DIGITAL MULTIMETERS FOR HOBBYISTS

14278

Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE FEBRUARY 1977/$1.25

NEW, PRACTICAL OP AMP CIRCUITS

includes a differential PC board tester

HOW TO ADD DIGITAL FREQUENCY READOUT TO SHORTWAVE RECEIVERS

TEST REPORTS:

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Acoustic Research AR-16 Speaker System

BUILD A LOW-COST LOGIC ANALYZER

Data-domain instrument for troubleshooting microcomputers and other digital equipment

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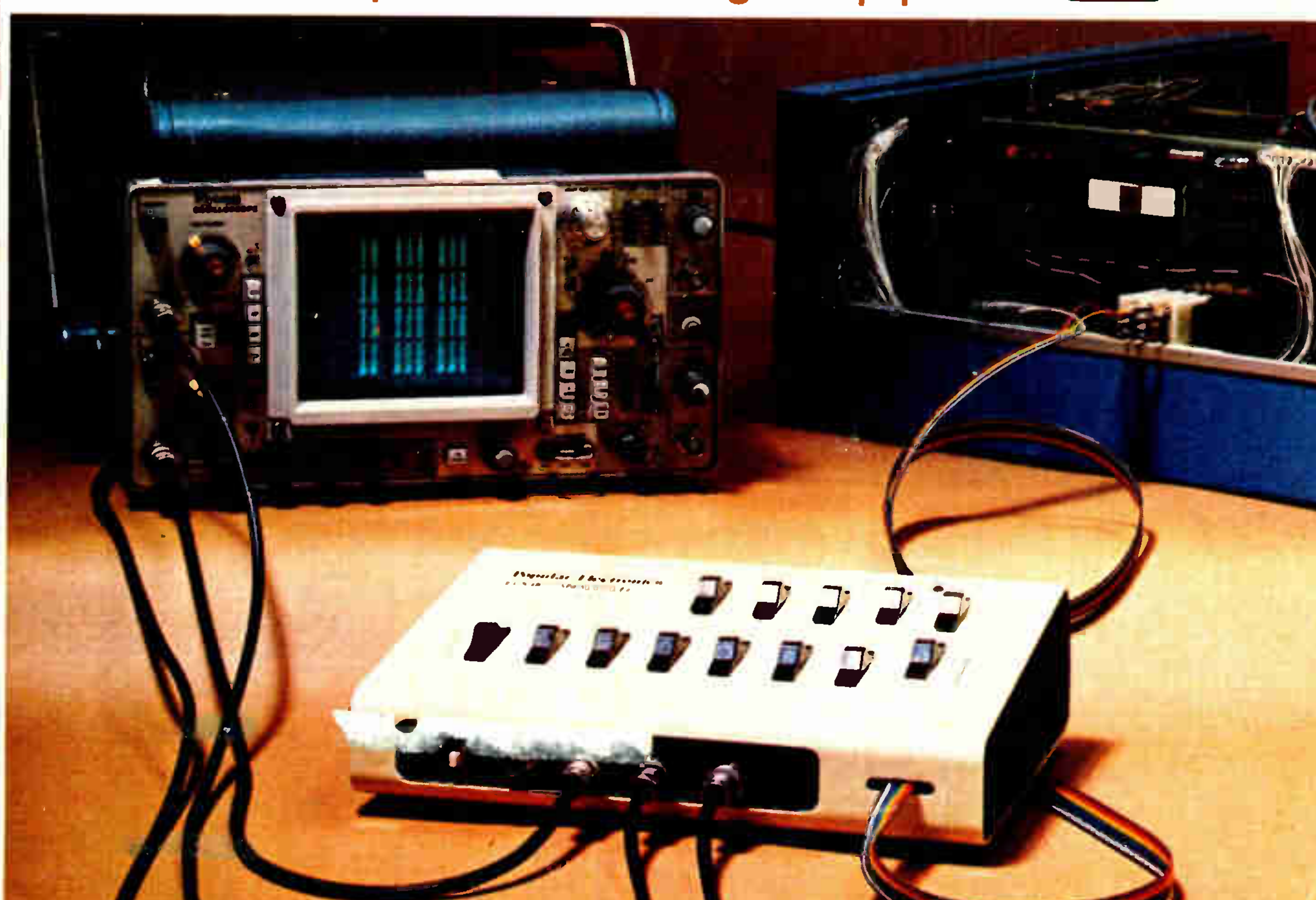

Remote Control Racer

A new fun leisuretime activity made possible by the new electronics.

Computer logic has added a new fun way to control remote control products.

The Remote Control Racer is a competition scale model race car controlled by a transmitter using computer logic.

Think of it. Remotely drive a model race car from as far as sixty feet—turning left and right, going forward and reverse. It's great fun for hobbiests, children and the whole family.

DIGITALLY PROPORTIONAL CONTROL

The steering is controlled as you control the steering wheel on your remote control unit. Turn the wheel slightly to the right and the car wheels turn slightly to the right. Turn your control fully to the left and the car wheels turn fully to the left.

There is no transmission required to go from forward to reverse as the high quality servo motor simply reverses polarity to change gears. Press the forward lever on your remote unit and you go forward. Press the reverse lever and you go in reverse. It's just that quick.

BUILT TO THE FINEST DETAIL

The camber caster-action front wheels parallel a full-sized car's suspension system and they actually tilt on the turns. An independent floating rear axle maintains positive traction even on rough terrain.

The Remote Racer replaces the gasoline powered remote control race cars that have sold for well over $100 a unit. Remote gas powered models give off odors and are often temperamental. The Remote Racer is quiet so it can be run indoors and it is not dangerous so even children can safely play with it.

The remote control unit (left) controls the race car's electronics (center). The four "C" cell batteries fit in the underside of the Racer.

SOPHISTICATED ELECTRONICS

The sophisticated electronics in the Remote Control Racer consists of 40 transistors. When you operate the control unit, the transmitter generates computer digital logic in a train of digital pulses which then are amplified and transmitted to the racer. The racer then has a sensitive receiver which receives the pulses and in turn translates them into data that eventually translates into power for the car.

The sleek lines of the Remote Control Racer follows the designs of some of the more popular race cars. The car measures 3½"x5"x12".

START A RACE CLUB

You can run as many as six different cars in a race as each car will be on a separate remote control frequency. There are four different colors available, red, white, blue, and yellow and each racer comes equipped with its matching remote control unit.

Start a local competition race club, entertain guests with your new adult toy, or give it to your children as one of their most prized possessions. There are many fun ways to use your Remote Racer.

There are two separate circuits used for forward and for reverse. Each circuit utilizes two "C" cell batteries available anywhere. If you only go forward, the two forward batteries will last approximately two hours.

The Remote Control Racer is a well built, well engineered electronic instrument with a 90 day limited warranty. JS&A further guarantees your satisfaction—if you are not absolutely satisfied with the value, quality or fun you are having, fine—return your racer within ten days for a full refund. You can't lose.

To order, credit card buyers simply call our toll-free number below and specify the color and quantity you want. Or send a check for $52.45 ($49.95 for each Racer plus $2.50 for postage, insurance and handling to the address shown below. (Ill. residents add 5% sales tax).

By return mail, you'll receive a Remote Control Racer, the remote control unit, batteries, a 90 day limited warranty and simple operating instructions. Your unit should never require service but if it should, JS&A's service-by-mail facility is as close as your mail box. JS&A is America's largest single source of space-age products and a substantial company—further assurance that your modest investment is well protected.

Find out the thrill and fun of racing model race cars remotely. Order one or two Remote Control Racers today.

$49.95

NATIONAL INTRODUCTORY PRICE

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FEBRUARY 1977 VOLUME 11, NUMBER 2

Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

FEATURE ARTICLES

CONSTRUCTION ARTICLES

COLUMNS

JULIAN HIRSCH AUDIO REPORTS

ELECTRONIC PRODUCT TEST REPORTS

DEPARTMENTS

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Editorial

HANGING FIRE

The October 1976 issue of the *IEEE Spectrum* (an electrical engineering society publication) had an interesting editorial focus entitled: "What Went Wrong?" In addition to covering such failures as the Northeast electrical blackout of '65 and a multi-million-dollar radar project that flopped, promising developments that got sidetracked or delayed were discussed. These included electronic video recording (EVR), ovonic devices, thermoelectricity, the video telephone, emitter-coupled logic, AM stereo, and two-way cable TV.

None of the above is "dead," but they have not exhibited the growth that the excitement of their debuts hopefully promised. Offhand, I can add easily to the list of slow-start concepts that float around. Some, like a virus, come to life many years later; others are not widely adopted for one reason or another.

For example, I edited a cover-story article on microwave ovens in 1959, which indicated that sales were expected to skyrocket. *What went wrong?* A scathing attack was presented by *Consumer Reports* on the appliance's safety (causing tightened standards) that turned off consumers for more than a decade.

Attending a press meeting in the early Sixties, I was treated to a new concept in hi-fi—a servo-feedback system, called "Integrand, that was supposed to counter distortion emanating from speakers." *What went wrong?* I have no idea, but it simply never got off the ground, though the more recent Philips "Motional Feedback" system uses the same general concept.

I recall, too, going to a final task force meeting on the type of stereo FM that should be recommended to the FCC. The majority of attendees chose the Crosby System, which did not degrade the signal-to-noise ratio of the second channel. *What went wrong?* The GE/Zenith proposals were adopted because it was felt by the FCC that many FM broadcasters would not be able to survive without an SCA channel to supplement income, which GE/Zenith retained (together with higher noise) and Crosby did not.

Then there was Educasting, using four channels multiplexed on FM, with receivers built by Sylvania Electric; Norelco's 45-rpm automobile record player (which I owned prior to auto tape's introduction); Ampex's floppy magnetic audio disc; wireless microphones; 35-mm audio magnetic tape introduced by Everest Records; a flame loudspeaker whereby flames modulated the air stream (Stanford Research Institute); the magnetic amplifier, which the Bureau of Ships, U.S. Navy, called ". . . the rising star of electronics in 1960"; and so on.

There are new, promising electronic stars on the horizon today. I wonder how they will fare when faced by the perspective of a few decades? These include the video disc (introduced in 1966) which is supposed to reach the marketplace sometime this year. (I viewed a third V-D system last week, Telefunken's TED. Color was great, but 10-minutes play time for a flexible disc that will sell for $4 to $10 on a machine that is expected to cost at least $500 appears to be out of the running for the public when contrasted with RCA's and Philips' longer playing time systems.) There is also a Class D audio amplifier that has been touted now for three years. And then there are Bubble Memories, which by their great density capability could take over the computer memory world if the price is driven down.

I won't count out any of the concepts, products, devices or systems that never live up to their promise, however. Not when I think of Michael Faraday's observation of semiconductor properties in 1833 and wireless detectors that were used in 1906. Just a little research laboratory twist, and a combined transfer and varistor device emerged in 1948. It is called a transistor.

Art Salsberg

Letters

HIGH-LEVEL FEEDBACK & TIM

The various articles in the "Special Focus on Audio" section in the September 1976 issue of POPULAR ELECTRONICS all propose operational amplifiers with input-to-output gains of one, meaning that very large amounts of feedback are employed. Dr. Matti Otala of Finland has shown that transient intermodulation distortion (TIM) becomes significant when feedback exceeds about 20 dB and is severe for larger feedback factors. Personal experience with high-gain op amps in a preamp circuit was that amplitude-versus-frequency response was controlled within 0.25 dB, but it "just didn't sound right." When I became aware of "Otala distortion," it was pretty obvious that this was the fault.—*Paul W. Klipsch, Klipsch & Associates, Inc., Hope, AR.*

SWITCH TO NEW SWITCH

In "Build the Roadmate CB Converter" (October 1976), a dpst switch is specified in the Parts List. This should be a dpdt switch. —*Andrew Ciffer, Somerset, NJ*

IDENTIFYING THE COMPUTER

In "How To Select a Hobbyist Microcomputer" (December 1976), the lead photo has no caption identifying the equipment shown. Could you please tell me what this equipment is? —*Claude Jolly, Granite City, IL*

The CRT terminal shown on page 51 is the Model D301 made by Informer, Inc., 8332 Osage Ave., Los Angeles, CA 90045. It sells for $1890.

A BETTER CAPACITANCE METER

I suggest the following changes for the "Low-Cost Capacitance Meter" featured in the October 1976 issue of POPULAR ELECTRONICS. First, to prevent the voltage rating from being exceeded with 3-, 6-, or 9-volt capacitors under test, two 1N914 diodes can be connected in series across *BPl* and *BP2*, with the anode of the pair going to BP1 and the cathode to *BP2*. This will limit the terminal potential to 1.5 volts maximum. Second, by installing a 47-ohm, ½-watt resistor between the rotor of *S2A* and ground, the switch contacts will last longer and the charge on the capacitor under test will discharge less rapidly. Third, by removing the connection between the OFF position of *S1A* and the anode of *D1*, no excessive current will flow through *Q1* as *C3* and *C4* discharge. Fourth, a mini DIP, such as the MC1558 or any dual 741 or amp, can be used to replace the two IC's if desired—*Marvin J. Moss, Atlanta, GA.*

PE SPARKS EXPERIMENTING

I feel I owe POPULAR ELECTRONICS a letter of thanks and commendation. I hadn't dabbled in electronics since the dawn of the solid-state era until January of this year. Since then, PE has been very helpful in updating my knowledge of semiconductor theory and application and refreshing my memory on general electronics. I was planning to build a chess clock by coupling together two digital clock kits until I noticed two articles in PE that made me opt for a better design. As a result of the sequence generator described in the February 1976 Experimenter's Corner and "How Multiplexed LED Displays Simplify Circuits" in the March 1976 issue, I was able to design my improved chess clock. Many thanks for accelerating my project to reality and elevating it to an interesting experience.—*James H. Williams, Knoxville, TN.*

HAM/CB'ER FOR SHARING BAND

I would like to compliment you on your Editorial, "Majority Rules—The Bitter Pill" (November 1976). As both a Ham (W6TNS/7) and an avid CB'er, I can vouch for the wisdom of your words. I am inexorably convinced that there must be a "common meeting ground" where hams and CB'ers can intermingle and learn from each other. CB'ers are extremely susceptible to peer pressure, and I do not buy the argument that this "unwashed multitude" will ruin whatever they touch.

The pressure on the amateur 220-MHz band by 15- to 30-million people is going to mount in the next few years in direct proportion to the skip interference on the Citizens Band. It seems to me that the amateur fraternity would be well-advised to invite the CB'ers to share this relatively unused band, rather than lose it as they did 11 meters. —*Donald L. Stoner, Mercer Island, WA*

QUESTION OF SAFETY

There is a serious error in "Propagation Forecasts For Radio Communications" (November 1976) on page 36, column 2. A Wratten No. 4 is not a neutral-density filter, per Kodak publication No. B-3 titled "Kodak Filters For Scientific and Technical Uses." The No. 4 is a light yellow filter. Neutral densities are Wratten No. 96, available in densities from 80% light transmission to 0.01% (neutral density 0.1 to 4.0). These are supplied in gelatin only. Should you wish to obtain these in glass, they can be supplied by Tiffen Mfg. Co., 71 Jane St., Roslyn, N.Y. —*John H. Rose II, Warren, MI*

Thanks. We endorse your recommendation. The author, however, confirms that he has been using the No. 4.

Only NRI 25" DIAGONAL designed-Color TV Quadraphonic

Two home training schools give you a hobby-kit Color TV to assemble. Two others give you a commercial set right off the shelf. Neither was designed to teach you how to repair Color TV's. Only NRI invested the time and money to design equipment with learning in mind!

No other home training school gives you both a solid state Color TV and SQ™ Quadraphonic Receiver complete with four speakers . . . all in one course. In fact, to even match this kind of thorough training at another school, you'd have to take an extra course costing hundreds of dollars more. And only NRI courses in Color TV/Audio servicing let you learn on equipment designed specifically for training.

™ Trademark of CBS, Inc

It's the only way you can (1) get the feel of typical commercial circuitry, (2) learn bench techniques while building complete units from the "ground" up, (3) perform over 35 "in-set" experiments during construction, and (4) end up with a 25" diagonal solid state Color TV with cabinet and a 4-channel Audio Center.

NRI passes the savings on to you

NRI engineering eliminates the cost of buying from an outside source. We pay no salesman's commission. Students are enrolled by mail only. The savings are passed on to you in the form of low tuition fees, extras like the TV's console cabinet and the Quadraphonic System; professional test instruments like a 5" triggered sweep oscilloscope, CMOS digital frequency counter, and integrated circuit Color TV pattern generator. You can pay hundreds of dollars more for similar courses and not

New Products

Additional information on new products covered in this section is available from the manufacturers. Either circle the item's code number on the Reader Service Card inside the back cover or write to the manufacturer at the address given.

MAGITRAN CB THEFT ALARM

From Magitran, the CB 10-33 Touch-Activated Alarm is a self-contained mobile equipment protection system. An ear-piercing 100-dB signal is emitted the instant a CB unit is

touched. Small enough to be concealed under the dash, the unit operates on a 9-volt transistor battery that will continuously sound the alarm for over three hours, according to the manufacturer. $29.95.

CIRCLE NO 92 ON FREE INFORMATION CARD

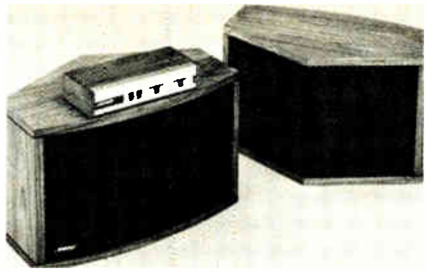
HEATHKIT "COMPUTER" COLOR TV

Heathkit's Model GR-2001 color TV receiver kit features a 25" (63.5-cm) black-matrix ultra-rectangular picture tube, PLL horizontal- and vertical-hold circuits and high-quality sound. With optional accessories, the receiver has complete programming capability through a computer-like system that can be set up for up to 32 channel changes during any two 12- or 24-hour viewing periods. Programming is via a calculator-type keyboard. Once accomplished, the programmer takes over operation of the receiver, changing channels automatically at the appropriate times. Other optional items include an on-screen digital clock and an automatic antenna rotor control. The latter automatically rotates the antenna to the pre-selected directions for best reception on each channel with each change of channels. Basic receiver kit price is $279.95; accessory items and cabinet are extra.

CIRCLE NO 90 ON FREE INFORMATION CARD

BOSE SPEAKER SYSTEM

The Bose Model 901 Series III speaker system retains the basic concepts used in the original Model 901 while providing better efficiency, low-bass capability, and adaptability



to a wider range of listening environments. It employs the 901's direct/reflected sound concept, multiple full-range drivers, active equalization, and uniform power radiation. New driver design and an Acoustic Matrix™ enclosure provide better efficiency. The one-piece plastic enclosure has partially isolated chambers, one for each driver. Each chamber joins one of three Reactive Air Columns to provide a controlled interaction between the different drivers. The enclosure does not affect system frequency or transient response. It is designed to reduce cone motion to increase accuracy and the dynamic range of the bass response. $749 for two speaker systems and equalizer unit.

CIRCLE NO 93 ON FREE INFORMATION CARD

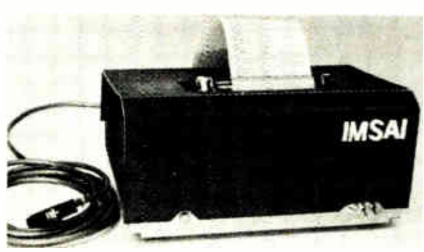
PRIDE FREQUENCY COUNTER & CLOCK

The Pride TF-1000 is a combined frequency counter and selectable 12- or 24-hour digital clock for CB and amateur radio use. The six-digit unit switches automatically from clock to frequency counter when the transmitter is activated. The clock continues to count, and the time is again displayed when transmission is completed. The TF-1000 operates from 1 to 40 MHz and can be used with CB and amateur transceivers with outputs from 3 to 200 watts. Measures 9¾"D × 8½"W × 3"H (21.6 × 7.6 × 24.8 cm). $179.95.

