area; pilot light, too. Lock-off switch prevents accidental heating of tip. Carries enough power to make up to 125 electronic joints per charge; automatically begins recharging when replaced in its stand; no wires to connect; no positioning of iron in its stand. 8 inches long with tip; 6 oz.; kit consists of cordless *Quick Charge* soldering iron, separate recharging stand, one *No. 7545* fine tip, one *No. 7546 heavy duty tip and instruction* booklet.—**Wahl Clipper Corp.,** 2902 Locust Street, Sterling, Ill. 61081.

Circle 31 on reader service card

ALARM, *Mach 4.* Keyless vehicle alarm can be installed in any vehicle in 30 minutes. Encapsulated electronics insures accurate timing and monitoring of all battery current flow, temperature stability and long product life. Designed with solid-state circuits and components. Arming the system is a throw of a hidden switch within the vehicle; hidden switch must be turned off within 15 seconds of entering the vehicle or powerful 114-dB siren will sound. Needs no fender hole or lock.—**Wolo Manufacturing Corp.,** 37 Jefry Lane, Hicksville, NY 11801.

Circle 32 on reader service card

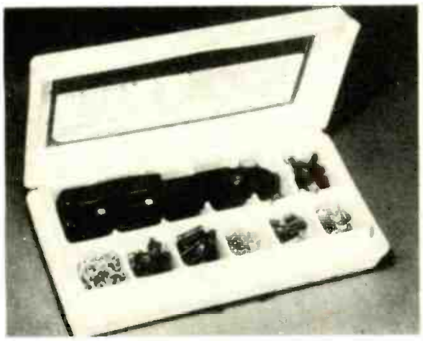
OSCILLOSCOPE, *PS29 Minute Man.* Automatic triggered pushbutton scope enables you to display any color TV or video waveform by simply pushing a button. Pushbutton displays include TV vertical, TV horizontal, 3.58 MHz for viewing color subcarrier information, five times expand and a completely front end vector display. Sixth button sets scope for 60 Hz line sweep used in sweep alignment work. Triggers internally on any signal down to 20 millivolts. External trigger allows you to sync on any signal above a dc voltage. Absence of input signal is indicated by continuous running baseline.



Has dc coupling, 500 V ac input protection, 10 MHz bandwidth with vertical sensitivity from 10 millivolts per div direct to 500 volts 1 div using 10x1 probe at 3% calibration accuracy. Push the 3.58 vari-speed button and horizontal sweep control activates which offers signal display for any non-video frequencies from dc to 10 MHz. $495.00.—**Sencore, Inc.**, 3200 Sencore Drive, Sioux Falls, SD 57107.

Circle 33 on reader service card

SOLDERLESS TERMINALS KITS. Only the 12 most popular types are included in each of the six kits, with wire sizes ranging from 22-18 through 12-10. Each kit comes with universal crimping tool with built-in bolt cutter and wire stripper. All kits are supplied in



reusable cases. Insulated terminals offer beveled mouth for wire insertion, multiple "V" groove for maximum holding power and minimum contact resistance, open barrel construction, one-piece, burr-free construction, uniform electro-tin plating.

K-120-A kit ($21.95) includes 520 pieces of non-insulated solderless terminals. K-130-A kit ($31.95) contains 600 insulated and non-insulated terminals. K-140-A ($39.95) has 600 insulated terminals. K-170-A ($13.95) has 180 non-insulated terminals. K-180-A ($14.95) includes 120 insulated terminals. K-220-A ($32.95) has 420 pieces of non-insulated and insulated quick-disconnect solderless terminals.—**Waldom Electronics, Inc.**, 4625 West 53rd Street, Chicago, IL 60632.

Circle 34 on reader service card

TURNTABLE, *PL-10.* Belt-drive turntable and pickup combination comes complete with its own electrically shielded spring suspension wood-grain cabinet and hinged dust cover. Uses belt-drive system with a 4-pole synchronous motor for stable speed rotation. Aluminum alloy die-cast 12 in. platter rotates at 33⅓ or 45 rpm regardless of line voltage fluctuations.

Signal-to-noise ratio is better than −47 dB; wow and flutter is less than 0.1% wrms. Statically balanced, S-shaped pickup arm

Circle 65 on reader service card

Circle 66 on reader service card

pivots on a point of hard alloy for reduced friction and improved tracking. Anti-skating control is independent of tonearm. Plug-in shell and oil-damped cueing, plus direct-reading stylus force scale on adjustable counterweight are additional features. Accepts cartridges weighing from 4 grams to 8.5 grams and provides a stylus overhand of 0.61 in. Operates on 120 V, 60 Hz; consumes 10 watts of power, maximum. 6$^{13}/_{32}$ x 16$^{13}/_{16}$ x 13$^{11}/_{32}$ in.; 14 lbs. 12 oz.; $99.95.—**U.S. Pioneer Electronics Corp.,** 75 Oxford Drive, Moonachie, NJ 07074.

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WIND GENERATOR, *stock No. 19,189,* taps inexhaustible energy source to supply current for battery charging, lighting, emergency current supplies, and various uses in isolated cabins or lodges.

Six-foot propeller turns 200-watt generator to supply 12 volts. Starts charging in 7-mph

winds, delivers 15 amperes with winds at 23 miles per hour. Air-brake governor automatically prevents overcharging.

Enclosed collector ring with double carbon brushes protects against dust, frost or ice. Special capacitors and grounding spring eliminate radio interference. Mounts on 10-foot, 4-leg angle-iron tower.

Comes with completely wired, insulated instrument panel and full instructions. Price (without 12-volt battery) $425 postpaid. **Edmund Scientific Co.,** 980 Edscorp Bldg., Barrington, NJ 08007.

Circle 36 on reader service card

COMPONENTS KIT, *Stock No. 199006* contains a variety of transistors, diodes and resistors plus one circuit breaker—29 components in all. Also included is a tube of white silicone heat sink compound. Parts location diagram fits into kit lid and simpli-

fies parts identificaton by showing exact location of each component in the kit. Cross reference chart shows usage of each part by chassis number and circuit symbol number. Components in the kit are used to service XL-100 chassis. $59.60.—**RCA Parts and Accessories,** P.O. Box 100, Deptford, NJ 08096. **R-E**

Circle 37 on reader service card

MINICOMPUTER MODIFICATIONS

(continued from page 43)

well as the gates needed to connect them.