CIRCLE NO 94 ON FREE INFORMATION CARD

IMSAI PRINTER

The Imsai Printer is a new 44-column dot-matrix printer designed for use with the Imsai 8080 and many other computers. The printer interfaces to an 8-bit parallel port. It is said to be simple to program and install. It is self-contained, with case, cable, power supply,



timing, control and character generation included. The font is the standard 64-character ASCII subset; double-size characters are software selectable. An automatic line-wraparound feature prints lines with more than 44 characters on two lines. Multiple copies can be printed using carbon or NCR paper. $399 kit, $549 assembled.

CIRCLE NO 95 ON FREE INFORMATION CARD

JENSEN THREE-WAY CAR SPEAKER

Jensen's flush-mount Triaxial is said to be the only car stereo speaker on the market with a woofer, tweeter and midrange driver in one unit. The woofer is 6" × 9", the 3" midrange is direct-radiating, 2" tweeter is solid state. Rated at 35 watts, the speakers are compatible with 4- and 8-ohm radio or tape units. The kit includes two speakers with 20-oz magnets, grilles, mounting hardware, and connecting cables, at $114.95.

CIRCLE NO 91 ON FREE INFORMATION CARD

GE 40-CHANNEL CB TRANSCEIVER

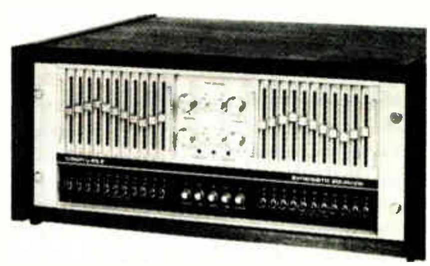
General Electric's Model 3-5812 40-channel mobile CB transceiver features a warning light that alerts the user that the antenna system needs adjustment. Other features include internal burnt-out protection for up to five minutes of transmission time, switchable noise blanker, ANL, delta tuning, PA,

squelch, and modulation indicator. Power output is rated at the 4-watt legal maximum; adjacent channel selectivity is 50 dB at ±10 kHz; and receiver sensitivity at 0.5 μV. Measures 8"D x 6½"W x 2¼"H (20.3 x 16.5 x 5.7 cm). $174.95.

CIRCLE NO 96 ON FREE INFORMATION CARD

CROWN STEREO EQUALIZER

The Crown Model EQ-2 is an 11-band/channel stereo equalizer that provides full equalization from 20 Hz to 20 kHz. Each band features a ±15dB boost or cut capability. The filters are half-octave, constant-bandwidth design, set nominally on octave centers. Each filter has an associated control that allows a



±0.5-octave adjustment of the center frequency. The two channels can be cascaded to produce a full-range, half-octave equalizer. Shelving-type tone controls permit adjusting bass or treble frequency response before detailed equalization. LED clipping-level indicators monitor four critical internal points to signal overloading. Automatic 5-to-7-second muting at turn-on prevents the passing of system turn-on transients to the speakers. Frequency response is 10 Hz to 100 kHz

±0.3 dB; 20 Hz to 20 kHz ±0.1 dB. Measures 19"W x 14½"D x 7½"H (48.3 x 36.8 x 19 cm). $899.

CIRCLE NO 97 ON FREE INFORMATION CARD

RAIDER ROOF-TOP CB ANTENNA

Designed for permanent installation, the Model 700 roof-top antenna from Raider is for pickup trucks, station wagons, campers, recreational vehicles and standard passenger cars. The snap-in mount provides support for the antenna, which is said to be largely unaffected by high wind velocities. The only tools required for installation are an electric drill with a ⅜" bit, adjustable wrench, and a pair of wire cutters. The 700 comes with a stainless-steel whip, chrome-plated shock spring, or snap-in mount, and 17 feet of coaxial cable with a standard PL-259 plug at one end. $19.95.

CIRCLE NO 98 ON FREE INFORMATION CARD

SCOTT STEREO RECEIVER

Scott's new medium-price Model R336 AM/stereo FM receiver, features clutched bass and treble controls. Rated at 42 watts per

channel with less than 0.3% THD, the receiver has less than 0.15% IM distortion. The receiver features two independent tape monitors, signal-strength and center tuning meters, and a three-position FM deemphasis switch. $400.

CIRCLE NO 99 ON FREE INFORMATION CARD

EDSYN DESOLDERING TOOL

The "Silverstat Soldapult" from Edsyn is a manual desoldering tool said to protect sensitive FET and MOSFET devices from failure due to static electricity, while isolating the operator from a direct short. The tool is a hand-held spring-loaded vacuum device with fully enclosed loading shaft, high/low vacuum adjustment, and fast bayonet-type disassembly. A conductive plastic tip and barrel housing is said to allow any built-up static charge to drain off harmlessly through the hand to ground.

CIRCLE NO 100 ON FREE INFORMATION CARD

ONEIDA COLOR PICTURE TUBE RESTORER

From Oneida, the Nu-Color restorer is said to restore all needed colors to old color picture tubes. The restorer plugs into most 70° and 90° picture tubes and has separate slide-potentiometer adjustments for the three colors. The original color strength is restored through "boosted and individual biasing networks that increase emission and maintain constant color levels." Two models (70A and 90A) accommodate most 12" (30.5-cm) through 25" (63.5-cm) color picture tubes. $24.95 each. Address: Oneida Electronic Mfg., Inc., Meadville, PA 16335.

news HIGHLIGHTS

Semiconductor Industry Booms

Sales of consumer electronics products reached approximately $10 billion in 1975. According to a report by the Business Communications Company, $2.5 billion of these sales came from a new group of products that include CB radios, scanners, hand-held calculators, wide-screen TV and telephone answering devices. Tied to the rapidly changing lifestyle of the typical consumer, this new group is expected to become a $7.7 billion market by 1980, reaching $13.5 billion by 1985.

Solar-Powered Calculator

Royal Solar I, a solar-powered hand-held electronic calculator, has been introduced by Litton Industries. The pocket-size unit operates without conventional batteries, recharging itself continuously when exposed to artificial light or sunlight. It uses 46 miniature solar cells on its surface. The display is a liquid crystal device with 8-digit capacity, signs for memory usage, minus sign and capacity overflow. It is expected to retail for $99.95.

Direct-to-Disc LP's

"Direct-to-disc" phono albums are being made available by Audio Technica. Unlike conventional LP's, direct-to-disc records bypass the tape recording stage of production. Studio performances are mixed and recorded directly onto a master disc, eliminating the problems of tape noise, distortion and limited dynamic range. The albums, available under the "Umbrella" label, will retail at $12.95.

1 × 2 Callsigns

The FCC has announced an amendment to its Rules to permit the issuance of specific 1 × 2 callsigns (callsigns with one letter, one digit and two letters) in the Amateur Band, with suffixes beginning with the letter "X" or prefixed by the letter "N." These will be available to eligible Amateur Extra Class applicants.

E.I.A. Activities

The EIA has spoken out against proposed legislation by Congress to form a new Federal agency to act as consumer advocate in all types of consumer action. The Consumer Electronics Group of the EIA questioned the need for this proposed agency as costly and unnecessary with the potential for creating problems for both business and the consumer. The threat of a presidential veto caused sponsors to drop the measure for the present. However, revised legislation is expected to be introduced in the future.

The American National Metric Council recently formed to study metrication and start a "think metric" program in the United States has named the EIA as secretariate to its Electronic Equipment and Components Sector Committee.

3-D Television

Three-dimensional television is no longer a science fiction writer's fantasy. A method of wide-screen 3-D video projection, developed by Bruce D. Stephens, a television producer and consultant, enables stereoscopic presentations of live or prerecorded television programming with the image size and width of a wide-screen motion picture. As is required of all stereoscopic methods, the left and right eye orientations of the same scene must be segregated and assigned to the appropriate eye of each observer. In this technique, the two differing orientations are projected through a polarizer and re-directed toward the screen so they are superimposed. "Polalite" viewing spectacles allow each eye to see only the viewpoint intended for it, resulting in full depth perception. Motion picture 3-D presentations used this principle in the past.

Kirlian Photography Debunker

Kirlian photography—recording on film the aura emanating from a human body—is said to be due to an electrical phenomenon related to the amount of moisture in the skin, according to researchers in *Science*. Some had purported that the brightness of an aura, as depicted in a Kirlian photograph, reflected one's mental and physical health. Researchers have found that the amount of water in the skin determines the size and brightness of the aura recorded on film. The dryer the skin, the brighter the aura. The moisture is said to be transferred to the film, changing the electrical discharge pattern that is triggered by the metal plate under the film.

Holiday Inns' CB Network

Holiday Inns has announced plans to provide a nationwide citizens band network to assist motorists who need road information or help due to mechanical breakdown. The program is currently being tested among 15 Holiday Inns in the Boston area. Also being studied is an arrangement set up by the Maryland State Troopers in cooperation with that state's department of tourism, where a separate channel has been reserved for dispensing road information. This eliminates most of the interference and interruptions that occur on the regular channels.

Hams to Sail

Licensed hams will be able to operate a high-power amateur station on board the *Santa Mercedes*, during a 56-day cruise offered by Prudential Lines. Departing from San Francisco April 26 (from Los Angeles April 28) the ship will cruise to Mexico, the Caribbean and completely around South America. Instruction in code classes and license upgrading will be available along with a variety of social activities. For additional information write: Prudential Lines, One California Street, San Francisco, CA 94111.

New Literature

ELECTRONIC PROJECT CATALOG

Graymark Enterprises offers a catalog listing over 50 electronic projects and 1000 electronic components. Among the items listed are a strobe light, color organ, metal detector and amplifier. Address: Graymark Enterprises, Box 17359, Irvine, CA 92713.

DIGITAL INSTRUMENT CATALOG

An 8-page catalog entitled "Digitals" covers a wide variety of digital instruments ranging from programmers, digital clocks, a digital clock/thermomenter and timers, to digital frequency counters. Each instrument is illustrated and complete specs are provided. Address: ESE, 505½ Centinela Ave., Inglewood, CA 90302.

BUYER'S GUIDE TO MULTIMETERS

A new brochure from Amprobe Instrument, "Buying One of the More Popular VOM's," describes features and applications of comparable VOM's from three major manufacturers. The brochure includes specification information on resistances, ac and dc current, temperature, sensitivity, fuse protection, ranges, dimensions and standard accessories. Address: Amprobe Instrument Div. of SOS Consolidated, Inc. 630 Merrick Rd., Lynbrook, NY 11563.

EDMUND CATALOG

Edmund Scientific's new 164-page catalog, #771, contains over 4500 items for experimenters, students and hobbyists. Among the many items described are an ultraminiature AM radio that measures only 1 11/16" × 1 3/16" × 11/16"; solar collector panels for house and water heating; and Biosone II, an alpha/theta monitor that identifies electrochemical activity in the human body. Address: Edmund Scientific Co., 380 Edscorp Bldg., Barrington, NJ 08007.

DATA COMMUNICATIONS BULLETIN

A new, 5-page bulletin from Tele-Dynamics describes its line of data communications equipment, including modems, acoustic couplers, frequency division multiplex subsets and test equipment. Each product is illustrated and specifications and applications information are provided. Also included is a section on available accessories. Address: Tele-Dynamics Division of AMBAC Industries, Fort Washington, PA 19034.

Stereo Scene

By Ralph Hodges

HALLOWEEN AT THE WALDORF

NEW YORK'S annual Audio Engineering Society convention (held at the Waldorf Astoria) generally falls on and around October 31. Since the business of this distinguished gathering is to exchange tricks and (one hopes) treats, the date is highly appropriate.

I had hoped in this single column to cover most of the highlights of the 1976 convention. As things have turned out, I've barely found room to deal with three papers out of dozens that were presented. All three do relate to a common subject, however—one that is perhaps especially seasonal because it involves a trick and also a bit of a masquerade.

The Ultimate Illusion. Many feel that the ultimate audio illusion—and the final objective of high fidelity—is to be able to turn (acoustically) a small room into a large one, a large room into an open-air environment, and an open-air environment back into a small room. As usual, several papers dealing with aspects of this subject were presented. Ignoring the quadraphony papers for the moment (or at least until I understand them), the rest dealt with how the illusion of acoustic space (i.e., large and small rooms, or no room at all) can be *simulated* with the ever-growing resources for signal processing we now have available. "Faking it" in this way bothers some purists, including myself. But it is probably true that if we *can* learn to fake it successfully, we will learn in the process how to design and place microphones so as to properly capture the real thing.

First of all, what makes rooms acoustical entities, identifiable as large or small, dead or bright, when we hear music played in them? Sound reflections reaching us from the room's surfaces, of course. But then, what differences in reflections account for the different sounds of rooms? Depending on the room, reflections differ in their arrival times (how long they take to reach us after the sound coming directly from the musical instrument is heard), spectral shape (alterations in the reflections' frequency balance), and density (number of reflections heard per unit of time).

To paraphrase Daniel Queen's latest paper (which he did not officially present, but which was available if you cornered him in the corridor and asked for it), arrival times of reflections fall into three categories (see Fig. 1): arrivals within 1 millisecond, those within 65 milliseconds, and those within 1, 2, or even 4 seconds. The 1-millisecond arrivals, if strong enough, are bad: they interfere with our localization of the original sound source (confuse the stereo image, if you will). Arrivals within from 1 to 65 milliseconds are generally good; they "fuse" with the direct sound, making it seem louder (however, they also profoundly affect the perceived spectral shape of the sound, which may not always be good). Arrivals after 65 milliseconds can be good or bad; they are perceived as room reverberation detached from the original sound, and they may be heard as a rich afterglow or a ragged string of echoes. As Queen points out, they tend to diminish intelligibility, but they are vital to our appreciation of certain types of music.

Fortunately, arrivals within 1 millisecond are rarely troublesome, because the reflecting surface has to be

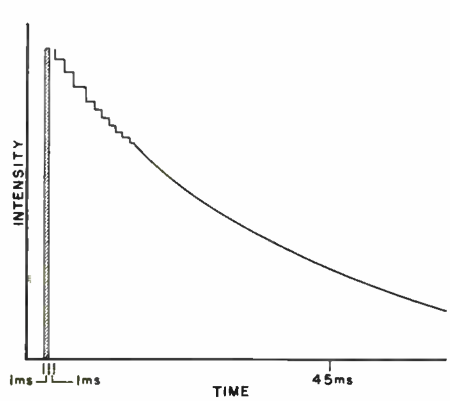


Fig. 1. A 1-ms sonic impulse and its reverberation train.

very close to either the sound source or the listener for them to occur (although the cabinets of some speaker systems provide such surfaces, as do the cases and lids of grand pianos, which can make them exasperatingly difficult to record). Arrivals within 65 milliseconds dominate in small rooms, which is why music sounds so loud in them. But after 65 milliseconds the absorptive materials in the small room have soaked up almost all this reflected sound energy.

In a large room such as a concert hall, a sound may easily have travelled for 65 milliseconds (roughly corresponding to 65 feet) before it undergoes even its *first* reflection from a wall or ceiling. Since it is these "bounces" from walls and ceilings that account for much of the absorption of sound (and in a small room many bounces will take place within 65 milliseconds for all possible sound paths), a concert hall doesn't even begin to assert its absorptive influence until many milliseconds have passed. That is why large auditoriums tend to have such prominent reverberation, and why architects strive so mightily to make that reverberation sound "nice." (This is not to say that concert halls provide the listener *no* reflective arrivals within 65 milliseconds; a good hall provides many, and they are very important.)

Turning the Trick. Well, that seems simple (although lengthy) enough. All we need do to turn our pitiful listening rooms into splendorous opera houses is to provide reflected sounds persisting longer than 65 milliseconds. And we can provide that (since our rooms cannot) with delayed sounds coming either from distantly spaced microphones (four-channel recordings of the "ambient" type, in other words), or with artificially created delays (tape delays, bucket-brigade or even digital delays, reverberation systems using metal plates, springs, or tiled bathrooms, long cardboard tubes with a speaker at one end and a microphone at the other, almost *ad infinitum*). Hence our resources are vast. Unfortunately, the results achieved with them have been generally disappointing.

Many people have by now heard four-channel stereo or some other technique that attempts to alter acoustical space. Few, I suspect, have ever heard the walls of the listening room seem to disappear, as they should. We admire the ingenuity of the hardware, the onward march of separation figures, and the exquisite construction of the theoretical foundation. We even hear improvement

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of sorts in each new generation of equipment. But we rarely, if ever, cross the threshold into a shift of perceived reality. The trick just doesn't get turned.

Heroic Measures. The shortcomings of these techniques have been acknowledged reluctantly (if at all) by the audio industry. But behind the scenes researchers have been occupied with them all the same. The main approach, if I may crudely generalize, has been a complicated and taxing game of "find the flaw"—explain why a system that seemingly should work doesn't.

It's good to see the opposite tack being taken at last; that is, the tack of creating something that does work, no matter what, and finding out why, rather than starting with something that doesn't work (too well, anyway) and attempting to discover why not. Two papers presented at the convention appear to adopt this pragmatic approach, taking as their starting points techniques of simulation—that is, their only intent is to deceive the listener with a *seemingly* realistic experience; for the present they are largely content to forget about absolute realism and its pursuit.

Audio/Pulse manufactures a digital reverberation "simulator" that is intended merely to process ordinary stereo programs, with its output ideally appearing at one or more pairs of "rear" speakers, the key pair of which is located to either side and perhaps above and just behind the listener. In a paper prepared by Audio/Pulse's Peter Mitchell and Richard DeFreitas, five "essential characteristics" of concert-hall ambience are laid down, which become five conditions to be met by a successful reverb simulator. In condensed form:

(1) A satisfactory simulator probably doesn't have to provide a duration of reverberation (reverberation time) equivalent to that of a typical concert hall. Instead, it should be able to feed off whatever reverberation has been captured in the recording to prolong the reverberation time.

(2) The spectral shape of the reverberant energy will inevitably be altered by the hall in which the music is played. The playback system should copy this spectral change, but it is not the function of the reverberation simulator itself to supply this equalization; nor should it.

(3) The simulator should be capable of closely approximating the arrival-time density of concert-hall reverberation. This density tends to be high.

(4) So far as is possible, the simulator should provide arrival times that are randomly spaced. Regularly spaced arrivals cause effects such as "flutter echo."

Fig. 2. The Acoustic Research Digital Time Delay System, showing six of the sixteen speaker channels and a side view of electronics.

(5) In a concert hall, the reverberant field can't be localized and is diffuse. The simulator's artificial field should have the same characteristics.

As a recipe for a successful reverb simulator (and the Audio/Pulse device has been shown to be capable of successful spatial illusions in several demonstrations), the above five points are gratifyingly straightforward. If we examine current four-channel systems in their light, several points stand out right away. For one thing, the usual rear-channel content of an ambient four-channel recording is merely a more distant miking of what the front channels reproduce. It is localizable in most cases, although localization is diminished somewhat by distance, and fixed microphone spacing and the nature of certain microphone arrays may prevent it from being sufficiently random in arrival times. Does this point the way to any new procedures for quadraphonic recording? Your guess is as good as mine.

AR's Acoustic Arena. Recent work at Acoustic Research has led to an especially interesting research tool for ambience experiments: a sixteen-channel concert-hall simulator (Fig. 2). This may recall Bolt Beranek & Newman's concert-hall simulator, which I described in this column almost two years ago. However, while BB&N's system derives signals from tape delays and reverb chambers, the AR configuration employs simple digital delays determined by a study of computerized models of real acoustical spaces.

To judge from a paper (by Paul Milner) distributed by AR at the AES convention, the AR experiments are beginning to bear fruit in determining the *minimum* and perhaps even *optimum* requirements for creating a spatial illusion. Milner used a six-channel system for his listening tests, with various combinations of simple fixed delays being fed to the four "rear" loudspeakers. By inference, the result was a satisfactory spatial effect. Then Milner progressively narrowed the frequency band over which the delays occurred, to learn at what point the spatial illusion would start to deteriorate. In other words, all four "ambience" speakers always reproduced a full-range signal, but the frequency band over which these signals underwent delays was increasingly narrowed. Outside of the delay band, the signal was not delayed.

Without going further into Milner's procedures, we can tackle the results (gleaned from the statistically analyzed impressions of a small listening panel) right away. They were that, below about 200 Hz, delaying the signal did little or nothing to enhance the spatial illusion. Likewise, eliminating delays above 6 kHz harmed nothing and in some cases improved conditions for certain listening positions in the room where long-delayed sharp transients would otherwise confuse localization.

For a digital delay system, such limiting of the delay bandwidth would bring very attractive reductions in the cost of each channel. And the apparent unimportance of processing frequencies below 200 Hz opens the door to a common bass system instead of full-range speakers for each channel.

These findings have been anticipated by others in the past, but never so well documented under real music-listening conditions. Put the AR results together with those of Audio/Pulse and you may see the emergent beginnings of a truly effective spatial-illusion system—perhaps even a genuine four-channel system—somewhere around the corner. ◇

Julian Hirsch Audio Reports

HIRSCH/HOUCK LABORATORIES

TAPE RECORDER HEADROOM EXPLAINED

ALTHOUGH the term "headroom" is frequently used in connection with tape recorders, it is not specifically defined by any single measurement standard. Nevertheless, it is one of the most important characteristics of a tape deck (actually more important in most cases than frequency response) and its significance must be appreciated if one is to realize the machine's potential.

Every tape recorder has some form of recording level indicator, usually a pair of meters that show the level in each channel and occasionally these are supplemented by a single fast-responding LED indicator that flashes on high-level peaks that are too brief in duration to register on the meters. The relationship between these two levels—the meter reading and the instantaneous peak—is closely connected with the concept of headroom and is the reason for its importance.

The level meter usually indicates the signal voltage present at some part of the recording amplifier. Depending on the characteristics of the recording head and the tape for which the machine is adjusted, the calibrated 0-dB meter level corresponds to some specific flux density recorded on the tape. Each manufacturer is free to choose his own "zero level," although there are several standard levels used in professional machines and some home recorders.

Flux levels are expressed in nanowebers per meter (nW/m) of tape width. The actual number of flux lines is of little importance to the user. Doubling the width of the recorded track on the tape doubles the number of flux lines passing the playback head gap during a given linear tape movement, which in turn doubles the output voltage from the head. This is the reason for the superior signal-to-noise (S/N) ratio of wider tape formats (e.g., half-track versus quarter-track, or any of the ¼" tape formats versus cassette tape).

A given tape formulation can be magnetized only up to a certain point before its magnetic coating begins to saturate. Beyond this point, a further increase in recording level does not produce a proportional increase in tape magnetization (and, correspondingly, in playback output). This affects the playback signal in two ways. First, the dynamics of the program are compressed, since a program peak that drives the tape into saturation does not produce more output during playback than a lower level portion of the program. Secondly, the distortion of the playback signal increases.

Although the magnetic storage ability of a tape is a function of frequency, we can simplify this discussion by assuming that the tape response is uniform across the audio band. Because of the recording head characteristics, however, it is usually necessary to preemphasize or boost the higher frequencies during recording to obtain a flat playback frequency response. Thus, the maximum tolerable level before which saturation occurs will decrease as the frequency increases. Since this effect becomes more severe at lower tape speeds, a cassette recorder is inherently inferior to an open-reel recorder in its ability to record high levels without saturation, especially at high frequencies.

Now let us return to that recording level meter, whose 0-dB mark supposedly indicates the maximum permissible recording level. It does, but that level is not the same for all machines. Ordinary meters respond relatively slowly to brief transients and may not give any indication on a peak that far exceeds the tape saturation level. Music and voice program material may have instantaneous peaks from 10 to 20 dB greater than their average levels as indicated by a typical level meter. For most amateur recording purposes, the lower figure is probably more realistic, especially if the program has already been recorded or broadcast, in which case its peaks have already been limited.

Suppose that a recorder's meters have been calibrated to indicate 0 dB when the signal is 5 dB lower than the low-frequency saturation level, which is usually considered to be the level that produces 3% distortion in the playback output. If the average level indicated by the meter is about −5 dB, one can reasonably expect to make a recording without serious peak compression, assuming a 10-dB peak/average ratio. In fact, one can often operate even closer to the 0-dB mark on such a machine (which is typical of many cassette recorders) without serious loss of quality. The headroom of this hypothetical recorder, at low and middle frequencies, is 5 dB. It is the difference between the indicated maximum recording level and the point where tape saturation occurs.

But what about the high frequencies, which are boosted during recording? Obviously, they will saturate with a lower input level than the low and middle frequencies. Because of this, tape recorder frequency response is measured at a reduced input level, usually −10 to −15 dB for open-reel machines and −20 dB for cassette recorders. A cassette recorder that gives a flat record/playback frequency response at −20 dB will have a marked loss of high frequencies in playback if the recording is made at 0 dB. Our test reports show both curves, giving some idea of the loss of high-frequency headroom, which is largely a function of the design of the recording head as well as of the tape characteristics.

Although each recorder manufacturer selects his own 0-dB level, many use the so-called "Dolby level" of 200 nW/m for cassette recorders. If all recorders used this level as a 0-dB reference, it would be easy to compare their midrange headroom. However, in the design of a recorder, there are trade-offs between frequency response, distortion, and S/N ratio, with each manufacturer selecting his own criteria. If the 0-dB level is set higher than 200 nW/m, the apparent S/N compared to a 0-dB level is increased. This is only "apparent" because the true S/N rating should be referred to the level giving 3% playback distortion instead of to the recorder's 0-dB reference. Since such a recorder will distort with only a slight overload, the user will speedily learn to keep his average recording level around −10 dB, which points up the fallacy of trying to "extend" dynamic range in this way.

The opposite effect occurs when the 0-dB point is set at a lower flux level, as in the Pioneer Model CT-F8282 reviewed this month. Pioneer has made 0 dB correspond to 160 nW/M, which is about 3 dB below the Dolby level. In effect, this gives an extra 3 dB of apparent headroom over the recorder's zero level before the reference distortion level is reached. When the total frequency-response characteristics of the machine are studied, it can be seen that Pioneer has not attempted to extend the high-frequency response beyond the 13,000-to-15,000-Hz range. Instead, the recording equalization and bias have been matched to the head characteristics to give a rather good high-frequency headroom characteristic so that a strong response is maintained to 10,000 Hz or beyond, even at 0 dB. This makes the published specifications less impressive than they might have been, but it results in cleaner, less compressed recordings. There is little or no audible loss from the attenuation of frequencies beyond 13,000 Hz or so, and the quality improvement from the headroom increase is much more likely to be heard and appreciated by the user.

To interpret our test data on cassette recorders (the same thing applies, to a much smaller degree, to open-reel machines), look at the S/N ratio referred to the 3% distortion level and the meter reading corresponding to that level. This will reveal, in a rough way, how high the average recording levels can be set to realize the full dynamic range of the machine. Then, look at the 0-dB and −20-dB frequency-response curves to see how much distance there is between them, and if and where they intersect. Most machines have an intersection of these curves between 12,000 and 18,000 Hz but some have curves that never intersect. The greater the gap between the two curves, and the higher their intersection frequency, the better the headroom.

PIONEER MODEL CT-F8282 CASSETTE DECK

Front-load deck features operating simplicity and solenoid controls.

HIRSCH-HOUCK LABS REPORT

Pioneer's Model CT-F8282 front-loading cassette deck has a two-motor, solenoid-operated tape transport, with a servo-controlled dc-motor capstan drive. A separate high-torque dc motor operates the tape hubs in fast-forward and rewind. The transport controls are short levers that extend horizontally from the front panel below the cassette well. They operate with a very light touch, since they merely energize the solenoids that perform the actual mechanical and electrical switching operations. The levers can be operated in any sequence, without going through STOP, obviating the risk of damaging the tape. A separate PAUSE switch is located to the right of the control levers. The deck can be set up in advance for unattended recording or playback, and will go into operation when power is applied by an external timer switch. It shuts down mechanically and disengages the heads when the tape ends.

The styling of the cassette deck matches other Pioneer components. The control panel and controls are satin-finished aluminum, and the wooden case is finished in walnut-grain vinyl. The deck measures 17¾"W × 13½"D × 7⅝"H (45 × 34.3 × 19.4 cm) and weighs 27 lb (12.3 kg). $400.

General Description. The cassette is installed vertically through a large opening in the front panel and can be covered by a swing-down clear-plastic window. Unlike other cassette decks, this one does not have an EJECT lever. Instead, with the tape stopped (even in the PAUSE mode) the cassette is simply pulled off the drive hubs and removed by hand. This is just about the simplest and easiest withdrawal system we have seen. It leaves the cassette completely visible while it is in the machine. The record/playback and erase heads feature ferrite construction.

To the right of the cassette well, the upper portion of the control panel contains two large illuminated level meters that are calibrated from −20 to +3 dB, the latter indicated as the Dolby level for calibration purposes. During playback, the meters show the level actually present at the LINE outputs and are controlled by the OUTPUT level controls. Between the meters, a red LED indicator comes on when the deck is in the RECORD mode and another flashes when program peaks reach +5 dB to warn of potential distortion from over-recording.

Below the meters are a three-digit index counter and four pushbutton switches. One switch activates the MEMORY REWIND feature, stopping the tape in REWIND when the index counter returns to a previously set 000 reading. Another turns on and off the DOLBY system, and an indicator light above the button. The remaining switches are labelled BIAS and EQ, with STD settings for high-performance ferric-oxide tapes and CrO_2 settings for chromium-dioxide tapes or the cobalt-treated equivalent tapes, such as TDK SA and MAXELL UD-XL II. When both buttons are depressed, a CrO_2 indicator above them lights. For recording on ferrichrome tapes, the STD bias and CrO_2 EQ settings are used; CrO_2 EQ should be used for their playback. A chart in the instruction manual suggests switch settings for most popular tapes.

Below the pushbutton switches are concentric INPUT level controls for the two channels and another concentric pair of OUTPUT playback level controls. At the right side of the panel are two ¼" (6.35-mm) MIC and PHONES jacks. At the lower left of the panel is the pushbutton POWER switch.

On the rear panel of the deck are the input and output phono jacks, a DIN socket, and a switch that connects the recording inputs to either the phono jacks or the DIN socket. The DIN switch also inserts a 10-dB attenuator in the recording inputs and can be used when high-level output microphones are plugged into the front panel jacks (replacing the LINE inputs with the MIC signals) to prevent overloading the input stages. There is also a single unswitched ac outlet on the rear panel.

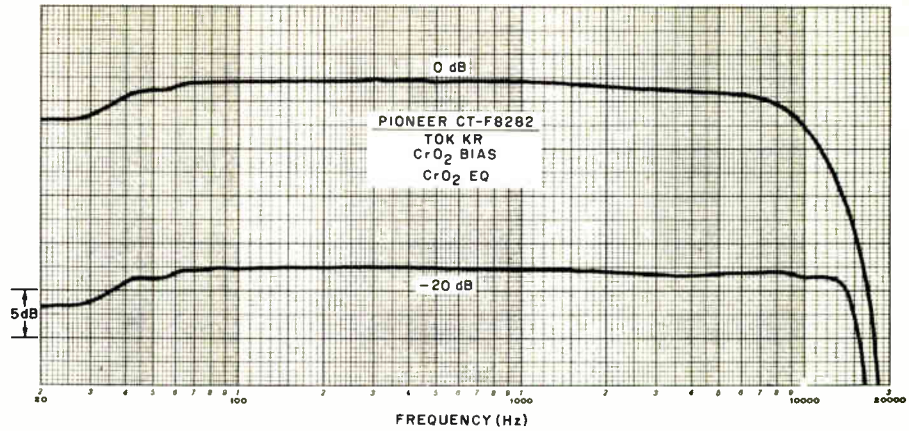
Laboratory Measurements. Although the instruction manual suggests control settings for many tape types, there was no indication of which specific tapes had been used at the factory for bias adjustments. Therefore, we measured the record/playback frequency response with a number of high quality tapes, including TDK Audua, SA, and KR (CrO_2), Maxell UD-XL I and UD-XL II, Scotch Master, and two ferrichrome tapes, Scotch Classic and Sony FeCr.

The response varied little among the several ferric-oxide tapes, but TDK Audua seemed to yield a bit better high-frequency response and was chosen for further tests with the STD bias and EQ settings.

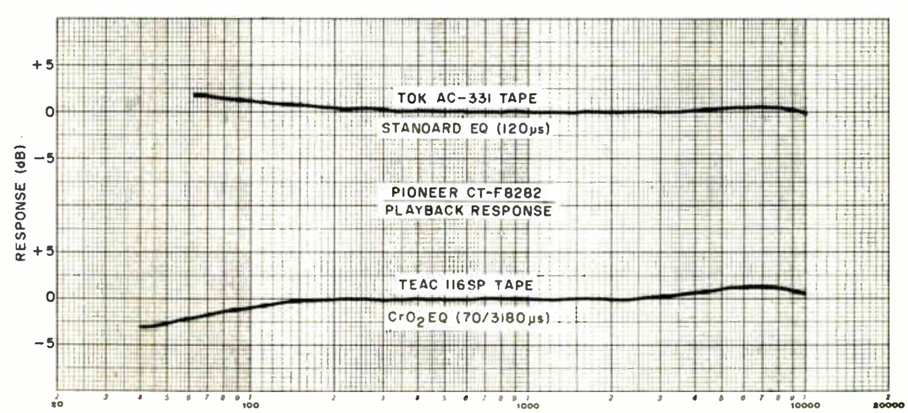
The TDK SA and Maxell UD-XL II tapes gave identical responses, but TDK KR gave the flattest overall response and was used with the CrO_2 bias and Eq. The Sony FeCr gave good results with the recommended FeCr settings, but Scotch Classic exhibited the loss of high frequencies, which we have observed in machines that have been biased for the Sony tape. Playback frequency response was measured using the new TDK AC-331 test tape for STD (120 μs) equalization, and with a Teac tape for CrO_2 (70μs) equalization.

The playback equalization was accurate with both switch settings, varying less than ±1 dB over the 63-to-10,000-Hz range of the TDK tape and between +1.5 and −3 dB over the 40-to-10,000-Hz range of the Teac tape. Most of the variation in both cases took place below 100 Hz. The record/playback response with TDK "Audua" tape was flat within 0.5-dB overall from 60 to 8000 Hz, dropping off to −3 dB at 35 and 12,000 Hz. Overall, the variation was ±3 dB from 20 to 13,500 Hz. TDK KR tape gave an almost ruler-flat response of ±1 dB from 37 to 13,500 Hz and ±3 dB from 20 to 15,000 Hz. The other tapes were generally similar to the TDK Audua in their response, with the output sloping off gently above 10,000 Hz and more rapidly above 13,000 Hz.

For a recording level of 0 dB, an input of 57 mV was required at the LINE inputs and 0.14 mV at the MIC inputs. The MIC circuit overloaded at a fairly safe 105 mV, which could have been increased to more than 300 mV with the DIN switch. The maximum output level from a 0-dB recording was between 0.6 and 0.75 volt, depending on the tape used. With the OUTPUT control set for a 0-dB meter deflection, the output was 0.5 volt. The PEAK indicator flashed at exactly +5 dB, with an abrupt switching characteristic



Response with TDK KR tape using CrO_2 bias and equalization.



Playback response with two tapes at different equalization settings.

that eliminated the ambiguity sometimes associated with LED-type peak indicators. The meter ballistics were slightly underdamped, giving a 2-dB overshoot with 0.3-second tone bursts. The crosstalk from track 2 to track 1 at 1000 Hz, measured with a TDK AC-352 test tape, was −40 dB.

At a 0-dB recording level (3 dB below the Dolby standard level of 200 nW/m), the harmonic distortion on playback was a very low 0.5% with TDK KR, about 0.9% with TDK Audua, and 1% with TDK SA tapes. The distortion increased gradually up to +5 dB, where it was respectively 0.9%, 2%, and 0.9%. To achieve a 3% playback distortion level, we had to record at +7 dB with Audua, +8 dB with KR, and +8.5 dB with SA tapes. These levels are far off scale on the meters giving the assurance that, so long as the PEAK indicator does not flash more than occasionally, the distortion should be negligible.

The S/N ratio was checked with the three tapes with and without Dolby and unweighted and with IEC "A" and CCIR weighting. The unweighted S/N, referred to the 3% distortion level, was 48 dB with Audua and 54 to 55 dB with the KR and SA tapes. Using "A" weighting and the Dolby system, the S/N was 61.5 dB with Audua and 63 to 64 dB with the other tapes. Using Dolby's preferred CCIR weighting, these figures were improved by 0.5 to 1.5 dB. Through the MIC inputs, at maximum gain, the A-weighted noise level increased by 10 dB, but at normal settings of the gain control the increase was much less. On our test unit, the Dolby circuit "tracking" error at a −20-dB level caused a dip of about 5 dB in the response in the 3000-to-6000-Hz range. At other recording levels, this effect was much less.

The wow was 0.02%, which is approximately the residual of the test tape and flutter (unweighted rms) was 0.1%. In a combined record/playback measurement, the results were identical.

In the fast-forward and rewind modes, a C-60 cassette was moved from end to end in 59 seconds.

User Comment. The "human engineering" that went into the design of the deck makes it very easy to use, especially since there is almost literally nothing one can do to operate it improperly, other than selecting the incorrect bias or equalization. Tape loading and removal procedures are ideal for eye-level operation and nearly as good at waist level. We appreciated not having the cassette pop out noisily as it does on some tape decks, and its insertion and removal are as simple as reaching into the roomy compartment and grasping the sides of the cassette. In addition, the transparent cover allows the exact playing status of the cassette to be seen at a glance, including how much tape remains to be played.

Even though most solenoid-operated tape transports use pushbuttons of one type or another to energize the solenoids, the lever system on this deck is equally convenient to use, with the advantage that the levers remain mechanically depressed after they are pushed. Hence, the operating status of the machine can be seen without recourse to signal indicators. The very light finger pressure required to operate the levers is an immediate "giveaway" to their electromechanical operation. Another nicety, which we have not seen on many recorders, is the access hole in the cassette head cover for azimuth alignment.

Although, technically speaking, the published record/playback frequency response ratings of the deck were met in our tests, it is clear that the response beyond 13,000 Hz has been slightly sacrificed in favor of low distortion and improved high-frequency "headroom." From the user's point of view, this is the proper compromise to make (and some compromise is always necessary in designing a cassette recorder) since frequencies beyond 13,000 Hz are rarely present in the program material. Their absence will rarely be noticed, whereas distortion, noise, and high-frequency tape saturation will. This deck has above-average performance in each of these respects.

The meters read line output levels in playback, rather than showing the playback level ahead of the OUTPUT control as in most recorders. Also, the usual Dolby level of 200 nW/m as a 0-dB reference is not employed. Pioneer uses −3 dB, or 160 nW/m. These criticisms, to be sure, are minor and do not in any way detract from the fact that the Pioneer CT-F8282 is a fine-sounding, easy-to-use, and handsomely styled tape deck. In the popular-price range (for top-quality two-head machines), the deck compares favorably with any competitive decks in sound and performance.

ACOUSTIC RESEARCH MODEL AR-16 SPEAKER SYSTEM

Small, 2-way system delivers true bass, smooth middles and highs.

HIRSCH-HOUCK LABS REPORT

The Acoustic Research people recently have designed some new speaker systems that supplement, but do not at present supersede the older, well-known AR systems. The smallest and least expensive of the new generation of AR speaker systems is the Model AR-16. This true bookshelf-size two-way system has an 8" (20.3-cm) acoustic-suspension woofer that crosses over at 1300 Hz to a 1" (2.54-cm) dome tweeter. A three-position toggle switch on the rear of the enclosure provides a modest increase or decrease in high-frequency output, relative to the normal or "flat" condition.

The compact speaker system measures 19⅞" × 9⅞" × 8½" D (50.5 × 25 × 21.6 cm) and weighs 21 lb (9.5 kg). Value is $115 with walnut-grain veneer, $99.95 with walnut-grain vinyl.

General Description. The AR-16's nominal system impedance is 8 ohms, and efficiency is similar to that of many small acoustic suspension systems. AR rates the speaker system to deliver an 85-dB sound pressure level (SPL) at a distance of 1 meter with 1 watt of drive power. Although it can be used satisfactorily with a 25-watt/channel amplifier, the speaker system is designed to withstand the output of a 100-watt/channel amplifier, driven to clipping 10% of the time with ordinary music program material. According to AR, the free-air resonance of the woofer is 25 Hz, and system resonance is at 55 Hz.