Expanding input ports

The basic Mark-8 computer has only two input ports which may not be enough for all purposes, particularly if we want to use one input port for an

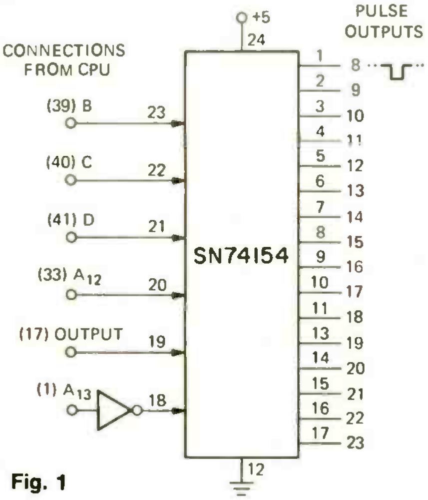

Fig. 1

ASCII keyboard and use the other for data input. We know that we can bus data to the other input port using three-state gates or open-collector gates with the decoders on an output port to select the data source. This was shown

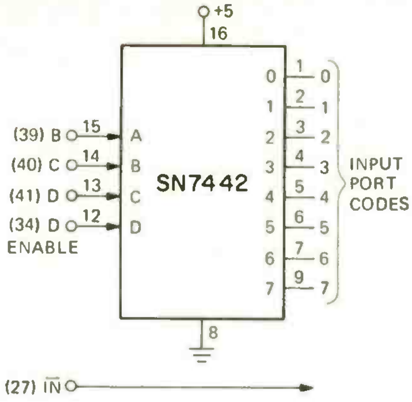

Fig. 2

in the dvm and counter example. This configuration takes extra software and hardware and doesn't allow for a great deal of flexibility for future expansion or for more complex systems.

The two 8263 multiplexers on the Input Multiplexer Board allow the computer to input data from the memory, input port 0 or input port 1. The selection of the data source is performed by the computer so that an INP1 instruction switches the multiplexers to the input port 1 data lines. We can simplify the multiplexer scheme so that it switches to input data whenever an INP type instruction

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new lit

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.

TAPE ACCESSORIES BOOKLET. 8-page booklet includes Ampex, Scotch, Craig, Concord, Dokorder, Capitol, Electro-Voice, Koss and others. Contains specifications, prices and photos of the tape accessories as well as what type of equipment each of the companies is offering.—**Saxitone Tape Sales,** 1776 Columbus Road, NW, Washington, DC 20009.

Circle 38 on reader service card

STEREO CATALOG. 32-page catalog contains systems, cartridges, stereo phono cartridges, turntables, changers, phono accessories, loudspeakers, tape recorders and players, tape accessories, 4-channel systems, professional audio equipment, tapes, microphones, mixers, headphones and audio/video electronic equipment. Many illustrations and prices; an order form is inserted in the center of the catalog.—**ADR Audio Warehouse,** 6200 Chillum Place, NW, Washington, DC 20011.

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LOOK FOR THE JANUARY ISSUE OF RADIO-ELECTRONICS AT YOUR NEWS DEALER DECEMBER 19

AUDIO FEEDBACK CIRCUITS
(continued from page 81)

places the corner frequency at about 300 Hz. Substituting 300 Hz for $f_{oL,B}$, C3 is calculated to be 5000 pF. (.005 μF). For symmetry reasons, $f_{oL,C}$ is also set at 300 Hz and as a result, C2 = C3.

Intermediate settings of this control will give intermediate amounts of boost and cut. 300 Hz will not be the corner frequency at these intermediate settings. The corner frequency will shift closer to the low end of the band when less emphasis or attenuation is required. The high and mid-frequencies will not be affected by the settings of the control.

The treble circuit is shown in Fig. 8. C1, R1, R3, and C4 are from Fig. 6. The potentiometer R2 has been drawn as a short circuit and omitted because at the high frequencies involved, C2 and C3 are effectively shorts across the bass control.

Effectively, with R5 at the maximum left hand setting (maximum treble boost), the control is a short across R1 and several other components. As a result, the high frequencies are fed more easily to the gate of the FET, than ar the lower frequencies. This meets the requirements of a treble boost circuit.

Similarly, at the extreme right hand setting of R5, C5 shorts R3 as well as several other components in the circuit. It feeds the high frequencies back from the output to the gate more readily than it does the lower frequencies. Hence there is treble cut.

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STAR REMOTE CONTROL
(continued from page 51)

Now birdie counting begins and continues until the desired channel is reached.

To summarize, channel acquisition is a three-step process involving:

(1) Setting the VCO to a frequency midway between the 24-HMZ comb;

(2) Scanning downwards until contact is made with the 24-MHz comb; ramp down;

(3) Upon contacting the comb, reversing the sweep and simultaneously posting a 6-MHz comb and counting to the desired channel, ramp up.

Accommodating Channels 5 & 6

Channels 5 and 6 are unique in that their frequencies lie out of step with the regular 6-MHz intervals which separate all other channels. A 6-MHz comb cannot be used in a direct way to lock onto these channels. A 4-HMz comb will, however, fall 1-MHz away from Channel 5 and 6 oscillator frequencies. The 31st harmonic of 4-MHz is 124-MHz which is 1MHz above Channel 5 L.O. frequency of 123-MHz. The 32nd harmonic of 4-MHz is 128-MHZ which is 1 MHz below the L.O. of 129-MHz for Channel 6. By properly decoding the birdie counter, it is possible to use a 4-MHz comb to lock a birdie counting system on Channels 5 or 6.

Two digits are required to address a channel. These are entered sequentially, first tens then units. The data may be entered through the keyboard or remote input. In either case, data is converted to binary form prior to entering the data decoder.

The data decoder accepts keyboard or remote data in binary form and decodes this into channel address or auxiliary functions. DATA VALID and LOAD ENABLE outputs are additionally derived from the data decoder.

Read-In sequence

Assume that Channel 45 is to be selected. A "4" is first entered into the data decoder (see Fig. 6). The data valid line immediately goes high indicating that a number between 1 and 15 is present at the data decoder input. The "4" is not immediately read into the system, however. Read in occurs only when valid data is present for a minimum of 70 ms. This assures that noise inputs less than 70 ms are not read into the system.

This delay is produced by C1, which charges to the upper trip point of ST 70 ms after the data valid line goes high. ST fires, generating a transfer signal. This signal activates the load control which first loads the contents previously stored in the units counter, into the tens counter, and subsequently loads the "4" into the units counter. These pulses appear on the load control output lines designated LOAD TENS and LOAD UNITS. Upon release of the "4," C1 discharges through the lower trip point of ST causing the transfer line to go to zero. This completes loading of the first entry. A similar sequence occurs for the second entry.

The second entry differs from the first in that the load control emits an extra strobe. This strobe triggers the DMV which in turn loads the contents of the units and tens counters into the units and tens buffer. At this time the number 45 is stored in the buffers and the scan sequence is initiated. Note that data was transferred to the buffers only after the second digit was entered. The character generator now displays Channel 45, the birdie counter is preset to 45 and the band de-coder recognizes operation in the uhf band. With these ingredients and with the initiation of the scan sequence, the system will tune to Channel 45.

Yes, the STAR system is complicated. But it is likely that we will be seeing many similar circuits in other makes of sets in the models to come. R-E

Heathkit electronics-today's technology is in your hands

A. Heathkit IB-1103 180 MHz Counter has phase-locked multiplier, extremely high resolution with 8½-digit readout. Pushbuttons permit multiplication by 1 (direct), 10, 100 or 1000. Also has temperature compensated crystal oscillator (TCXO) and pushbutton selection of 1 msec., 100 msec. and 1 sec. gate times. Input sensitivity is 50 mV to 120 MHz and 100 mV to 180 MHz. Has lighted indicators for MHz, kHz, Hz, Gate, Overrange and unlocked conditions. $349.95*. Shipping weight, 12 lbs.