CB servicing is PROFITABLE with the B&K-PRECISION 40-channel CB Test Bench

MODEL 1040
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· Audio wattmeter · Audio generator · Distortion meter · RF wattmeter/dummy load · DB meter · SWR bridge

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MODEL 1403A—3", 5 MHz Recurrent Sweep Oscilloscope

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MODEL 1640—Regulated Power Supply

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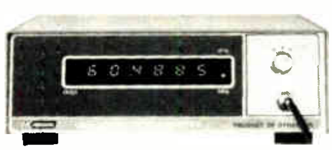
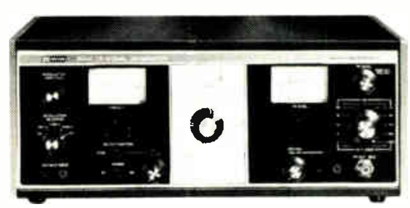


MODEL 1801—Digital Frequency Counter

To quickly determine the exact frequency of a CB channel, the 1801 automatically displays it for you in large, easy-to-read digits. You can tune oscillators precisely, conduct audio frequency analysis tests. Six digit display is updated five times per second. Accuracy guaranteed to 40MHz; 60MHz typical. **$240**



MODEL 2040—40-Channel CB Signal Generator

Covers all 40 channels, AM and SSB with built-in capability. Ultra-stable crystal-controlled, phase-locked-loop frequency generation. Has 5 ppm accuracy. Output attenuator and vernier provide calibrated outputs from 100,000 μV to 0.1 μV for receiver sensitivity measurements. Includes EIA standard noise test signal generator to check receiver noise suppression. Internal 400, 1000 and 2500 Hz modulating frequencies—can also be externally modulated. Internal protection against 5W RF input. **$475**

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For additional information, contact your B&K-PRECISION distributor for our comprehensive brochure describing the operation of the Model 1040 CB Servicemaster and the CB Service Center—or write us for your free copy.

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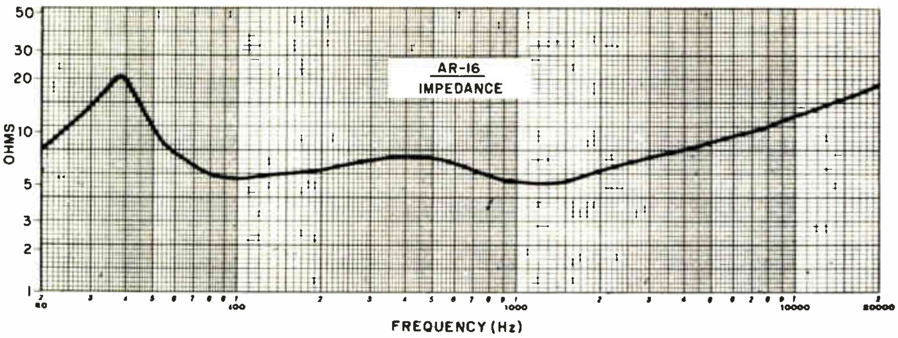


Impedance curve shows peak slightly below rated system resonance.

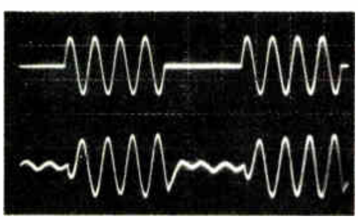
To minimize diffraction effects, which can occur when the speaker drivers are recessed behind the mounting board and which can produce an irregular polar response, the drivers are mounted flush with the front surface of the speaker board. The front is finished to match the rest of the cabinet, and the drivers are covered by a removable acoustically transparent foam plastic grille.

Laboratory Measurements. The frequency response of the speaker system was measured in the reverberant field of our test room at a distance of 12′ to 15′ (3.7 to 4.8 m) from the speakers over a frequency spectrum ranging from 100 Hz upward. The woofer response, up to several hundred hertz, was measured with a closely spaced microphone to simulate anechoic conditions and eliminate the influence of the room on the measurement. Splicing the two curves, and correcting for the known response of the microphone and room, we obtained an unusually "flat" frequency response of ±1.5 dB from 100 to 15,000 Hz. There was a 3.5-dB rise at the bass resonance of about 60 Hz. The overall response variation was an impressive ±2.5 dB from 30 to 15,000 Hz.

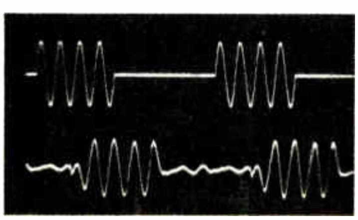
Our measurements were made with the tweeter switch set to NORMAL. A boost or cut of 3 to 5 dB at frequencies above 1500 Hz was measured with the switch set to its other positions. Driving the speaker with the equivalent of 1 watt into an 8-ohm load (2.8 volts), the total harmonic distortion (THD) below 100 Hz was less than 2% down to 45 Hz and increased smoothly to 10% at 33 Hz and 20% at 26 Hz. When we increased the drive level to 10 watts, the distortion characteristic had a similar shape, but the actual distortion levels were considerably higher. The measured distortion at 10 watts was between 3% and 7% from 100 to 45 Hz and increased to 20% at 36 Hz.

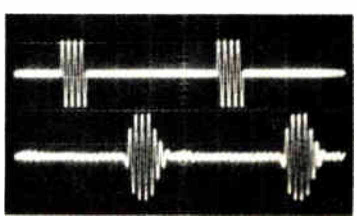
The system impedance was about 6 ohms at its minimum points of 100 and 1300 Hz, but it was typically 6 to 8 ohms over much of the audio range. It rose to a peak of 20 ohms at 38 Hz (well below the rated system resonance of 55 Hz) and climbed smoothly beyond 2000 Hz to 20 ohms at 20,000 Hz. The impedance was not significantly affected by the setting of the tweeter level switch.

In our "efficiency" measurement (actually a sensitivity measurement), when the speaker system was driven at a nominal 1-watt level by an octave of random noise centered at 1000 Hz, the SPL was 91 dB at a distance of 1 meter from the front surface. This is slightly higher than we have measured from some other larger acoustic-suspension systems, even when allowance is made for the 1.25-dB apparent increase in efficiency due to the actual impedance's being 6 ohms instead of 8 ohms at the test frequency.



Tone-burst responses at 100 Hz (left), 1300 Hz (below left), and 10,000 Hz (below).





Noting that there was no sign of the crossover frequency in the response curve, we carefully examined the tone burst response in the crossover region as well as at lower and higher frequencies. We could find no trace of the anomaly that sometimes occurs in the tone-burst response at the crossover point. The tone bursts were reproduced very well at all frequencies.

User Comment. In the simulated live-versus-recorded listening test, the Model AR-16 was a very accurate reproducer, though not quite "perfect" on any of the music selections we used in this test. The departures from facsimile reproduction of the live sound were difficult to define in terms of frequency response. In general, they took the form of a slight "coolness" or "dryness" in the lower midrange. It is in this frequency range that the speaker system was notably free of the artificial emphasis that is all too common with other systems.

The sound from the Model AR-16 belies its compact dimensions. It is not surprising, though nonetheless gratifying, to find a small, inexpensive speaker system that can deliver a smooth, well-dispersed middle- and high-frequency response, but we have come to expect a certain thinness of low bass from such systems. This was not our experience with the Model AR-16; it can deliver a room-filling, true bass when required.

This is not a speaker system that can be played loud enough to rattle the walls, unless you are willing to accept appreciable distortion levels. The 10-watt distortion curve clearly illustrates that, although the woofer does not "fall apart" when driven hard, it is not at its best under these conditions. AR suggests that a pair of Model AR-16's, driven with 25 watts/channel of amplifier power will produce a 103-dB SPL in a typical 3000 cu ft (85 cu m) living room. We did not attempt to verify this because we were satisfied that the speaker system is more than equal to the task of supplying larger-than-life, clean sound in a typical home environment, with no obvious coloration.

The Model AR-16, in our opinion, is a worthy addition to the AR product line. Comparing it to its predecessors should convince anyone that there has been substantial progress in speaker system performance, much of which is embodied in this diminutive system.

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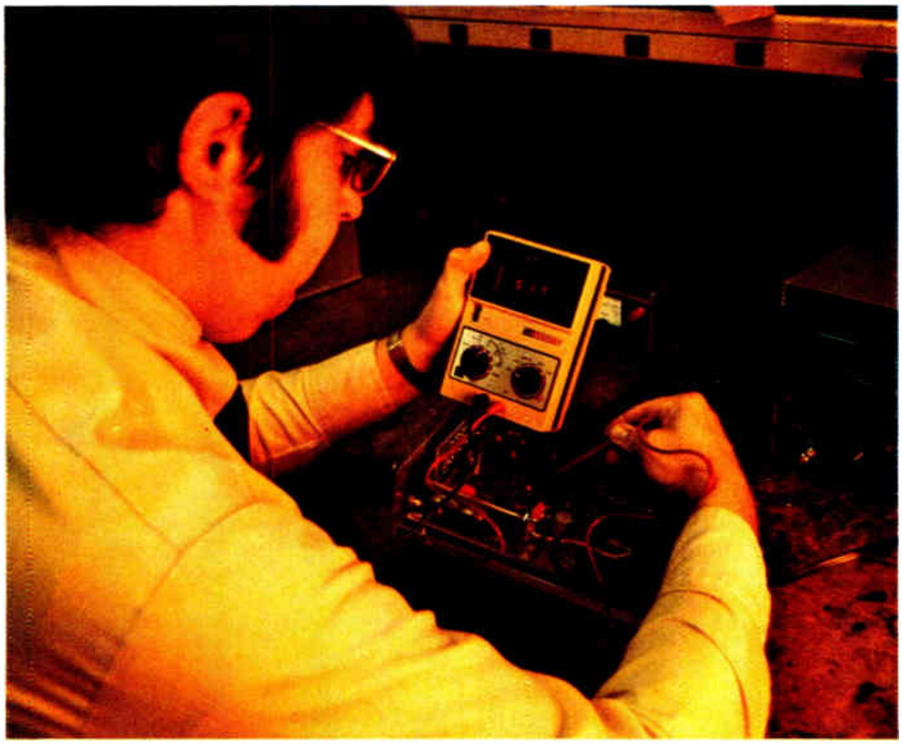


MULTIMETERS FOR ELECTRONICS

BY CLAYTON L. HALLMARK

PART 2: *Digital Multimeters*

LAST MONTH, we discussed the traditional VOM and analog, or meter-type, electronic multimeters. Here, the focus is on the newest type of electronic multimeter—the digital multimeter, or DMM.

DMM's offer most of the advantages of analog-type instruments, plus a few that are unique. The use of numeric displays in place of meter movements, for example, makes reading measurements easier and eliminates interpretation errors common with multi-scale analog meters. They also make possible a more accurate instrument, since a measurement with more digits is obtained than is possible with an analog instrument.

Technical Details. The accuracy of a DMM is stated in percentage of reading, rather than in percentage of full-scale. This means a more uniform accuracy throughout a given range. To illustrate, a DMM with a 2% accuracy on the 100-volt dc range would be accurate to within 2 volts at 100 volts *and* 0.4 volt at 20 volts. Therefore, at 20 volts, the DMM would be five times as accurate as the analog meter. (In practice, this disparity might be even greater, considering that many DMM's are more accurate than the 2% figure in our example.)

In addition to the stated accuracy, the DMM may be off by ±1 count in the least-significant (farthest right) digit. This means that, if 1000 volts is displayed by an instrument with a 0.1%, ±1 digit accuracy, the actual potential being measured can be anywhere between 998 and 1002 volts, based on a deviation of 1 volt for the 0.1% error and 1 volt for the one-digit error.

Ac accuracy. Ac voltage accuracy is usually somewhat worse than the dc accuracy and is usually limited to a specified bandwidth. Outside the specified frequency range, the accuracy drops off rapidly. Also, ac accuracy is usually specified for a sine-wave input; any other type of waveform will degrade the accuracy. In addition, distorted sine waves produce serious accuracy errors.

Resistance power. Sounding like a contradiction in terms, resistance power simply means how much current/voltage will be applied *to* the device under test by the DMM when using the instrument in the resistance-measuring mode. On low ohmic ranges, the excessive current or voltage can be sufficient to damage sensitive semiconductors.

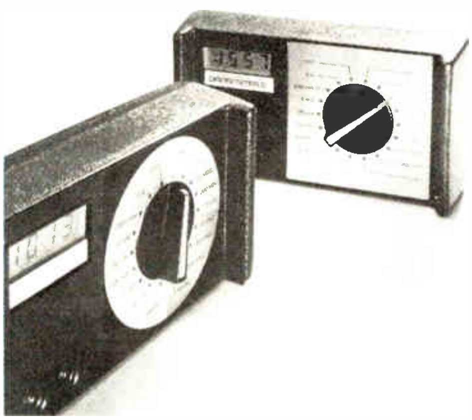
Protection. You will pay good money for a DMM, so you will want to use it as long as possible. Always keep in mind that someday you might use the resistance-measuring function to try to measure line voltage. Unless your meter is protected on all ranges and functions, it will likely be damaged beyond repair. And if you accidentally set it up on the wrong range or function, it may cost almost as much to repair as to replace it, if it is damaged.

Ruggedness. If you are going to use your DMM in the field, make sure it has an "impact-resistant" case and, if possible, a case that will protect the knob and switch controls and display from damage if the instrument is dropped onto a hard surface on its face.

Digits. A common way of classifying DMM's is by the number of digits in its display. This can often be confusing because an instrument that displays a maximum count of 1999 has 3½ digits, not 4 as a first glance might lead you to believe. The initial digit is actually a half digit that is either blanked or displayed as a 1 and only a 1. The half digit is sometimes called the "overrange" digit, since it permits measurements to be made somewhat beyond the selected range.

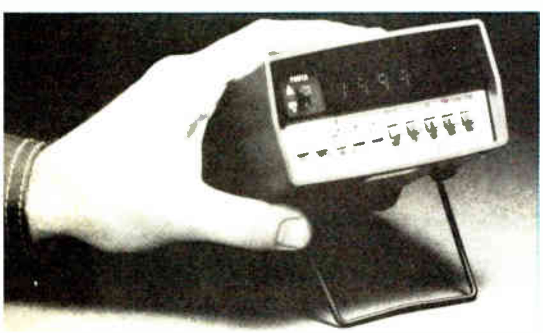
If a 3-digit instrument with overranging is used to measure a potential that changes from 99.9 to 100.2 volts, the second potential could be read to the nearest 0.1 volt without having to change ranges. Without overranging capability, the meter would have to be

B&K Precision Model 280 (shown also on preceding page).



Danameter 2000A and Danameter II 2000A

Viz WD-750A VoltOhymst



John Fluke Model 8030A

Simpson Model 380

Data Tech Model 21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Shakespeare comes on strong for the new 40 channel era. With high performance CB antennas that turn on the power on all 23 or 40 channel CB transceivers.
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switched to the 1000-volt range, where it would correctly indicate 100 volts to the nearest 1 volt instead of the nearest 0.1 volt.

Overranging. This is sometimes specified as a percentage by which this feature extends the range capability of the instrument. Hence, if a 4½-digit DMM has a maximum display capability of 19999, it is said to have 100% overranging because 19999 is about 100% greater than 9999. And if a 4½-digit DMM has a maximum display count of 11999, it is said to have 20% overranging because the maximum without overranging would be 9999.

Resolution. A related DMM specification is resolution, which is one part in the maximum reading. The resolution of a 4-digit instrument with 20% overranging is one part in 11,999.

Sensitivity. This is sometimes confused with resolution and is the lowest displayable increment of voltage that is represented by the least-significant digit in the display when the meter is set to its lowest range. A 4-digit meter with a 100-mV lowest range and the capability of displaying 100.00 mV has a sensitivity of 10 microvolts.

DMM's For Servicing. There are many digital multimeters from which the service technician and hobbyist can choose. (A list of manufacturers of such instruments is given in the table. The manufacturers can supply technical literature and prices for the digital instruments they make.) Most instruments for servicing and hobby use are in the low- and moderate-price ranges. They offer a wide variety of ranges, functions, and features that can be matched to just about any test and measurement job you might have.

Controls. The front-panel controls and jacks on most DMM's are similar to and serve the same purposes as in the VOM. This means that the typical DMM is operated in a manner similar to that of a VOM. The RANGE and FUNCTION switches in DMM's are generally separate controls. The "hot" input jack is usually labelled V Ω for ac and dc voltage and resistance and MA for ac and dc current, both referenced to a COM jack. Some DMM's also have a ZERO control that is used to set the display to all zeros when the two test probes are shorted to each other.

Overrange indication. The "overrange" indication is displayed whenever the input to the instrument is greater in magnitude than the setting of the RANGE switch allows. In some instruments, the indicator for this condition is an OVER (or OVERRANGE) lamp, while in others the overload is indicated by a 1 in the half-digit position with the other digits blanked or by some other distinctive display feature.

Polarity display. Almost all modern

(continued on page 38)

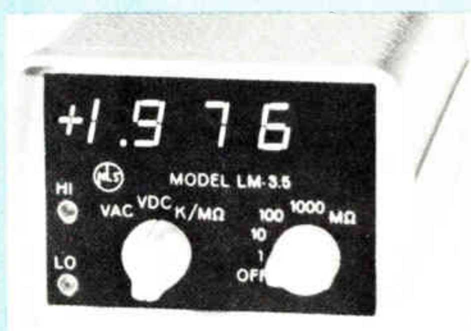
Data Precision Model 175

Hewlett-Packard Model 3476A

Hickok Model 3300A

Heathkit Model IM-102

Sencore Model DVM35



Non-Linear Systems Model LM-3.5

Digital circuits cannot by themselves measure such analog parameters as voltage, current, and resistance. It is necessary, therefore, for the digital circuits in a DMM to be preceded by analog-to-digital (A/D) converters that present analog information in a form that digital circuits can use. Essentially, the A/D converter feeds a set number of pulses to the digital counting circuits, the number of pulses depending on the magnitude of the parameter being measured. The greater the magnitude of the analog parameter (or the longer a gate is held open), the greater the number of pulses delivered to the counting circuits. There are basically two types of converters used in DMM's today. One is the single-slope converter shown in diagram A, the other is a dual-slope converter, shown in diagram B.

The single-slope converter, used in many low-cost DMM's, contains a capacitor that is linearly charged from a constant-current source. The potential across the capacitor is applied to the inverting (−) input of a voltage comparator, a form of operational amplifier. The unknown voltage to be measured is applied to the noninverting (+) input of the comparator. In a voltage comparator, when the potential at the + input is greater than that at the − input, the output from the comparator is high.

As the potential across the capacitor, and hence across the − input of the comparator, reaches a level that just slightly exceeds, by a few millivolts, the potential at the + input, the comparator switches to a low-output state.

The output of the comparator is fed to a three-input gate, along with the pulses from a stable oscillator of known frequency and a control signal that can be either high or low. When both the comparator and control signals are high, the oscillator pulses can pass through the gate and on to the counter circuit. If either the comparator output or the control signal are low, the gate will be disabled, preventing the oscillator pulses from passing through to the counter.

In operation, the control signal causes the counter to reset to zero and, via electronic switching, turns off the gate and discharges the capacitor. Hence, the oscillator signal cannot pass through the constant-current source. As the unknown voltage at the input is greater than the potential across the capacitor, the output of the comparator is high and allows the oscillator signal to pass on to the counter. As soon as the capacitor potential exceeds the unknown voltage, the comparator switches state and disables the gate, preventing any more oscillator pulses to be passed on to the counter. Another signal then causes the display to indicate the state of the counter. After a predetermined interval, the special control signal resets the gate, discharges the capacitor, and prepares for the start of a new cycle.

Note that the accuracy of the single-slope converter depends on the stability of the oscillator, voltage comparator, and constant-current source and the quality of the capacitor. Noise on the input signal can produce faulty indications in this system.

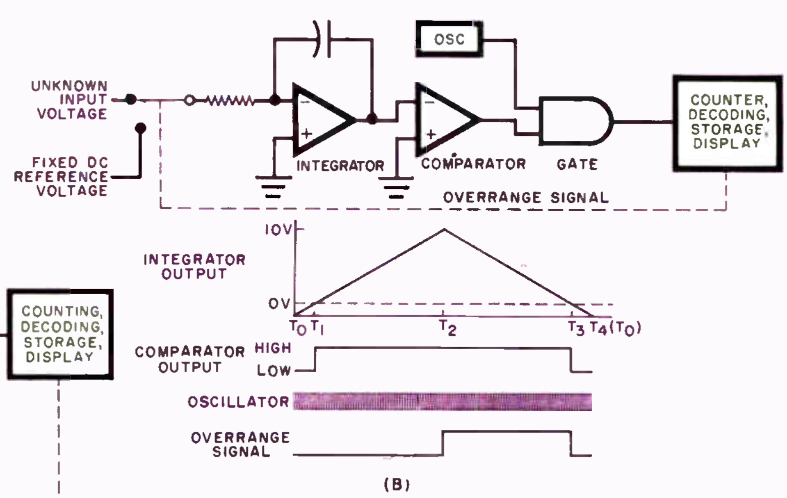
Better digital multimeters use dual-slope conversion (circuit B). This system also uses a capacitor that is charged by a constant-current source, but charging is performed by an integrator circuit, using an op amp. In this manner, the capacitor can be linearly charged and then linearly discharged to provide the voltage/time conversion required. This eliminates long-term drift due to component instability, temperature variations, and noise on the input signal and provides for better accuracy, the last between 0.5% and 0.01%.

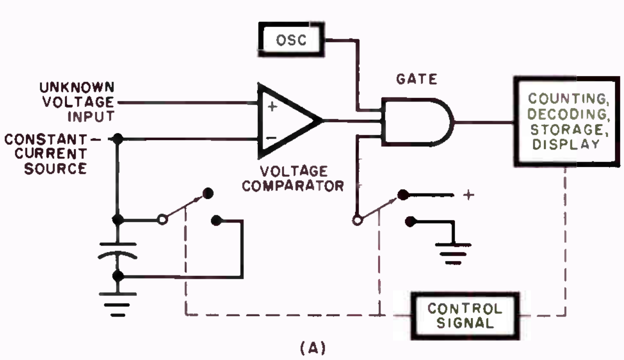
In circuit B, let us assume that the system has been reset so that the integrating capacitor has been discharged and the counter/display is at zero. The control signal connects the comparator input to the unknown input voltage, which is negative in this case. Due to the arrangement of the circuit, at time T0, the output at the integrator will be slightly negative and the output of the comparator, whose + input is referenced to ground, will be low. Under these conditions, the gate will not allow the oscillator signal to pass through, since its other input is low.

The unknown potential at the input applied to the − input of the integrator causes the op amp to charge the capacitor. As this voltage passes through zero (time T1), it turns on the comparator which, in turn, allows the oscillator pulses to pass through the gate to the counting circuits. The capacitor continues to charge and the counter continues to count until it reaches, in this case, the 10-volt count. At this time, the counter generates an "overrange" signal. The overrange signal occurs at time T2 and electronically switches the integrator input from the unknown input voltage to an internal fixed dc reference voltage of positive polarity. Note that the time from T1 to T2 completely fills the counters once. This time is not fixed because the charging rate is determined by the level of the unknown voltage. A high voltage reduces the T1-to-T2 period, while a low voltage increases it.

At time T2, the reference voltage starts the integrator in the opposite direction and linearly discharges the capacitor. The reference voltage is held stable by internal circuitry. The linear discharge continues, as does the count (gate held open by the high level of the comparator's output), until the decreasing ramp passes through zero (time T3), forcing the comparator to change output state and shut down the gate to stop the counter.

When the gate shuts down, the counters display a count that is directly proportional to the ratio of the unknown voltage to the reference voltage. If a high-quality integrator capacitor and a stable reference voltage are used in the circuit, the accuracy of the system can be quite good.





Two types of converters used in DMM's: single-slope (A) and dual-slope (B).

COMPARISON OF METER SPECIFICATIONS

		DVM	VTVM	FETVOM	VOM
Accuracy (%)	(S*)	0.1-2	3-5	3-4	1-5
	(L*)	0.4-0.004	1-3	1-2	
Frequency Limit	(S)	20Hz-20 kHz	To 4 MHz, 250 MHz with probe	To 3 MHz, 250 MHz with probe	To 100 kHz
	(L)	To 100 MHz	To 700 MHz	To 1 MHz, 500 MHz with probe	
Ac impedance	(S)	10 megohms	10 megohms	1-10 megohms	0/5 kilohms per volt
	(L)	1-10 megohms	10 megohms	10 megohms	20 kilohms per volt
Waveform response	(S)	Avg.	Peak, p-p	Peak, p-p	Avg.
	(L)	Avg., rms	Avg., rms	Avg.	
Voltage readings (min. and max.)	(S)	10 μV–1000 V	0.2 mV–1500 V	0.1 mV–1500 V	5 mV–6000 V
	(L)	1 μV–1000 V	20 μV–1000 V	200 μV–1000 V	
Resistance readings	(S)	1 ohm-10 megohms	0.2 ohm-1000 megohms	0.2 ohm-1000 megohms	0.2 ohm-100 megohms
	(L)	0.0001 ohm-10 megohms	0.2 ohm-5000 megohms	0.2 ohm-500 megohms	

*S = Service type. L = Laboratory type.

DMM's feature automatic polarity indication in the display, activated by internal circuitry according to the polarity of the dc voltage or current being measured. (In some instruments, + is implied, while other instruments display both + and −.) With the autopolarity feature built into a DMM, there is no need to transpose test probes or to flip a polarity-reversing switch, which further simplifies instrument operation. And positioning of the decimal point in the display is also automatic whenever the RANGE switch is operated.

Probes. Some DMM's come with probes that have switchable isolation resistors in them to prevent capacitive loading when making dc voltage and r-f circuit measurements. High-voltage and r-f probes are also available to extend a meter's basic voltage and frequency ranges.

Since most DMM's are average-sensing and rms-calibrated, any input other than a pure sine wave on the ac function can cause an error in the reading obtained. At low signal levels, the ±1-count ambiguity can lead to serious measurement errors. If a 3-digit DMM is set to the 0.1-volt range and the indicated display is 0.010, for example, the one-count ambiguity would mean that the true potential could be 0.009 or 0.011 volt, an error of 10%.

Choosing a DMM. You must determine which type of DMM best suits your needs. If you plan on using your DMM as a bench-only instrument, a line-powered DMM will probably be your first choice. On the other hand, if you intend to use your DMM almost exclusively in the field, battery power is a must. An instrument that must be used for both field and bench testing should be capable of being operated on battery power in the field and line power on the bench.

The number of digits in the display will influence the type or model instrument you choose. In most cases, every added digit boosts the cost of the DMM. So, if you are working with 20% resistors and capacitors and most schematic diagrams indicate tolerances to only two decimal places, a 2½-digit DMM is all you really need. Of course, if you are working with high-level technology, do not look for an instrument with less than 3½ digits in the display.

The type of display you choose may also be important. The three most popular types used in DMM's today are the red LED, orange gas-discharge, and LCD (liquid crystal display) displays. Except for the gas-discharge type, which can be either seven-segment or individual 0-through-9 format, the displays are arranged in seven segments. For most indoor work, the LED display is convenient. You can work with an instrument with a LED display even where ambient light levels are quite low, since the display itself lights up. For outside work, where the ambient light is very bright, a LED display is likely to wash out and become unreadable unless a light hood is used. Here, the LCD offers a high degree of legibility, since contrast increases with increasing light levels. The disadvantage of the LCD is that it is very difficult to read when the light level is relatively low. The gas-discharge display bridges the gap between the LED and LCD displays.

Although most DMM's that would be used by the experimenter/hobbyist have a 10-megohm input resistance, you may find instruments with different input impedances specified. Keep in mind that the input resistance will be in parallel with the device or circuit being measured and that even a 10-megohm input resistance across a 10,000-ohm load represents a loading error of 0.1% that must be added to the instrument's accuracy specifications. If you are thinking of using a DMM with a 1000-megohm or greater input resistance to avoid loading effects, remember that changing temperature will introduce errors in the measurement. Also keep in mind that there is quite a difference between input resistance and input impedance. Input

DMM MANUFACTURERS

Ballantine Laboratories, Inc.
Box 97, Boonton, NJ 17005
B&K Precision
6460 W. Cortland, Chicago, IL 60635
Dana Laboratories, Inc.
2401 Campus Dr., Irvine, CA 92713
Data Precision Corp.
Audubon Rd., Wakefield, MA 01880
Data Technology Corp.
2700 S. Fairview Rd., Santa Ana, CA 92704
DeForest Electronics
40 Fairfield Pl., W. Caldwell, NJ 07006
Dynascan Corp., B&K
1801 W. Belle Plaine Ave., Chicago, IL 60613
John Fluke Mfg. Co.
Box 43210, Mountlake Terrace, WA 98043
Heath Co.
Benton Harbor, MI 49022
Hewlett-Packard
1501 Page Mill Rd., Palo Alto, CA 94304
Hickok Electrical Inst. Co.
10514 Dupont St., Cleveland, OH 44108
Leader Instrument Corp.
151 Dupont St., Plainview, NY 11803
Non-Linear Systems Inc.
Box N, Del Mar, CA 92014
Sencore Inc.
3200 Sencore Dr., Sioux Falls, SD 57107
Simpson Elect. Co., Div. of AGM
853 Dundee Ave., Elgin, IL 60120
Systron-Donner Corp., Instrument Div.
10 Systron Dr., Concord, CA 94518
Tektronix Inc.
Box 500, Beaverton, OR 97077
Viz Test Instrument Group
335 E. Price St., Philadelphia, PA 19144

resistance is specified for dc measurements, while input impedance is for ac measurements. Too, besides input resistance, there is also input resistance due to capacitance of the test-probe cable with which to contend.

Depending on the type of work you will be doing, even a basic DMM may not be what you need. If you do a lot of alignment, where tuned circuits must be "tweaked" for maximum or minimum response at some particular frequency, you will need a "trend" indicator incorporated into your DMM. This device is usually an analog-type meter movement. The numeric display will indicate the value of the parameter being measured, while the meter movement will indicate the trend taking place.

There are some mechanical considerations, too. For a portable field instrument, look for a handle that can also double as a tilt stand to elevate the front of the instrument at a convenient viewing angle. Such handles are usually standard equipment on modern DMM's. Another thing to look for is nonskid rubber "feet" on the bottom of the instrument's case. The feet will not only prevent the DMM from being accidentally brushed off your workbench onto a hard floor, it will also make using the DMM easier by keeping it in place when you press a switch with only one hand.

The matter of instrument size is usually a personal taste. Obviously, if you plan to use the DMM primarily for field service, the smaller the better. You may also want a very compact instrument on your workbench, which is fine if the instrument packs all the ranges, functions, and features you need. But bear in mind that larger instruments often offer functions and conveniences not avaialbe in a compact DMM.

Actually, which digital multimeter you buy depends on the applications for which it is intended and how much money you have to spend. You would not, for example, pay the premium price demanded for a 0.01% laboratory-grade DMM when a 0.1% accuracy is all you will ever need.

The best advice is to tailor the instrument to the type of work you will be doing. Once you fulfill your needs for functions, ranges, features, and size, look into such things as accessories, autoranging, etc., if your budget will allow them. The new DMM's on the market (and those still to come) are offering features and functions that either did not exist before or commanded very high prices in the past. The newer instruments offer more for less money. ◇

PE TESTED *BREAKTHROUGH PROJECT*

Low-Cost Digital Logic Analyzer

Data-domain instrument for troubleshooting any type of digital system including microcomputers.

BY G. MUETHING, I. SPECTOR, AND C. WONG

Digital circuitry has spawned a variety of troubleshooting aids, including logic probes, pulse generators, IC clip-type testers, logic comparators, and multiple-trace oscilloscopes. All are most useful—up to a point. That point is reached when the digital equipment contains a microprocessor, as in computers, scanning monitors, video games, microwave ovens, etc.

In such cases, how does one examine a number of operating interdependent circuit lines for debugging purposes? Industry knows how—with a "logic analyzer," an instrument with a bottom price of about $2500. Now, however, you can build your own logic analyzer for less than $190.

The Logic Analyzer presented here features eight input lines and an ability to examine sequential data before or after a reference event, displaying a truth table consisting of 1's and 0's on any oscilloscope CRT. This is called a data-domain logic analyzer. (There are, of course, other types of analyzers, one of which displays a timing diagram on a scope's CRT.)

Why a Logic Analyzer? Because digital logic operates at two different voltage levels (0's and 1's), the first special-digital test instrument was the simple digital probe. The digital probe uses some type of indicator, usually a LED, to indicate the presence or absence of a signal at any selected single point in a circuit. Since digital circuits usually consist of a number of IC's that all operate from a common timing clock, even if a single digital probe gives a proper indication at a given test point, there is no way of determining if the observed pulse is correctly timed.

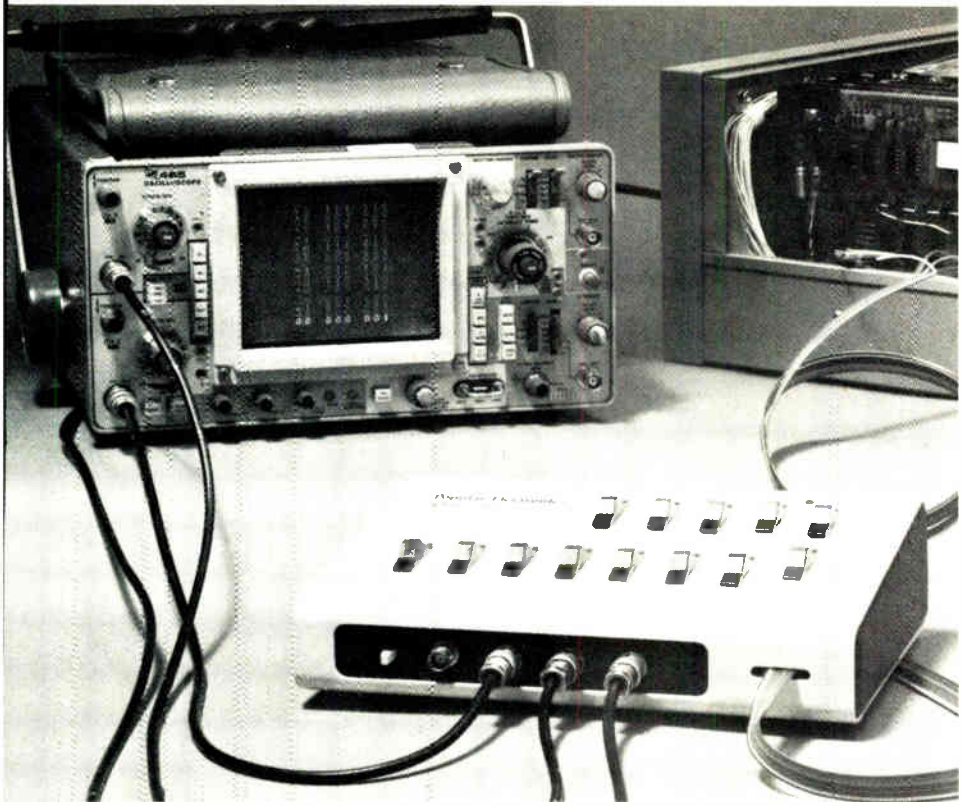
The shortcomings of the digital probe led to the development of the IC "clip" tester in which 14 or 16 LED's could indicate the logic states at each of the IC pins. Note that the status of the logic is of interest only at a specified instant in time related to the clock. This brings up another problem—clock speed. With most clock rates, single 14/16-pin LED indicator probes may display only a blur (except at the ground and power pins of the IC), with the blur rate, or light intensity, a function of the clock speed. Hence, unless you are able to drastically slow down the clock rate, you still will not be able to discover anything but the presence or absence of signals, whether or not they are correctly timed.

Using a logic analyzer with an oscilloscope, you can display a "truth table" of the digital circuit being tested under actual operating conditions. Simply by selecting a "trigger word" consisting of a particular set of 1's and 0's, the analyzer will freeze the 15 8-bit digital words that precede the selected trigger word and display the data so that it can be analyzed at your leisure. A switch also allows the observation of the 15 digital words that follow the trigger word if the problem is thought to lie in that direction. By changing the trigger word, which is brightness accented in the display, as you step through the truth table, it becomes possible to examine the digital logic from start to finish. In essence, then, the Logic Analyzer is a form of electronic "time machine" that can freeze digital events before or after any selected point in time.

Because a computer consists of a number of interlocking digital circuits, each carefully timed from a common clock signal, the misplacement of one bit among thousands can cause a great deal of trouble. Programs that can be properly written will not run because of an erroneous bit being generated within the system.

Why not use a conventional oscilloscope? True, you can see a small group of bits at any given time. But if the system under test is running at the usual clock rates, the picture displayed will keep changing and be blurred. The scope can display a signal only after it has been triggered. If you happen to trigger on the problem itself, you have further complications. Because computers, peripherals, ROM's, and other digital devices may not repeat the same state over and over again, a scope without storage capability cannot display a "snapshot" of a one-time logic event for subsequent analysis. In some cases, the scope is a necessity, as only a scope can display the detailed waveform information that can give the user an insight by an intuitive process where a waveform "just doesn't look right". A good scope can also show up fast transient "glitches" that, although they disturb circuit operation, may not show up on an analyzer. However, if you rely strictly on a scope for analysis, solving many system problems would be virtually impossible.

The low-cost Logic Analyzer in this article will add a form of storage to any oscilloscope, perform the sixteen 8-bit data word freeze as previously described, and provide the electronics experimenter with a state-of-the-art digital test instrument that rivals those costing several hundred dollars more. In use, you simply connect the three analyzer outputs to the horizontal, vertical, and



blanking inputs of a scope and connect the eight data-input and the clock and ground probes to the circuit being analyzed. When the trigger word keyed in via control-panel switches appears, the Analyzer will automatically trigger, collect, store, and display 16 sequential 8-bit words in either octal or hex format, as shown in Fig. 1. The analyzer will accept data rates as high as 8-million bytes/second.

Another front-panel control allows the user to select either "positive time" in which the selected trigger word appears intensified on the top of the CRT screen with the next 15 sequential data words below it, or "negative time" in which the 15 data words leading up to the trigger word appear first with the brightened trigger word at the bottom of the screen.

One other control provides the choice of a "snapshot" that catches and displays an individual 16-word table for as long as you like or a "moving picture" display in which the data for each table is collected and automatically displayed so you can dynamically observe the operation of the circuit. The specifications for the logic analyzer are shown in the box.

Circuit Operation. Operation of the analyzer can best be understood by referring to the block diagram of Fig. 2. (The complete schematic diagram is shown in sections in Figs. 3 through 7.) The inputs to the system are the 8-bit signals (BIT 0 through BIT 7), the system clock, and the common or ground bus of the digital circuit under test. The data and clock inputs are buffered by *IC1* and *IC2*. The eight data signals are latched by *IC4* and *IC5* before loading into data memory *IC6* and *IC7*. This 16-word data memory is the "heart" of the analyzer. It stores sequential data words from the digital system under test.

The buffered clock signal is fed to half of *IC2* that can be set to operate on either the negative or positive edge, depending on the setting of *S10*. This signal is applied to the display control logic made up of *IC11* through *IC15*. The other input to the display logic is from comparator *IC3*. This circuit uses *S1* through *S8* to set up the desired trigger word, with the switches set to either 1, 0, or X as required. (The X is a "don't care" state.) When the comparator receives the input data word that matches its switches, a signal is passed to the display control logic. When *S11* is set to the POS TIME position, for example, data collection begins when the comparator detects the trigger word. After 16 clock pulses, data collection stops so that the memory contains the trigger word followed by the next 15 data words. In the NEG TIME position of *S11*, the memory stores data continuously until the trigger word occurs. When this happens, data collection is halted, leaving the memory with the 15 data words leading up to the trigger, plus the trigger word itself.