B. Heathkit ID-1290 Weather Station has Uni/Mag® barometer for 2½ times greater pointer deflection; 8 wind-direction compass points that light-up in combination to give you 16-point resolution; wind speed indicator with 2 switch selectable ranges, 0-30 and 0-90 mph; dual-sensor thermometer with switch selection of indoor and outdoor temperatures. Includes weather cup and wind vane assembly, simulated walnut housing. $99.95*. Weight, 9 lbs., 50′ cable, 6.95*, 2 lbs.; 100′, 12.95*, 4 lbs.; 150′, 17.95*, 6 lbs.

C. Heathkit GC-1005 Electronic Alarm Clock. A six-digit timepiece that displays hours, minutes and seconds on highly visible cold-cathode readout tubes. Gentle "beeper" alarm can be set for 24-hour cycle, features snooze switch for seven more minutes of sleep. Displays time in 12-hour, or 24-hour format. $59.95*. Mailing weight, 4 lbs.

D. Heathkit ID-1390 Digital Thermometer. A solid-state device that monitors indoor and outdoor temperatures. Switches set thermometer for alternate display of indoor/outdoor temperature at 4-second intervals, for constant display, and for readout in either degrees Fahrenheit or degrees Centigrade. Includes 85′ cable and 2 sensors. $62.95*. Mailing weight, 5 lbs.

E. Heathkit AR-2020 4-Channel Receiver offers 15 watts per channel†, built-in decoder for reproducing matrixed 4-channel material, and an AM/FM tuner that boasts 2μV sensitivity, 2dB capture ratio. Push-buttons for all modes of operation and inputs to accommodate phono, tape and auxiliary source in stereo or 4-channel combinations. The solid-state circuitry mounts on plug-in boards for easy assembly and self-service. And the low kit price includes the cabinet, too! $259.95.* Mailing weight, 31 lbs. †Power measured at 8 ohms with less than 0.5% total harmonic distortion from 20-20,000 Hz, all channels driven.

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In the new Heathkit GR-500, GR-400 and GR-300, Heath brings you another industry first — a new generation of small-screen color TV receivers featuring on-screen digital channel readout, an optional digital clock accessory, and a host of other exciting new design innovations. The new precision in-line gun tube uses a slotted shadow mask for far greater light output. And, in the GR-400 & 500, a negative matrix screen is used for greater contrast and brightness. A wider bandwidth IF amplifier with fixed LC filter was added. This, coupled with luminance and video circuits with black level clamps maintains the true brightness level of the televised scene, with picture realism you never dreamed possible.

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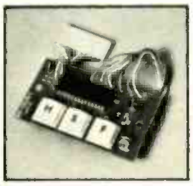

Optional digital clock module

Optional roll-around cart

Improved VHF tuner design. Another area receiving special attention was the VHF tuner. It was given a new mixer circuit featuring a dual gate FET to achieve better cross modulation performance. The RF amplifier is also a dual gate FET, resulting in a low noise figure, high gain and low cross modulation. The four circuits of the tuner (most have only three) offer far greater selectivity than ordinary sets.

Total VHF/UHF detent tuning convenience — with on-screen channel display. Every VHF and UHF channel is selectable simply by turning the channel selection knobs until they click to your favorite channel with precision detent action. As you turn the knobs, every channel number is displayed on the TV screen in big bright digits, completely adjustable as to brightness, position on the screen, and length of display time. And the same goes for the optional digital clock. Fine tuning (AFT) is automatic.

New one-button Preset Picture Control (PPC). An important new convenience feature is the PPC button located on the front panel. Once the brightness, contrast, color and tint have been correctly set by the rear preset controls, a touch of the PPC button returns the picture to perfection instantly — no matter how much the front-panel controls have been disturbed.

Other design innovations include Instant-On operation with a front-panel defeat switch for vacation-time shutdown; hi-fi output jack and TV speaker defeat switch; 75-ohm VHF antenna input; a new high voltage power supply with voltage tripler circuit for plenty of reserve power; a new quasi-complementary-symmetry vertical deflection circuit that eliminates the need for an output transformer; new slide-out chassis, plus interconnecting cables using plugs and sockets, for easier adjustment and servicing.

Get with the new generation of Heathkit small-screen Color TV now . . . in time for the holiday fun!

Kit GR-500, less cabinet, 88 lbs., Exp./Frt. **499.95***

GRA-500-1, table model cabinet for GR-500 (main illus.), 35 lbs., Exp./Frt. **39.95***

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Kit GR-400, with cabinet, 104 lbs., Exp./Frt. **489.95***

Kit GR-300, with cabinet, 90 lbs., Exp./Frt. **449.95***

GRA-403-18, roll-around cart for GR-300, -400 & -500, 23 lbs., Exp./Frt. **21.95***

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Kit IC-2100, 4 lbs., mailable . . **119.95***

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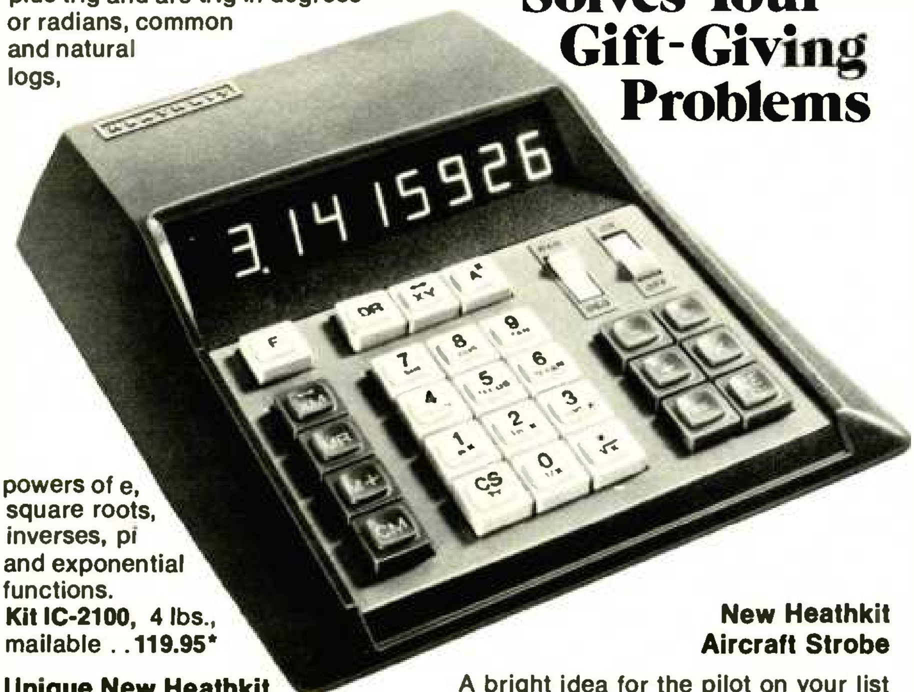
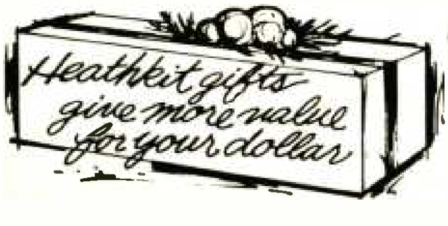


Unique New Heathkit AM/FM Digital Clock Radio

Our outstanding clock radio makes even sleepy Santas happy.