During the data collection period, the display control logic sends a signal to the blanking logic system made up of *IC22* through *IC24*, *Q1*, and *Q2* to inhibit the display. At the end of this period, the blanking signal is removed and a bit-by-bit scan of the memory contents is initiated. Scanning is accomplished by data multiplexer *IC16*, which is controlled by three of the eight output bits of horizontal control ROM *IC19*. Thus, even though the data memory provides a full 8-bit wide data word to the input of the multiplexer, only one bit at a time is sent to the 1-0 character generator made up of half of *IC20*, and *Q3*.

The character generator uses this information and the CRT beam positioning signals from the *IC20* horizontal D/A (di-

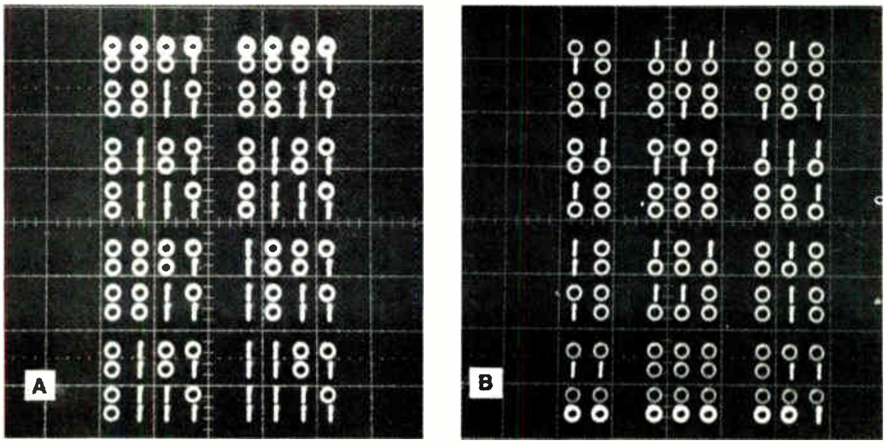


Fig. 1. Trigger word is intensified at top of hex display (A) with the 15 following data words. In octal display (B), trigger word is at bottom with the 15 data words leading up to it.

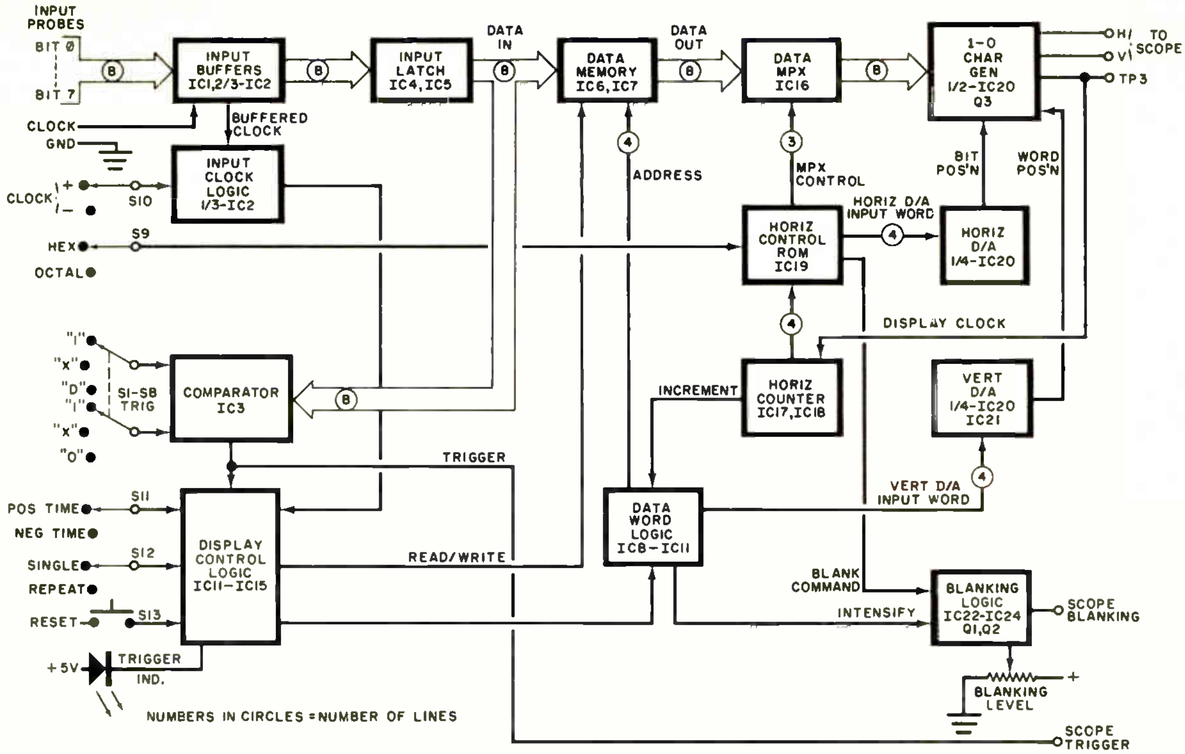


Fig. 2. Block diagram of analyzer shows basic signal routing.

PARTS LIST

C1—2200-μF, 16-volt electrolytic capacitor
C2—220-μF, 50-volt electrolytic capacitor
C3—10-μF, 50-volt electrolytic capacitor
C4,C5—150-pF, 10% disc capacitor
C6—15-pF, 10% disc capacitor
C7,C8,C9,C10—0.1-μF, 20% disc capacitor
C11—300-pF, 10% disc capacitor
C12—180-pF, 10% disc capacitor
C13—0.01-μF, 20% disc capacitor
D1,D2,D3—1N4002 or similar rectifier diode
IC1,IC2—74LS14 Schmitt-trigger input hex inverter (Fairchild 15-V input only)
IC3—74S15 open-collector output triple three-input AND gate
IC4,IC5,IC9—74LS175 quad latch
IC6,IC7—7489 RAM (16×4)
IC8—74LS161 four-bit synchronous counter
IC10—74LS83 four-bit adder
IC11,IC12,IC22—7400 quad two-input NAND gate
IC13,IC14,IC18—74LS73 dual JK flip-flop (do not substitute)
IC15—7473 dual JK flip-flop (do not substitute)
IC16—74LS151 8-to-1 multiplexer
IC17—74LS90 decade counter
IC19—8223 256-bit open-collector output PROM, or imilar
IC20—LM3900 quad current amplifier
IC21—7407 open-collector output hex buffer
IC23—74LS21 dual four-input AND gate
IC24—7406 open-collector output hex inverter
IC25—LM309K 5-volt regulator
J1 through J4—UG-625 BNC connector
LED1—Light-emitting diode (any color)
Q1,Q3—2N3904 silicon transistor
Q2—2N3905 silicon transistor
The following resistors ¼ watt, 5%:
R1 through R27—4700 ohms
R28—3300 ohms
R29—470 ohms
R30—1000 ohms
R31,R32,R33—8200 ohms
R34,R35,R36—2700 ohms
R37—1800 ohms
R38—2000 ohms
R39,R40—33,000 ohms
R41,R42—56,000 ohms
R43,R44,R45—22,000 ohms
R46,R47—24,000 ohms
R48,R49—130,000 ohms
R51,R52—180 ohms
R53—47,000 ohms
R54,R55—11,000 ohms
The following resistors ¼-watt, 2% tolerance:
R56—4700 ohms
R57—2400 ohms
R58—5100 ohms
R59—2700 ohms
R50—5000-ohm trimmer potentiometer (Spectrol 43P502 or similar)
S1 through S8—double-pole 3-position pc-mounted switch
S9 through S12—dpdt pc-mounted switch
S13—momentary-action dpst pc-mounted switch
S14—spst switch (panel mount)
T1—dual-winding power transformer with 16-volt CT and 22-volt winding
Misc.—Line cord, strain relief, mounting hardware, 3 feet of Spectra-Strip multicolored flat ribbon cable (26 gauge), 16-pin DIP socket, 16-pin flat ribbon DIP plug, heat sink for voltage regulator, hookup wire, solder, suitable case and mounting brackets, probe tip connectors, etc.
Note: The following items are available from Paratronics, Inc., Dept. 100, Los Gatos, CA 95030: Complete kit of parts, No. LA-100KIT, with tested IC's, power supply, pc board, case, and manual for $189.00. For separate parts: drilled double-sided printed circuit board, No. LA-100 PC, $29.95; programmed horizontal control ROM, No. LA-100ROM, $15.95; power supply, No. LA-100PS, $39.95; complete set of switches, connectors, hardware and data probes, No. LA-100HW, $39.95; Case, No. LA-100CASE, $39.95. Comprehensive applications and assembly manual, LA-100MAN $4.95. Please add 5% to above items for shipping and handling within U.S., 10% outside the U.S. California residents, add 6% sales tax.
Free copies of etching and drilling guides for the pc board, components-placement diagram, and horizontal control PROM programming information are available on request by sending a self-addressed stamped 9" × 12" envelope with 26¢ postage to: Popular Electronics, Dept. LA, One Park Ave., New York, NY 10016.

gital/analog) and the *IC20-IC21* vertical D/A circuits to write a 1 or 0 at the proper location on the CRT screen.

The horizontal D/A circuit receives its 4-bit data word from the horizontal control ROM, which receives its address data from the horizontal counter made up of *IC17* and *IC18*. It is the incrementing of the horizontal counter that causes the beam to move from right to left across the face of the CRT as the data word is written.

When the last bit is displayed, horizontal counter *IC17-IC18* "rolls over" to 0 and sends the increment signal to the data word logic *IC8* through *IC11*. This causes the address of the data memory to advance to the next word location and simultaneously sends a command to the vertical D/A converter that causes the CRT beam to move down one row in preparation for display of the next word. This process continues until all sixteen of the words of interest have been written on the CRT screen.

If *S12* is set to the SINGLE mode, the display control logic prevents the data memory from collecting new input data so that the same information is written on the CRT screen. The writing speed is fast enough so that a flicker-free "snapshot" of the memory contents is displayed. This snapshot will remain on the screen until the RESET switch *S13* is operated, at which time the TRIGGER LED comes on and the analyzer is armed to "capture" another 16-word data set. When *S12* is in the REPEAT mode, the display control logic provides an automatic reset signal after the display of each 16-word truth table.

Blanking between bits is provided by the remaining bit of the horizontal control ROM. This ROM performs three separate functions: control of the data multiplexer, control of the horizontal D/A converter, and blanking control. This use of a ROM as a controller is called "microprogramming," an efficient design technique used in a number of high-level computers. An "intensify" command from the data-word logic permits the trigger word to appear brighter than the other data words on the CRT screen.

The trigger pulse generated by comparator *IC3* occurs each time the trigger word appears. The resultant output pulse can be connected to the sync input of an oscilloscope anytime it is necessary to "look" at a specific signal in the circuit under test. This important feature is useful for troubleshooting equipment for glitches, timing, or intermittent problems that occur only during particular logic states.

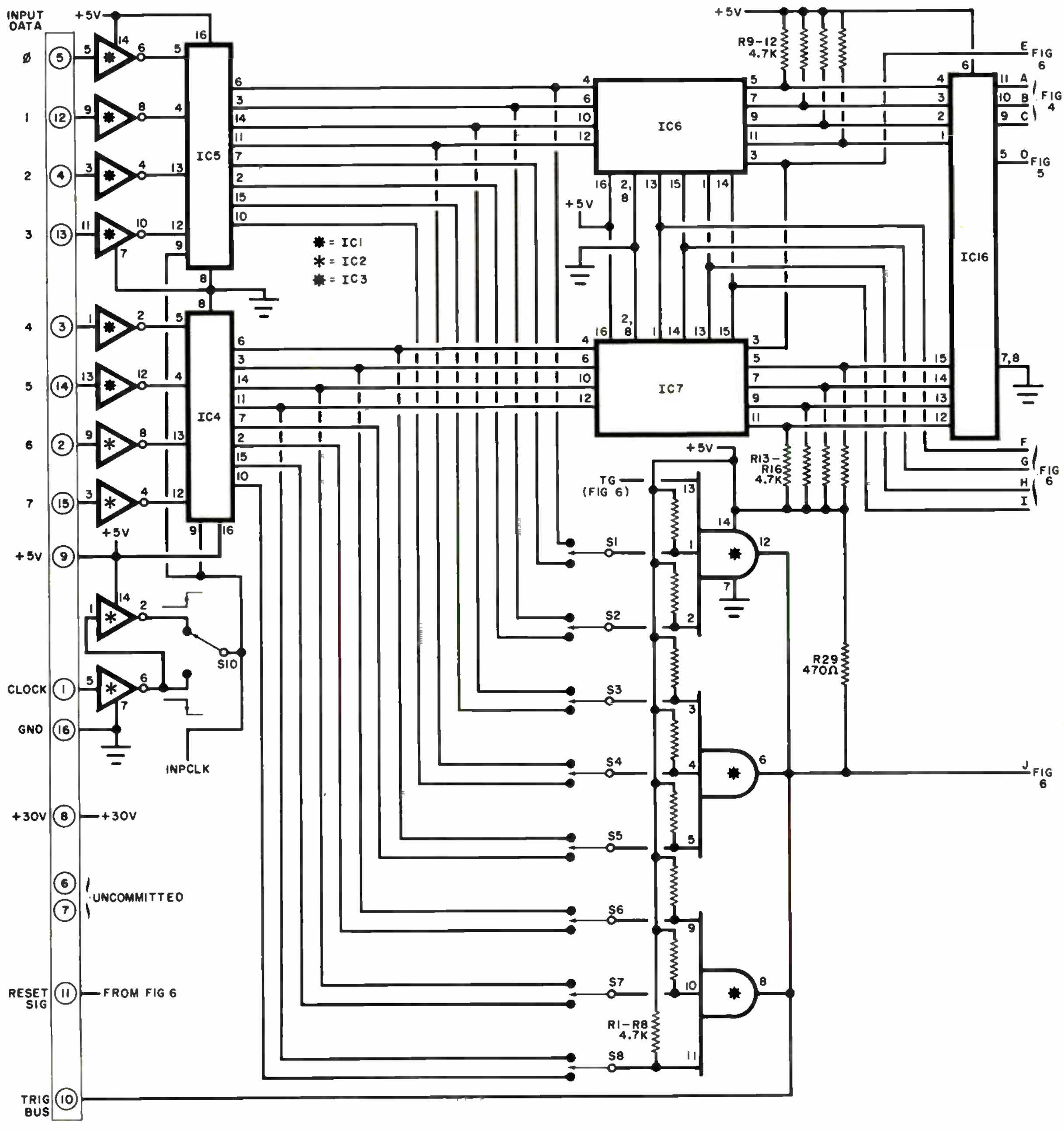


Fig. 3. Input buffers, trigger detector, memory, and data multiplexer.

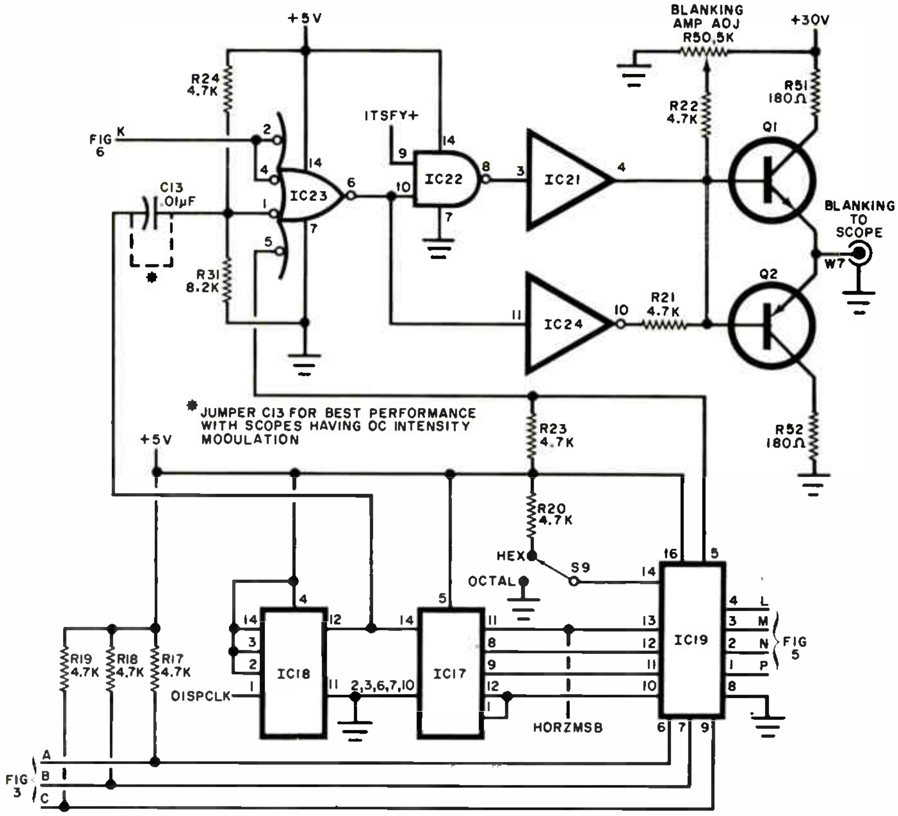


Fig. 4. Vertical control and blanking.

Construction. Because of the complexity of the circuit, and the critical placement of certain components, such as the 1-0 character generator, a high-quality, two-sided pc board with plated-through holes is highly recommended for this project. (See Note in Parts List for source from which etching and drilling guide, component layout diagram, and programming information for the horizontal control ROM can be obtained).

Both sides of the pc board contain components. Start assembly by installing the optional sockets for all the IC's on the side of the board labelled IC SIDE. Then mount all resistors, capacitors, and diodes, making sure that polarity-sensitive devices are correctly oriented.

Mount voltage regulator *IC25* in place, using silicone grease, or a thermally conductive gasket between its case and the board. A suitable heat sink should be used if the board is to be mounted inside a case. The case provided with the kit comes with a heat sink. Install the IC's, transistors, and blanking control *R50*. The IC side of the board should look like the assembled board shown in Fig. 8 when you are finished.

Turn the board over to the SWITCH SIDE and mount the 13 control switches. Then, making sure that its base is high enough off the board so that it can protrude through its hole on the top of the case, mount *LED1*. Install the 16-pin DIP socket for the flat ribbon probe cable. This completes the assembly of the board.

Mount the BNC scope connectors and on-off switch *S14* on the front of the case. Then drill a hole so that the blanking amplitude potentiometer mounted on the pc board can be adjusted from outside the case. The top of the case should be punched to accept the 13 switches and the LED indicator. Make sure that all switches can be moved into all their positions. Then put a slot in the front apron to accommodate the flat ribbon cable.

Mount the transformer wherever convenient at the rear of the case. Bring the three-wire ac line cord into the case through a strain-relief.

The input probe cable is made up of a 3′ (about 1-m) length of 10-conductor, flat-ribbon cable. The last conductor in the cable is coded black for ground. Connect the ribbon cable to the 16-pin DIP plug with the black cable (ground) mating with pin 16. The other conduc-

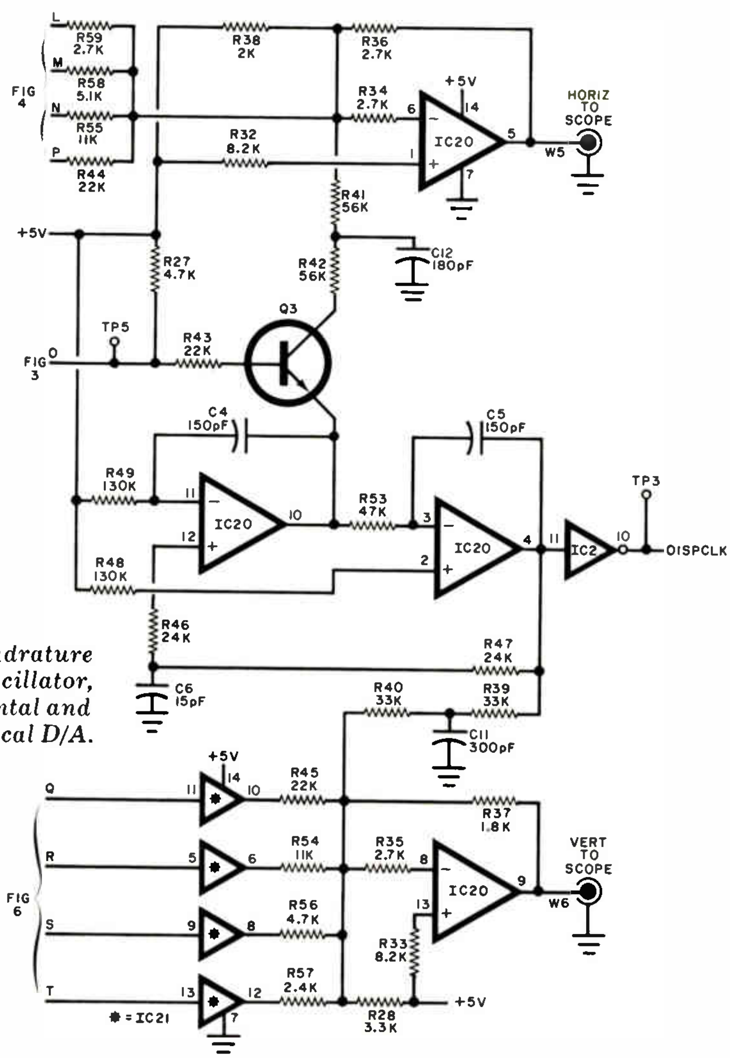


Fig. 5. Quadrature oscillator, horizontal and vertical D/A.