The electronic clock with snooze alarm features a gentle "beep" with adjustable volume. Or wake to the component-quality AM/FM radio. Standby batteries (not included) keep the clock on time during power interruptions. **Kit GR-1075,** 10 lbs., mailable **129.95***



New Heathkit Aircraft Strobe

A bright idea for the pilot on your list —or for anyone who needs an emergency marine or marker light. It meets FAR 23.1401 and assembles easily in just one evening. For 12 VDC neg. ground. With clear lens, optional red and red/clear lenses available.
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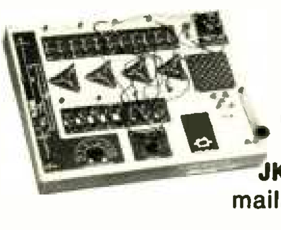
The JK-18A teaches kids electronics the easy learn-by-doing way. 35 exciting projects include light meter, sound meter, transistor radios. For safety, it's battery powered and requires no soldering. (Batteries not included) **Kit JK-18A,** 10 lbs., mailable . . **34.95***



New Heathkit Electronic Clock/Timer for Car, Boat or Plane

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Time/Alarm

Time/Date

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new Heathkit dual-trace DC-15MHz scope

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- Vertical amplifier delay lines for pulse analysis capability
- Digitally controlled triggering for exceptional stability
  - Typically triggers up to 45 MHz—guaranteed to 30 MHz

It offers a lot more than just a low price

The Heathkit IO-4510 is your best 'scope buy for two good reasons—it does more and it costs less.

Time base sweep up to 100 nsec/cm. There's always a reference baseline, even when there's no trigger signal. The time base can be precisely triggered at any point along the positive or negative slope of the trigger signal. In automatic mode, it triggers at the zero crossing point.

Modes of display. Either channel can be displayed as a function of time or both can be displayed together. In X-Y operation, channel 1 provides horizontal deflection and channel 2 provides vertical deflection. There are 22 calibrated time bases from 0.2 sec/cm to 0.1 μsec/cm. The sweep speed is continuously variable between switch positions. Any speed can be expanded five times by pulling out the control knob.

For easy calibration, a 1 volt peak-to-peak square wave is available on the front panel. The regulated supply operates from 100-280-volt AC power.
Kit IO-4510, 34 lbs., mailable **549.95***

Assembled SO-4510, factory-wired & calibrated version of the IO-4510, 34 lbs., mailable **750.00***

New Low-Cost Heathkit Function Generator

A true function generator, not an oscillator, delivers sine, square and triangle waveforms from 0.1 Hz to 1 MHz. Short-proof output supplies 10 volts peak-to-peak into 50-ohm load. A calibrated step attenuator adjusts from 0-50 dB (10V to 30 mV) in 10 dB steps. A variable control provides up to 20 dB of additional attenuation at each step. Attenuator accuracy is ±1 dB; frequency accuracy is ±3%. Nonlinearity of the triangle waveform is 5% max., symmetry is within 10%. Sine wave THD is 3% max. from 5-100k Hz. Square wave rise and fall times are 100 nsec max. 105-130 or 210-260 VAC. **Kit IG-1271,** 7 lbs., mailable **99.95***

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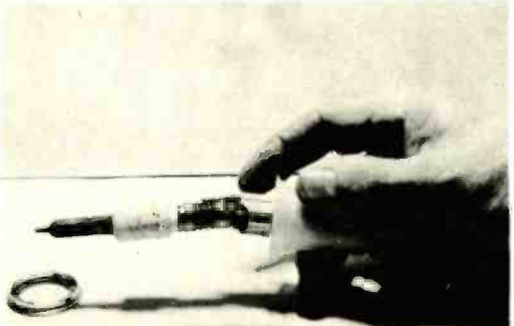
try this

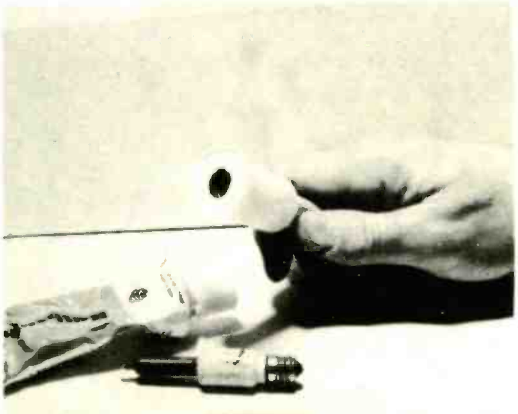
PENCIL IRON REPAIR

Has that small pencil iron fallen off of the workbench for the last time, its plastic socket container broken and the shell socket is exposed? If so, it probably looks like the "before" photo.

Don't throw this pencil iron holder away. Take a tube of silicone rubber bath tub seal, which can be purchased



BEFORE



AFTER

at drug and hardware stores, and repair it. Remove the soldering iron tip and center the socket into the broken plastic piece. Pour or squirt the rubber cement around the socket. Level or bevel off the excess rubber silicone cement and insert retainer ring. See "after" photo. Let the mixture set up for twenty-four hours. You now have a new soldering iron holder that bounces when it is dropped upon the floor.—*Homer L. Davidson*

SILVERTONE COLOR SETS

When servicing many of these sets, you have to pull the chassis to adjust the reactance or color oscillator coils. The standard alignment tool is just too long.

To alleviate this problem, cut the plastic alignment tool in half. Shortened, it is easy to insert and saves broken coils and slugs.—*Andrew M. Hejnar* **R-E**

NEW CB RULES ARE COMING

There are more channels being added to the CB band and some complications too. To keep up with the new FCC rulings and to find out how they affect you, don't miss the January 1975 issue of Radio-Electronics. It goes on sale December 19.

AUDIO FEEDBACK CIRCUITS

(continued from page 87)

Both the boost and cut circuits are in the operational amplifier circuit and Equation 10 does apply. Converting R1, R3 and R1 mathematically from a "tee" to a "delta" configuration to facilitate analysis, will yield a corner boost frequency at f_{obb} and a corner cut frequency at f_{obc}. They are both equal to 1/6.28C5 (R1 + 2R4).

The intermediate settings of the control will yield intermediate amounts of treble boost and cut. As was the case with the bass control, the corner frequency is shifted away from the center frequency when less boost or cut is required at the upper ends of the band. The setting of the control will not affect the center or low frequency regions of the band.

The value of C5 was set at about 100-pF, so it would not load the input circuit excessively and yet be large enough not to be affected by stray capacitances in the circuit.

f_{obb} was chosen for about 16 dB of boost at 10,000 Hz. An approximate curve used to determine the corner frequency is shown in Fig. 9. At the maximum setting of the control, $f_{obc} = f_{obb} = 1.5$ kHz. Since R1 and C5 are already known, R_4 is calculated to be about 500,000 ohms.

R5 must be made as small as practical when compared to the reactance of C5 at the highest audio frequency that must be boosted. A 500,000-ohm linear center-tapped potentiometer was found to be satisfactory.

A low-gain amplifier or lower impedance bipolar transistor are frequently used in the feedback tone control circuit in place of the JFET. As these components cause the operational amplifier to differ radically from the ideal, the components must change from the calculated values to produce results similar to those outlined above. The circuit should be designed in the laboratory in this case. Since the function of each component has been detailed, the effects of changing a component is known and the design procedure does not have to be haphazard.

A complete tone control circuit has been drawn in Fig. 10 showing the bass and treble controls. The following factors affecting the various functions of the control should be noted.

The amount of boost and cut produced by the treble control is affected by R4 and C5. Make either component larger if more treble action is required. To a lesser degree, increasing R1 increase the amount of treble boost, while increasing R3 affects the size of the treble cut.

As for the bass circuit, C3 and R3 must be increased to further emphasize the boost while C2 and R1 must be increased to accentuate the cut. **R-E**

MOS SHIFT REGISTERS

(continued from page 62)

correlators, and Fourier series calculators. And, as a final and obvious application, shift registers are being used to replace magnetic discs as medium-speed, high-density storage systems for computers. These are often called *silicon disc* files.

Getting started

If you are new to shift registers, pick up a few of the bargain surplus units and try experimenting with them. You'll get best results if you stick with the static units at first and avoid the older metal gate ±15 volt circuits as they are hard to interface. Remember to pick up several units at once if you are buying seconds. Above all, have the exact data sheet on hand, and if possible, some application notes as well. Be sure to have your power supplies well decoupled and regulated and make sure your clock lines and drivers *exactly* meet the specified requirements. Keep your clock pulse widths down around the minimum recommended values to minimize internal heating and try to derive the clock widths and spacing from digital logic and timing rather than using adjustable monostable delays. **R-E**

MINICOMPUTER MODIFICATIONS

(continued from page 85)

is executed by the computer. The second input port on the Input Multiplexer Board will not be used.

Data is now input to the computer on eight input lines using either a three-state or open-collector bus and data is strobed on the bus from the selected source. Since the multiplexer will switch to input data with every input instruction, we still need some method of selecting the data source. Instead of using the output port and decoders we can use the IN signal and decode the MMM bits in the input instructions, 01 00M MM1. This gives the capability of up to eight input ports on the Mark-8. We will need eight gates on each input port, one per bit of information and these should be either SN7403 types for the open collector bus or DM8095 types for the three state bus. The additional circuitry is shown (Fig. 2 and 3) and the Input Port Code and IN signal are NORed together to activate the selected eight bit input port. An example of each type of bus is also shown in Fig. 3.

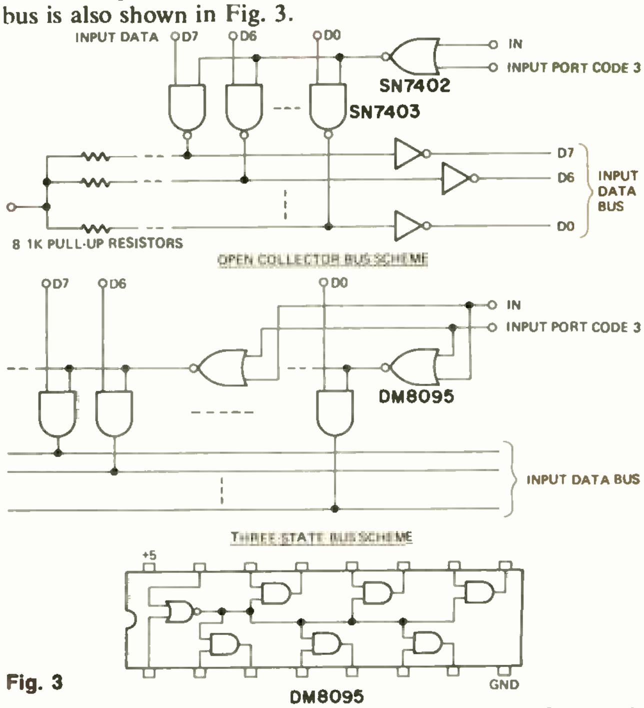


Fig. 3

In both of the bus examples we have used INP3 to activate the selected device. The open-collector bus used SN7403 gates and since these will invert the data, we invert it again before it is input to the computer. Pull-up resistors must be used and the IN and Input Port Code 3 were NORed together using an SN7402 quad two input NOR chip. The three-state bus example used DM8095 three-state gates where the NOR gate is included on-chip just for this gating purpose. IN and Input Port Code 3 are applied directly to the DM8095. These gates do not invert the data and pull-up resistors are not needed.

We must modify the Input Multiplexer Board slightly so that the eight input lines of Input Port 0 are activated on each input instruction. Input port 0 now becomes the bus input and input port 1 is not used. Input ports zero through seven are now constructed with external gates and use the IN and Input Port Code to select the set of gates to input data. Remember, port 1 is no longer on the board.

To modify the multiplexer, remove IC-7, the SN7442 decoder, and using the IC solder pads, connect a jumper from hole 1 to hole 8 (ground), and connect another jumper from hole 2 to hole 16 (+5 volts). This will disable the input port 1 lines and cause the multiplexer to switch to the input port 0 lines whenever an input instruction is executed. **R-E**

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2.2 UFD/50V	14c	12c	11c	33 UFD/25V	13c	13c	12c	330 UFD/25V	[illegible]	[illegible]	[illegible]
3.3 UFD/25V	14c	12c	11c	47 UFD/16V	13c	14c	13c	470 UFD/16V	[illegible]	[illegible]	[illegible]
4.7 UFD/35V	14c	12c	11c	47 UFD/25V	16c	15c	14c	470 UFD/25V	[illegible]	[illegible]	[illegible]
10 UFD/16V	14c	12c	11c	100 UFD/16V	16c	15c	14c	1000 UFD/16V	[illegible]	[illegible]	[illegible]
10 UFD/25V	14c	12c	11c	100 UFD/25V	24c	18c	17c	1000 UFD/25V	75c	60c	55c
22 UFD/16V	14c	12c	11c	220 UFD/16V	24c	18c	17c	2200 UFD/16V	75c	60c	55c
22 UFD/25V	15c	13c	12c	220 UFD/25V	35c	25c	24c				

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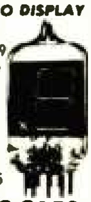