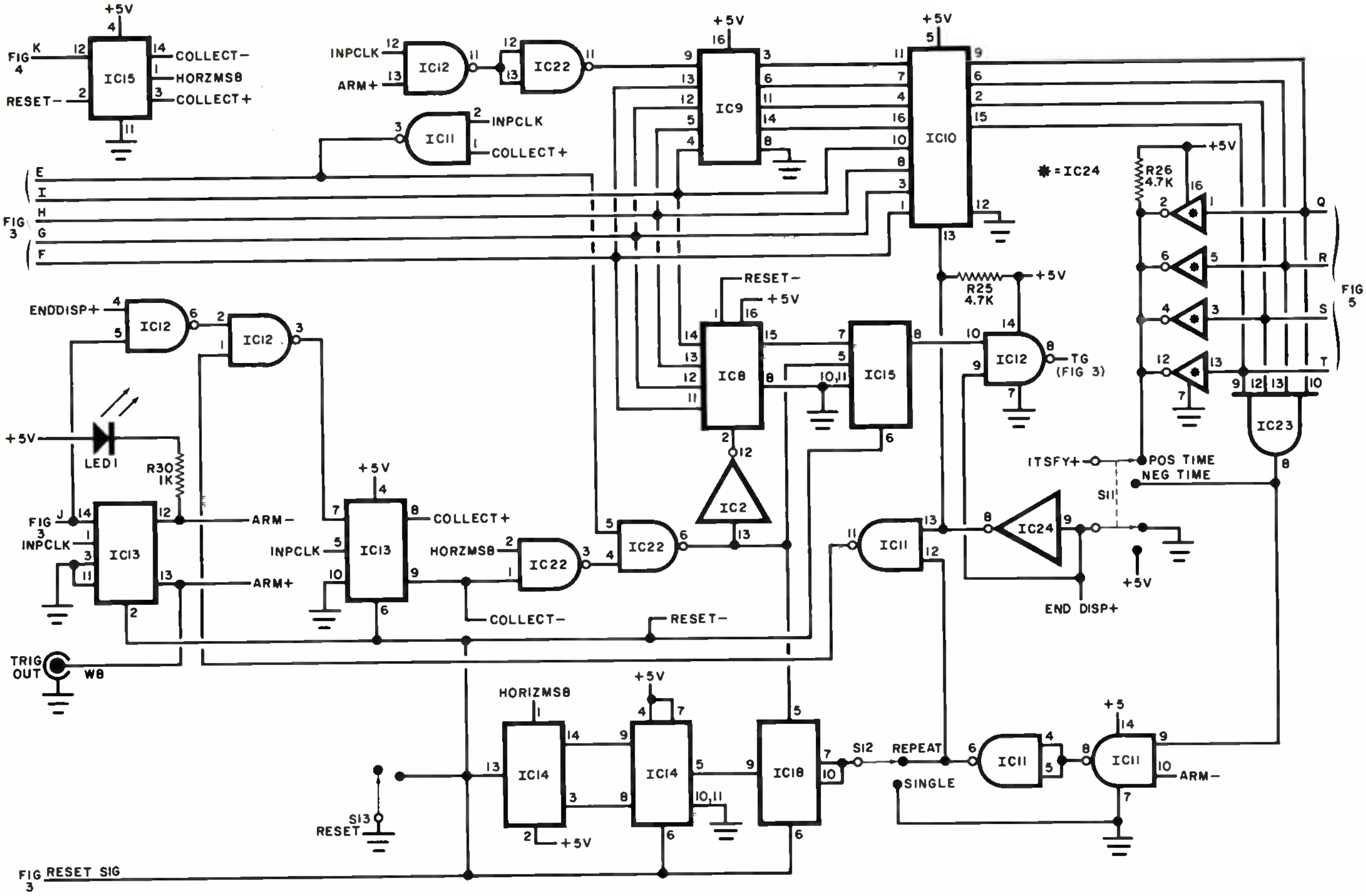


Fig. 6. Horizontal logic and mode control logic.

tors can go to the plug pins in a color-coding scheme.

At the free end of the ribbon cable, separate the 10 leads at least 4" (10.2 cm) and attach universal pin connectors. This type of connector will mate with conventional IC clips and wrapped-wire pins. If desired, ball clips or EZ hooks can be substituted. Plug the probe assembly connector into its socket on the pc board and pass the cable out of the case through its slot on the front apron and assemble the case.

Checkout. Plug the line cord into an ac outlet and turn on the power. Verify the output of the 5-volt power supply at *TP1* using a voltmeter. With an oscilloscope, check for the presence of an approximately 20-kHz clock at *TP3*.

Activate the blanking output at *W7* by placing the eight trigger switches to the "X" (center) position, selecting the SINGLE mode, depressing the RESET pushbutton to activate the front-panel LED, and flipping the clock polarity switch (*S10*) one or more times. This last step generates switch contact bounce that simulates an incoming clock pulse train. When the LED goes off, the blanking signal will appear at board pad *W7*.

Using the oscilloscope, measure the peak amplitude of the blanking pulse. This pulse can be adjusted up to approximately 30 volts by adjusting *R50*. ***Do not*** exceed the manufacturer-specified blanking requirements for your scope.

Set the scope vertical attenuator to approximately 0.5-volt/cm and check the D/A signals at *W5* (horiz) and *W6* (vert). The waveforms should appear as "descending staircase" waveforms, with the *W5* signal much higher in frequency.

Using the scope in the XY mode, connect the horizontal, vertical, and blanking outputs of the analyzer to the appropriate scope connectors. To assure a clean display, it is suggested that you use coaxial cables for the interconnections between the analyzer and scope.

Place the scope horizontal and vertical amplifiers to approximately 0.5-volt/cm. With the analyzer *input* probes unconnected, and the trigger switches still set to the "X" (center) position, depress the RESET pushbutton to illuminate the LED. When the clock polarity switch (*S10*) is flipped, a truth table should appear on the CRT. Adjust the scope controls until the display is centered on screen and fills most of it.

Adjust the focus and intensity controls to obtain a clear well-defined display.

One interesting feature of the Logic Analyzer is that it can be used to observe and learn its internal operation.

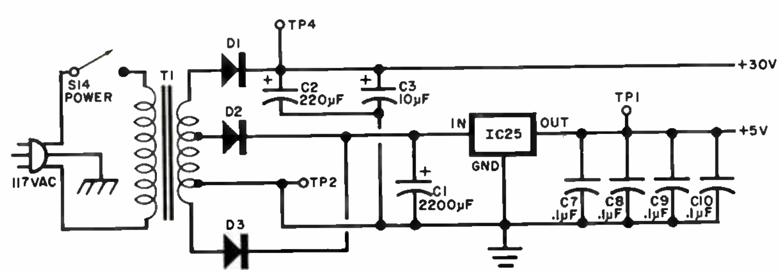


Fig. 7. Power supply is 5 volts, regulated.

For example, to see how the 4-bit address of the data memory sequentially changes during data collection, connect the first four data probes (BIT 0 through BIT 3) to pins 14, 13, 12, and 11 respectively, of *IC8*. The remaining four probes should remain unconnected. Connect the input clock probe to *IC2* pin 10 (or *TP3*) and set the analyzer controls to HEX, REPEAT, NEG TIME, and the clock-polarity switch to the falling edge position. Set the first four trigger switches (*S1* through *S4*) to 1111 and the last four to X. The selected trigger word should appear intensified at the bottom of the table, with the 15 prior binary address words listed in sequence above it.

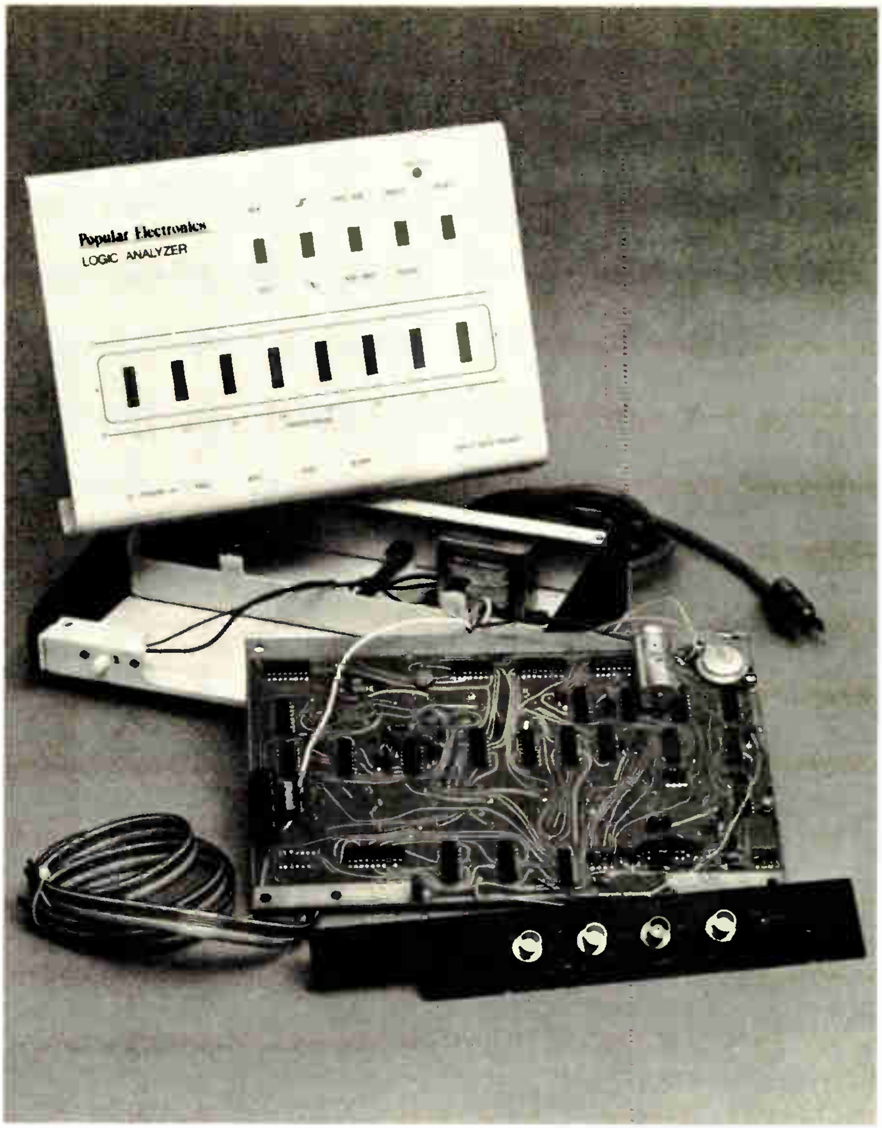


Fig. 8. Completed board and connector panel ready for assembly.

LOGIC ANALYZER SPECIFICATIONS

Trigger Word: 0 to 8 bits wide; selected by eight 3-position switches; choose 0, 1, or X (don't care).

Display Format: Sixteen sequential 8-bit words arranged in an octal or hexadecimal truth table.

Positive Time Display: Trigger word intensified at top of truth table with next 15 data words listed *below*.

Negative Time Display: Trigger word intensified at bottom of truth table with prior 15 data words listed *above*.

Single Mode: Continuous display of one 16-word truth-table until RESET button is activated.

Repeat Mode: Display of sequential 16-word truth tables.

Maximum Input Data Rate: 8 million bytes/second.

Input Clock: Provides timing reference for input data; selectable positive or negative clock edge.

Trigger Indicator: LED on front panel indicates when trigger word has occurred.

Trigger Output: Auxiliary scope sync pulse; generated when trigger word occurs.

Input Probes: Constructed of color-coded flat-ribbon cable terminated in universal pin connectors.

Input Load: Inputs are buffered for minimal loading and have hysteresis for noise rejection.

Power Supply: +5 volts at 700 mA, +30 volts at 25 mA.

Logic Family Compatibility: TTL, DTL, RTL, MOS, CMOS, to 15-volt logic swing.

Continue to familiarize yourself with the operation of the analyzer by triggering from different address locations and changing the settings of the display control switches. The probes can be moved to other portions of the circuit, such as the horizontal counter, display-control logic, and the data-word logic.

You can couple the first four probes to the counter (7490 or similar) in any digital counter circuit to examine the operation of that circuit. In fact, the right side of the hex portion of the display in Fig. 1 shows the output of a "good" 4-bit counter while the left side shows the output of a counter whose MSB (most significant bit) is stuck at 0. Using this technique, you can follow the signals through almost any digital circuit and be able to "snapshot" any block of pulses so that they can be examined for faulty pulses.

The analyzer shows its flexibility when used to check a computer or program. The octal portion of Fig. 1 shows the steps of a typical 8080 ADD and STORE program leading up to a branch instruction. The trigger word 00 000 001 is the branch address and is intensified at the bottom of the display.

In Closing. The Logic Analyzer we have described can be used for all types of testing and troubleshooting of digital circuits and systems. However, its true flexibility is revealed when the instrument is used for testing and troubleshooting digital-computer and other time-dependent circuits and systems. What makes our Logic Analyzer particularly attractive is its relatively low price. Used as an accessory to an existing oscilloscope and built from scratch, it costs only a fraction of commercially made logic analyzers on the market. ◇

NEW, PRACTICAL OP AMP CIRCUITS

BY SOL D. PRENSKY

including a differential pc board tester

AS WE WILL learn from the two very useful circuit applications described here, the operational amplifier (or op amp) can be used in strikingly different ways.

In-Circuit Current Testing. Since an op amp is basically a differential amplifier, it can be used in a unique metering circuit to determine the presence of current flow in a conductor—and approximately the amount of current—whether or not the conductor is a copper wire or a pc foil trace. This can be done without breaking the conductor.

Such a metering device can come in handy if you have a crowded pc board and you suspect one of the active elements (transistor, diode, or IC) is not working. Instead of risking pc board damage due to the heat required to remove the suspect semiconductor, or having to cut a trace to insert a meter, all you have to do is press a couple of sharp probe tips to the copper trace at (for example) the supply bus, and see if that particular element is drawing current, and if the magnitude of the current is within specifications.

The circuit for the current tester is shown in Fig. 1 in two forms—depending on whether you want to use a low-level (1-volt) dc voltmeter or a current meter as the readout.

Operation is based on the fact that at room temperatures, all conductors have

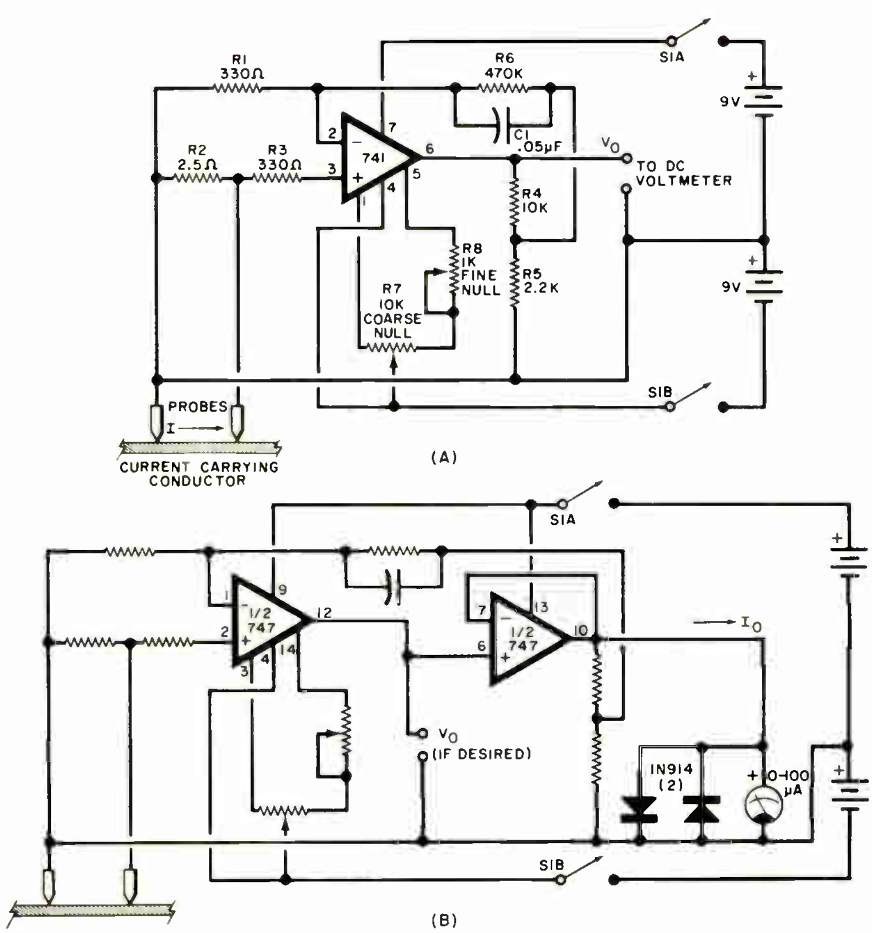


Fig. 1. Op amp in (A) measures slight voltage differential between two probes, amplifies it, and drives dc voltmeter. Addition of another op amp in (B) permits driving ammeter.

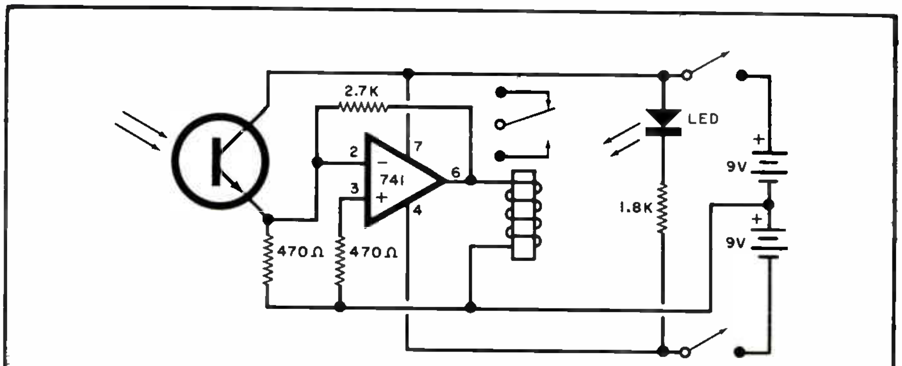


Fig. 2. Phototransistor and op amp unite to form light-sensitive relay driver that can be activated by a flashlight across the room.

some resistance (albeit small) and, when current flows through the conductor, there is a slight voltage drop between any two points along the conductor. Typically, such voltage drops are in the microvolt range; but with a voltage amplifier having a gain of 1000 or more, the minute voltage can be brought up to a reasonably measurable value.