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.1	12c	9c	7.5c	6c

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EN918	TO-106	.21	.185	.165	EN930	TO-106	.21	.185	.165
EN2222	TO-106	.21	.185	.165	EN2369A	TO-106	.21	.185	.165
2N2712	TO-98	.18	.160	.145	EN2907	TO-106	.21	.185	.165
2N3391A	TO-98	.22	.190	.175	2N3392	TO-98	.22	.190	.175
2N3393	TO-98	.22	.190	.175	2N3394	TO-98	.22	.190	.175
2N3563	TO-106	.20	.175	.160	2N3565	TO-106	.20	.175	.160
2N3638	TO-105	.20	.175	.160	2N3638A	TO-105	.20	.175	.160
2N3640	TO-106	.22	.190	.175	2N3641	TO-105	.20	.175	.160
2N3643	TO-105	.20	.175	.160	2N3645	TO-105	.20	.175	.160
2N3646	TO-106	.22	.190	.175	2N3904	TO-92	.25	.225	.200
2N3906	TO-92	.25	.225	.200	2N4124	TO-92	.27	.240	.220
2N4126	TO-92	.27	.240	.220	2N4401	TO-92	.32	.290	.260
2N4403	TO-92	.32	.290	.260	2N5087	TO-92	.27	.240	.220
2N5089	TO-92	.27	.240	.220	2N5129	TO-106	.19	.170	.150
2N5133	TO-106	.19	.170	.150	2N5134	TO-106	.19	.170	.150
2N5137	TO-106	.19	.170	.150	2N5138	TO-106	.19	.170	.150
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7401N	.32c	28c	7438N	.51c	44c	7480N	.74c	65c	74154N	$2.25	$2.00
7402N	.32c	28c	7440N	.32c	28c	7482N	$1.02	91c	74155N	$1.46	$1.29
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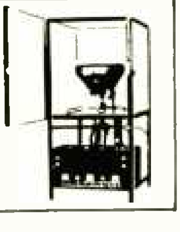

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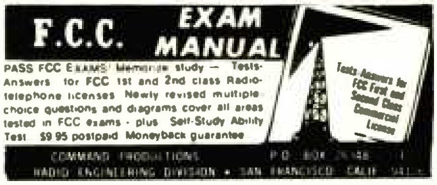

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7405N	.29	7483N	1.01	74155N	1.49
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7439N	1.01	74121N	.54	74192N	1.49
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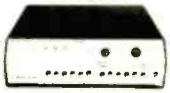

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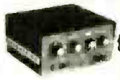

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7405	.22	7454	.39	74154	1.59
7406	.39	7460	.19	74155	1.19
7407	.39	7464	.39	74156	1.29
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7409	.25	7472	.36	74161	1.39
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7411	.29	7474	.43	74164	1.89
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7415	.39	7476	.47	74166	1.65
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7422	.29	7489	2.75	74180	1.09
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7425	.39	7491	1.29	74182	.89
7426	.29	7492	.79	74184	2.69
7427	.35	7493	.79	74185	2.19
7430	.22	7494	.89	74190	1.59
7432	.29	7495	.89	74191	1.59
7437	.45	7496	.89	74192	1.49
7438	.39	74100	1.65	74193	1.39
7440	.19	74105	.49	74194	1.39
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74L10	.33	74L74	.69	74L164	2.79
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74L30	.33	74L85	1.25		
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74H01	.33	74H22	.33	74H60	.39
74H04	.33	74H30	.33	74H61	.39
74H08	.33	74H40	.33	74H62	.39
74H10	.33	74H50	.33	74H72	.49
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8123	1.59	8551	1.65	8831	2.59
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MAN6	.6" high solid seg	6.95
MAN7	Red 7 seg. .270"	1.35
MAN8	Yellow 7 seg. .270"	3.95
MAN64	.4" high solid seg	4.50
MAN66	.6" high spaced seg	4.65
DL707	Red 7 seg. .3"	2.15
MCD2	Opto-iso diodes	1.09
MCT2	Opto-iso transistor	.69

DTL

930	$ .17	937	$ .17	949	$ .17
932	.17	944	.17	962	.17
936	.17	946	.17	963	.17

4000 SERIES – RCA EQUIVALENT

CD4001	.55	CD4013	1.20	CD4023	.55
CD4009	.85	CD4016	1.25	CD4025	.55
CD4010	.85	CD4017	2.95	CD4027	1.35
CD4011	.55	CD4019	1.35	CD4030	.95
CD4012	.55	CD4022	2.75	CD4035	2.85

LINEAR CIRCUITS

300	Pos V Reg (super 723)	TO-5	.79
301	Hi Perf	mDIP TO-5	.32
302	Volt follower	TO-5	.79
304	Neg V Reg	TO-5	.89
305	Pos V Reg	TO-5	.95
307	Op AMP (super 741)	mDIP TO-5	.35
308	Micro Pwr Op Amp	mDIP TO-5	1.10
309K	5V 1A regulator	TO-3	1.65
310	V Follower Op Amp	TO-5 mDIP	1.19
311	Hi perf V Comp	mDIP TO-5	1.05
319	Hi Speed Dual Comp	DIP	1.29
320	Neg Reg 5.2, 12, 15	TO-3	1.35
324	Quad Op Amp	DIP	1.95
339	Quad Comparator	DIP	1.69
340T	Pos Volt Reg (6V-8V-12V-15V-18V-24V)	TO-220	1.95
370	AGC/Squelch AMPL	TO-5 or DIP	1.15
372	AF-IF Strip detector	DIP	.79
373	AM/FM/SSB Strip	DIP	3.25
376	Pos. V Reg	mDIP	.59
377	2w Stereo amp	DIP	2.69
380	2w Audio Amp	DIP	1.49
380-8	.6w Audio amp	mDIP	1.25
381	Lo Noise Dual preamp	DIP	1.79
382	Lo Noise Dual preamp	DIP	1.79
550	Prec V Reg	DIP	.79
555	Timer	mDIP	.99
560	Phase Locked Loop	DIP	2.75
562	Phase Locked Loop	DIP	2.75
565	Phase Locked Loop	DIP TO-5	2.65
566	Function Gen	mDIP TO-5	2.75
567	Tone Gen	mDIP	2.95
709	Operational AMPL	TO-5 or DIP	.29
710	Hi Speed Volt Comp	DIP	.39
711	Dual Difference Compar	DIP	.29
723	V Reg	DIP	.69
739	Dual Hi Perf Op Amp	DIP	1.19
741	Comp Op AMP	mDIP TO-5	.35
747	Dual 741 Op Amp	DIP or TO-5	.79
748	Freq Adj 741	mDIP	.39
1304	FM Mulpx Stereo Demod	DIP	1.19
1307	FM Mulpx Stereo Demod	DIP	.82
1458	Dual Comp Op Amp	mDIP	.69
LH2111	Dual LM 211 V Comp	DIP	1.95
3065	TV-FM Sound System	DIP	.69
3075	FM Det-LMTR & Audio preamp	DIP	.79
3900	Quad Amplifier	DIP	.59
3905	Precision Timer	DIP	.65
7524	Core Mem Sense AMPL	DIP	1.89
7534	Core Mem Sense Amp	DIP	2.59
8038	Function Gen	DIP	5.95
8864	9 DIG Led Cath Drvr	DIP	2.50
75451	Dual Peripheral Driver	mDIP	.39
75452	Dual Peripheral Driver	mDIP	.39
75453	(351) Dual Periph. Driver	mDIP	.39
75491	Quad Seg Driver for LED	DIP	.79
75492	Hex Digit Driver	DIP	.89

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TRANSISTORS

DEVICE	FUNCTION	CROSS REF ** SK	HEP	HFE	VCEO	VCBO	VEBO	IC(A) AMP	IB(A) AMP	TOT DIS (WATTS)	FREQ MHZ	CASE	PRICE
	PWR AMP AUDIO												
40411	"	3036		35-100	80	90	5.0	30	15	150	1.5	TO-3	$3.75
40636	"	3027	704	20-70	95*	95*	7.0	15	7.0	115		TO-3	1.95
2N3714	"	3036	704	25-90	80	100	7.0	10	4.0	150	4.0	TO-3	2.59
2N3715	"	3036	704	50-150	60	80	7.0	10	4.0	150	4.0	TO-3	2.75
	RF PWR AMP												
2N5320	"	3512	53002	30-130	75	100	7.0	2	1.0	10	50	TO-5	1.65
2N5322 (P)	"			30-130	75	100	7.0	2	1.0	10	50	TO-5	1.75
2N5321	"	3512	53010	40-250	50	75	5.0	2	1.0	10	50	TO-5	1.65
2N5323 (P)	"	3513		40-250	50	75	5.0	2	1.0	10	50	TO-5	1.65
	PWR DRIVER												
2N5679 (P)	Audio/RF		53031	40-150	100	100	4.0	1.0	0.5	10	30	TO-5	1.70
2N5681				40-150	100	100	4.0	1.0	0.5	10	30	TO-5	1.70
	AUDIO DRIVER												
40594	"	3024	53002	70-350	95*		4.0	2.0	1	10	1.0	TO-5	1.45
40595 (P)	"	3025	53031	70-350	95*		4.0	2.0	1	10	1.0	TO-5	1.65
2N5781 (P)	"			20-100	65	80	5.0	3.5	1	10	1.0	TO-5	1.75
2N5784	"		53002	20-100	65	80	5.0	3.5	1	10	1.0	TO-5	1.75
2N5864 (P)	RF & Audio			25-500	70	90	5.0	1.5		8.75	50	TO-39	1.35
40348	"	3044	243	30-125	40	60	7.0	1.5	0.5	8.75	1.6	TO-5	1.72
40544	"	3045		35-200	50*	50*	5.0	0.7		7.0	100	TO-5	.79
	GEN PURP AMP												
2N2895	RF & Audio	3024		40-120	65	120	7.0	1.0		1.8	120	TO-18	1.25
2N930A	Lo-Noise	3039	50	100-300	60	60	6.0	.03		1.8	45	TO-18	.95
2N2219A	Audio-UHF Amp/SW	3024	53001	75-375	40	75	6.0	.8		1.8	300	TO-5	1.05
2N2846	High Speed Sw	3024		30-120	30	60	5.0	.8		3.0	250	TO-5	1.55
	HF GEN PURP												
2N3933	VHF/UHF Amp	3039	56	60-200	30	40		.002		.2	750	TO-72	1.55
40894	VHF/UHF RF Amp	3039		50-250	12	20	2.5	.05		.3	1200	TO-72	1.10
40895	VHF/UHF Mix, Osc	3039		40-250	12	20	2.5	.05		.3	1200	TO-72	.95
40897	VHF/UHF IF Amp	3039		70-250	12	20	2.5	.05		.3	800	TO-72	.90
2N5179	LoNoise, Amp, Osc, Mix, Conv	3039	709	25-250	12	20	2.5	.05		.3	2000	TO-72	1.10
2N918	VHF/UHF Amp Mix, Conv	3039	709	20 Min	15	30	3.0	.05		.3	600	TO-72	.95
2N2905A(P)	DC, VHF, Amp Hi Sp Sw	3025	708	100-300	60	60	5.0	.6		3.0	200	TO-5	1.15

**Manufacturers' (SK – RCA, HEP – MOTOROLA) Suggested Cross Reference. *External Res (R_{BE}) = 100 OHMS

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RESISTORS

15	ohm	5%	1w Corning	Film	.08
15	ohm	5%	25w Ohmite	WW	.75
28.7	ohm	1%	1w Dale	Film	.25
75	ohm	5%	8w Ohmite	WW	.39
102	ohm	1%	½w Corning	Film	.15
200	ohm	5%	5w Intl. Tect.	WW	.30
220	ohm	10%	½w Stackpole	C Comp	.07
330	ohm	5%	½w Stackpole	C Comp	.10
390	ohm	5%	2w Allen Bradley	C Comp	.25
450	ohm	5%	5w Dale	WW	.30
500	ohm	5%	1w Allen Bradley	C Comp	.19
620	ohm	5%	½w Stackpole	C Comp	.10
681	ohm	1%	¾w Dale	Film	.20
750	ohm	1%	¾ Dale	Film	.20
1	Kohm	1%	½w Corning	Film	.15
1	Kohm	5%	10w Dale	WW	.35
1.2	Kohm	1%	1w Intl. Rect.	C Comp	.25
1.6	Kohm	5%	½w Stackpole	C Comp	.10
2	Kohm	1%	¾w Dale	Film	.20
2	Kohm	5%	5w Intl. Rect.	WW	.30
2.15	Kohm	1%	½w Corning	Film	.15
2.4	Kohm	1%	5w Intl. Rect.	WW	.50
2.5	Kohm	5%	25w Ohmite	WW	.75
2.7	Kohm	5%	5w Dale	WW	.30
3.01	Kohm	1%	½w Electra	Film	.15
4	Kohm	5%	10w Dale	WW	.35
4.7	Kohm	1%	½w Corning	Film	.15
5.6	Kohm	5%	2w A.B.	C Comp	.25
7.5	Kohm	5%	½w Burroughs	C Comp	.10
8.25	Kohm	1%	½w Electra	Film	.15
9.09	Kohm	1%	½w Corning	Film	.15
9.1	Kohm	5%	2w A.B.	C Comp	.25
10	Kohm	1%	½w Corning	Film	.15
15	Kohm	10%	½w Stackpole	C Comp	.07
17.4	Kohm	1%	½w Corning	Film	.15
20	Kohm	5%	1w A.B.	C Comp	.19
23.7	Kohm	2%	¼w Corning	Film	.15
39	Kohm	1%	½w Corning	Film	.15
51	Kohm	5%	½w Burroughs	C Comp	.10
75	Kohm	1%	½w Corning	Film	.15
100	Kohm	1%	½w Corning	Film	.15
120	Kohm	5%	½w Burroughs	C Comp	.10
130	Kohm	5%	½w Stackpole	C Comp	.10

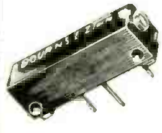
CAPACITORS

.0033	mfd	100V	5%	Skottie mylar axial	$ .10
.0047	mfd	100V	10%	G.E. mylar axial	.09
.0047	mfd	100V	10%	Gen. Inst. mylar axial	.09
.01	mfd	200V	20%	Aerovox paper axial	.05
.02	mfd	100V	1%	Sprague mylar axial	.15
.1	mfd	600V	3%	Aerovox paper axial	.20
.1	mfd	400V		Aervox paper axial	.20
.1	mfd	200V		CDE paper axial	.15
.1	mfd	200V		Aervox paper axial	.15
.5	mfd	400V	10%	Gen. Inst. mylar axial	.35
1.0	mfd	350V	.68%	Mallory Elec axial	.50
2.0	mfd	200V	20%	Aerovox Elec axial	.20
4.0	mfd	350V		Sprague Elec axial	.45
5.0	mfd	25V		Gen. Inst. Elec axial	.15
10	mfd	150V		Sprague Elec axial	.30
30	mfd	300V		Mallory Elec axial	.35
60	mfd	350V		Mallory Elec axial	.75
1,000	mfd	100V		Sangamo Comp grd can	2.65
1,000	mfd	50V		CDE Elec axial	1.25
2,000	mfd	15V		Mallory Elec can	.85
6,000	mfd	25V		Sangamo Comp grd can	3.75
50	mfd	285V		I.C.C. oil imp bathtub	.60

SWITCHES

SPST	1A Momentary Return P.B.-A.H.&H.	.25
SPST	15A Micto switch Flat leaf	.50
DPST	5A Micro switch Pin plunger	.75
DPST	10A Micro switch-mini Pin plunger	.65
DPST	10A Pin plunger	.65
4P3T	6A Slide Stackpole	.25

MISC. COMPONENTS



1 ohm 25w 5A Memcor wire wound pot.	1.95
100 ohm ½w Bourns EZ trim WW 30 turn pot.	1.50
10 Kohm ½w Bourns EZ trim WW 10 turn pot.	1.50
MDA 962 Motorola fullwave bridge 10A-100V	4.95
AEX 43-1 TEC selenium Rectifier	.05
IN 2990A Motorola 33V 1w zener diode	1.95
LA 2751 Fenwell Thermister 550-100	.75
6113 Elwood Thermal	.75
Panel Light PTT red DPST SW W/ Mount Tec	.95
Panel Light red Neon W/NE 2 Bulb Snap Mount	.45
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25000	6	2x4-1/2	3100	75	2-1/16x4-3/8
40000	7	2 x 5	3600	75	2-1/16x4-1/4
15000	10	2x4-1/2	1500	80	2x4-1/2
15000	12	2x4-1/2	400	100	1-7/16x2-1/2
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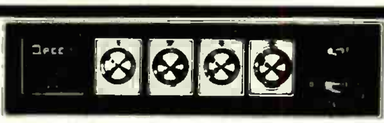

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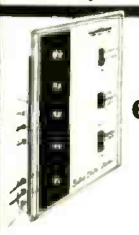

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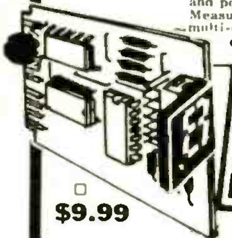

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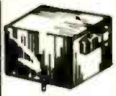

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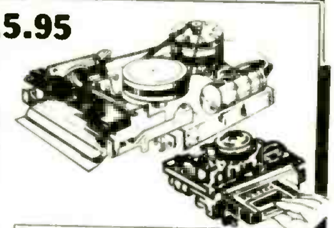

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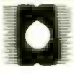

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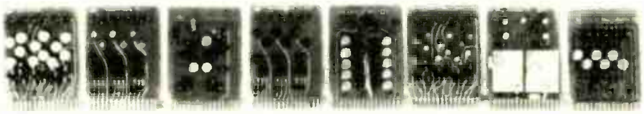

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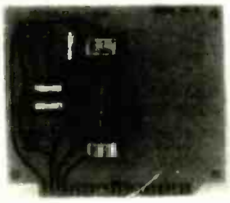

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7407	.37	7492	.75
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7411	.30	7496	.95
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7416	.37	74121	.60
7417	.37	74123	1.00
7420	.18	74125	1.40
7426	.30	74126	1.40
7427	.33	74150	1.15
7430	.18	74151	.95
7432	.30	74153	1.10
7437	.44	74154	1.65
7438	.37	74157	1.25
7440	.21	74163	1.60
7441	1.05	74164	2.05
7442	1.00	74165	2.05
7445	1.10	74173	1.80
7446	1.15	74177	1.80
7447	1.15	74181	3.60
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200	.70	1.10	1.75	.60	.70	1.60
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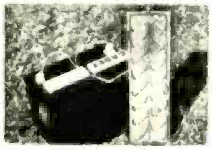

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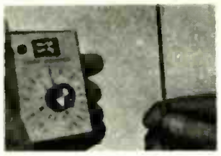

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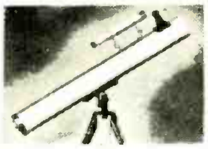

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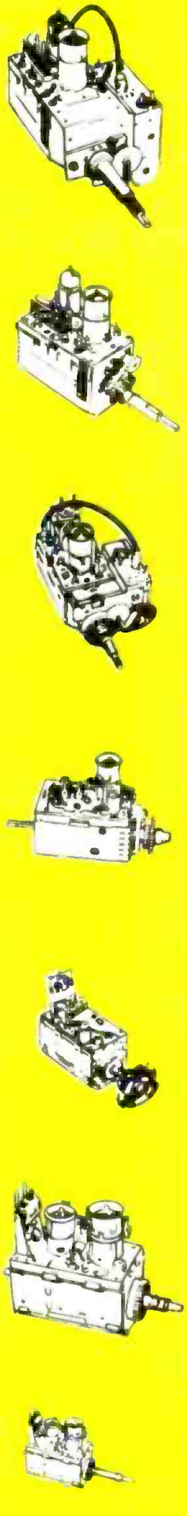

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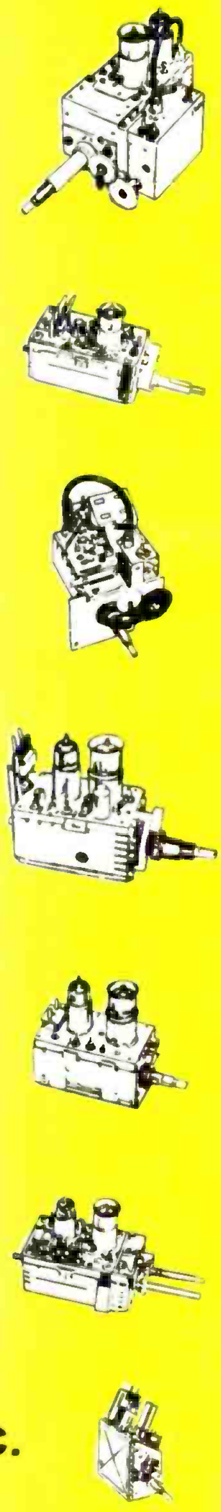

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