The basic circuit shown in Fig. 1A uses an 8-pin mini DIP 741 with a dc voltmeter. This circuit takes advantage of the high common-mode rejection ratio (CMRR) of the op amp to reject any noise pickup voltages that are common to both input terminals. To keep the value of feedback resistor *R6* to a reasonable value, the output of the op amp (pin 6) drives the combination of *R4* and *R5* with the feedback taken from the junction of these two resistors. This voltage divider action in the feedback voltage multiplies the conventional gain (1 + *R6*/*R1*) by the voltage divider ratio (*R4* + *R5*)/*R5* to produce a theoretical voltage gain of approximately 1400 times 5.5 or 7700.

Since any residual offset voltage generated within the op amp is also multiplied by this factor, two offset (coarse and fine) potentiometers (*R7* and *R8*) are provided to trim the offset close to zero with the input probes shorted.

Figure 1B uses a 747 dual op amp package to drive a 100-μA meter that is used as the readout. Two diodes are used to protect the meter from accidental overloads. Operation of the circuit is otherwise the same as that of Fig. 1A.

In experiments with these circuits, probing a current-carrying conductor produced "ball-park" figures of 12 mV/inch or 12 μA/inch, for each milliampere of current flow. In general, it would be too much to expect either precision or close calibration results from such a general-purpose circuit as opposed to a specialized (and expensive) instrumentation amplifier. Nevertheless, the circuits of Fig. 1 do indicate current flow in a conductor and can be reasonably calibrated. For improved stability, a premium op amp such as Precision Monolithics OP2, National LF156, etc., may be used. Where currents greater than approximately 1.5-mA are concerned, the sensitivity of the circuit can be reduced by lowering the value of feedback resistor *R6*.

Photo Switch. The circuit shown in Fig. 2 illustrates how an op amp, in conjunction with a phototransistor and relay, can be used to activate a relay with a conventional flashlight used as the remote "transmitter." With the relay connected across the speaker coil leads, this circuit makes an excellent "commercial killer." The op amp's pinout is for an 8-pin mini DIP.

The phototransistor is connected to the op amp to produce an inverter amplifier gain of about 50. For most "across the room" distances, using a typical flashlight, the output of the op amp will be sufficient to energize a sensitive relay. (A Sprague 401-A050-A05 requires about 6 mA at 3 volts, for example.) If any other type of relay is to be used, keep in mind that the op amp can deliver only about 10 mA at best, so if higher currents are required, a transistor relay driver must be used.

Although almost any type of sensitive phototransistor can be used, the prototype involved half of an opto-isolator (LED and phototransistor in one package) that had been sawed in half. In these units, the phototransistor sensitive area is protected from ambient light by a built-in IR filter so that the quiescent current before flashlight illumination is practically negligible. The LED power-on indicator requires about 10 milliamperes for operation and may be eliminated if it is not required. ◇

BY DAVID L. MATTIS

DIGITAL FREQUENCY READOUT FOR SHORTWAVE RECEIVERS

Programmable counters provide direct display of received frequency to 30 MHz.

ALTHOUGH "beginner's" shortwave receivers provide an inexpensive entry to a fascinating hobby, they do have limitations. A major one is poor dial calibration, which makes monitoring and QSL procedures difficult.

Fortunately, external circuitry can compensate for this limitation. The digital frequency display project presented here will allow the user to determine a transmitter's frequency to the nearest kilohertz on a bright, stable LED display. It accepts an input signal from the receiver's local oscillator, converts the signal to a TTL-compatible form which is then counted. Programmable counters are pre-loaded to compensate for the receiver i-f, thus allowing direct readout of the received frequency. The project will work with most single- and multiple-conversion receivers from the longwave broadcast band through 10 meters (30 MHz). Total project cost is about $110.

About the Circuit. The schematic diagram of the digital frequency readout is shown in Fig. 1. An input signal from the receiver's local oscillator is coupled through *C1* and *R1* and applied to the gate of *Q1*, an n-channel FET. Diodes *D1* and *D2* clip signals exceeding + or −0.7 volt, protecting the FET from excessive signal voltages. The output of *Q1*, developed across *R3*, drives emitter follower *Q2*, an npn bipolar transistor. This combination results in a two-stage amplifier presenting a high input impedance to minimize local oscillator loading and a low-impedance output at TTL levels. Ferrite beads *L1* and *L2*, together with disc capacitor *C3*, are used for r-f decoupling on the +5-volt line.

A two-stage Schmitt trigger composed of NAND gates *IC1A* and *IC1B* converts the amplified local oscillator signal into a square wave, which is then gated by *IC1C*. The gating interval (10 milliseconds) is provided by a crystal controlled time base and divide chain. A 4-MHz square wave generated by *IC19* is first divided by 4 by the flip-flops in *IC2*. The 1-MHz output of the second flip-flop is further divided by two dual decade counters (*IC3* and *IC4*) to yield a 100-Hz reference signal. The second decade counter in *IC4* is wired as a bi-quinary counter to provide a symmetrical square-wave output signal. This counter also supplies three control signals to *IC5*, which generates the latch and preset control pulses at the end of each counting (gate) interval which govern the counting and display IC's.

For a 10-ms counting interval, a 50-Hz gating signal is required. It is obtained by dividing the symmetrical 100-Hz output of *IC4* by two. This is performed by *IC6*, a JK flip-flop. The 50-Hz square

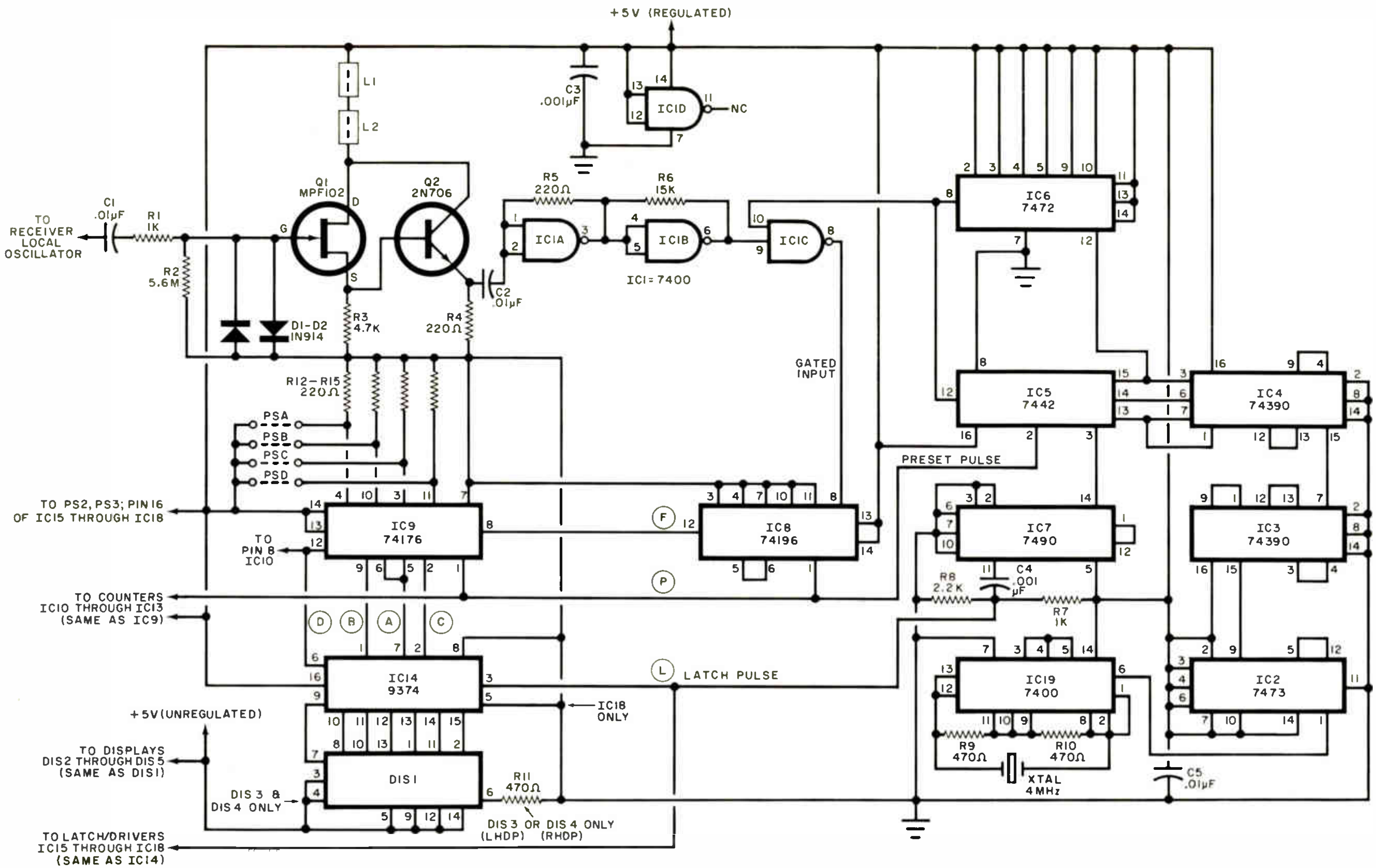


Fig. 1. Schematic diagram. For simplicity, only one decade of display is shown.

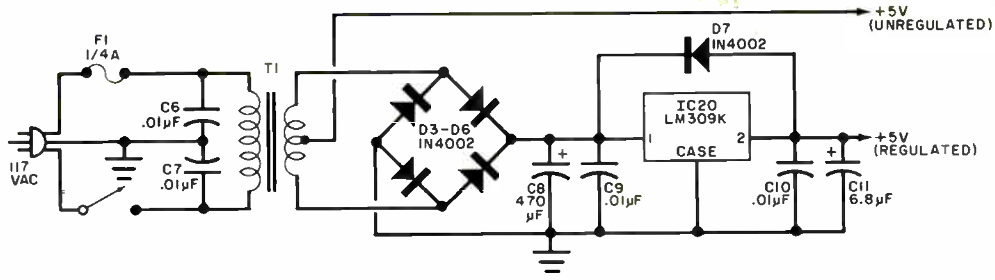


Fig. 2. Schematic diagram of the power supply.

wave is applied to both *IC5* and to one input of NAND gate *IC1C*. When the gate signal is high (for 10 ms), *IC1C* passes an inverted version of the squared local oscillator signal to counters *IC8* through *IC13*. During the 10-ms "low" period, *IC5* produces the latch and preset control pulses.

Even though the counters resolve the local oscillator frequency to the nearest 0.1 kHz during the 10-ms gate interval, the received frequency is displayed only to the nearest kilohertz. The use of the undisplayed 0.1-kHz counter (*IC8*) eliminates the bothersome "bobble" in the least significant digit in other frequency readouts, thus providing a steady frequency display. A 1-kHz bobble occurs only when the counter is at the borderline between two frequencies—for example, 6.1649 and 6.1650 MHz.

Counter *IC8* is specified as a 74196 programmable counter IC, but *IC9* through *IC13* are specified as 74176 IC's. The 74196 is used to insure reliable performance to 30 MHz. However, a hand-picked 74176 which can function up to 30 MHz can be used in place of the costlier 74196. The preset feature of these IC's permits the display of the received signal's frequency, even though the counters are working with the local oscillator frequency, which is actually higher or lower by the intermediate frequency of the receiver. Counters *IC9* through *IC13* can be pre-loaded with any value determined by programming jumpers or switches at points *PSA* through *PSD*. The counters are loaded with this number at the reception of the preset pulse prior to the initiation of each counting interval.

At the end of every tenth counting cycle, a latch pulse appears at the output (pin 11) of *IC7*. It is then differentiated by *C4*, *R8*, and *R7* and applied to latch/decoders *IC14* through *IC18*. When this happens, the binary information accumulated in the programmable counters is transferred, stored, and decoded for display on seven-segment LED readouts *DIS1* through *DIS5*. The latch pulse is generated by *IC5*. Although preset pulses are produced after each counting interval, only one in every ten counts is transferred to the 9374 latch/decoders (*IC14* through *IC18*). This is so because *IC7* divides the input signal from *IC5* to produce a latch pulse with a frequency of 10 Hz.

As a result, the display flickers noticeably when the frequency is changing. Also, blurring and readout of spurious eight's—common problems with seven-segment displays—do not occur during a shift in frequency. Rather, the 10-Hz latch rate permits the display to track each frequency change with legible readout values.

The project's power supply (Fig. 2) is

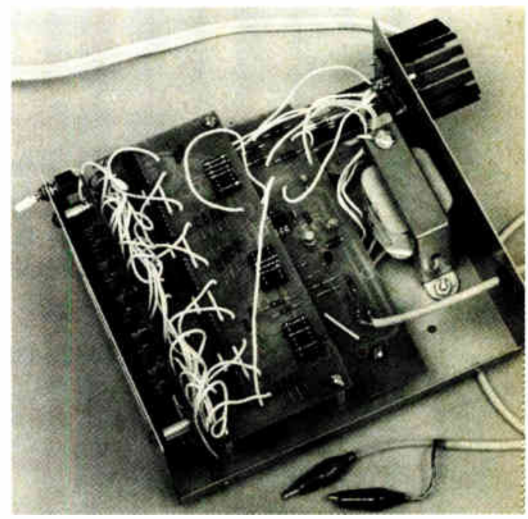


Fig. 3. Photo of prototype.

PARTS LIST

C1,C6,C7,C9—0.01-µF, 1000-volt disc ceramic capacitor
C2,C5,C10—0.01-µF, disc ceramic capacitor
C3,C4—0.001-µF disc ceramic capacitor
C8—470-µF, 25-volt electolytic capacitor
C11—6.8-µF, 25-volt tantalum capacitor
D1,D2—1N914 switching diode
D3 through D7—1N4002 rectifier
DIS1 through DIS5—MAN-1 or MAN-64 common anode seven-segment LED display
F1—¼-ampere, 250-volt, 3-AG slow-blow fuse.
IC1,IC19—7400 quad 2-input NAND gate
IC2—7473 dual JK master-slave flip-flop
IC3,IC4—74390 dual 4-bit decade counter (Texas Instruments)
IC5—7442 BCD-to-decimal decoder
IC6—7472 JK master-slave flip-flop
IC7—7490 decade counter
IC8—74196 45-MHz presettable decade counter (see text)
IC9 through IC13—74176 25-MHz presettable decade counter
IC14 through IC18—F9374PC latch/7-segment decoder/driver (Fairchild)
IC20—LM309K 5-volt regulator
L1,L2—Ferrite bead (⅛" × ⅛" or 3.2 × 3.2 mm)
Q1—MPF102 n-channel JFET
Q2—2N706 npn transistor
The following resistors are ¼-watt, 5% tolerance:
R1,R7—1000 ohms
R2—5.6 megohms
R3—4700 ohms
R4,R5,R12 through R29—220 ohms
R6—15,000 ohms
R8—2200 ohms
R9 through R11—470 ohms
S1—SPST miniature toggle switch
PS1 through PS3—DIP switches (see text)
T1—12.6-volt, 1.2-ampere center-tapped transformer
XTAL—4-MHz, 0.0025% tolerance crystal
Misc.—Suitable enclosure (7¼" × 6¼" × 2¾" or 18.4 × 15.9 × 7 cm suggested); red Plexiglas bezel (5¼" × 1" or 13.3 × 2.5 cm); transistor sockets; IC sockets or Molex Soldercons; heat sink compound; TO-3 heat sink (1¼" or 3.2-cm fins); metal spacers; machine hardware; line cord; coaxial cable; rubber grommets; hookup wire; solder; fuseholder; etc.

Note: The following are available from Mattis Electronics, Box 162, Morton Grove, IL 60053. Set of three etched, drilled and plated pc boards (No. SW-1), $18.95; 4-MHz precision crystal (No. SW-2), $9.95; Five F9374PC latch/decoder/driver IC's (No. SW-3), $15.95; Kit of parts including three pc boards, crystal, IC's, discrete semiconductors and pc board components (No. SW-4), $74.95; Complete kit of parts including enclosure and power-supply components (No. SW-5), $109.95. All prices include shipping charges within the USA. Illinois residents add 5% sales tax.

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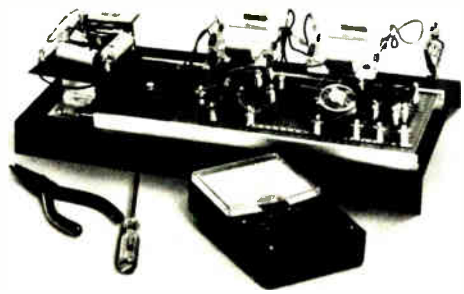

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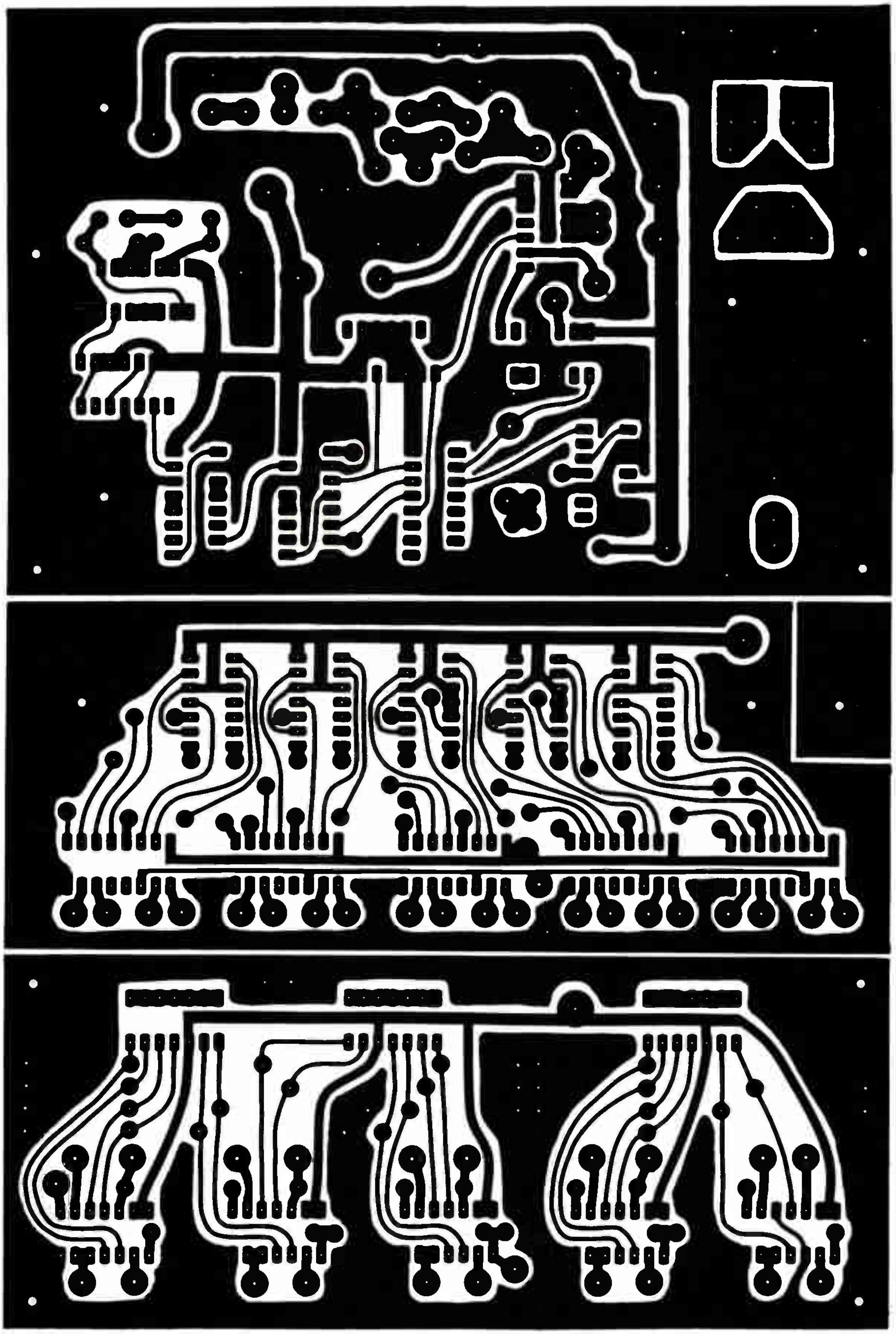

Fig. 4. Etching and drilling guides for main (top), display (center), and counter (bottom) pc boards.

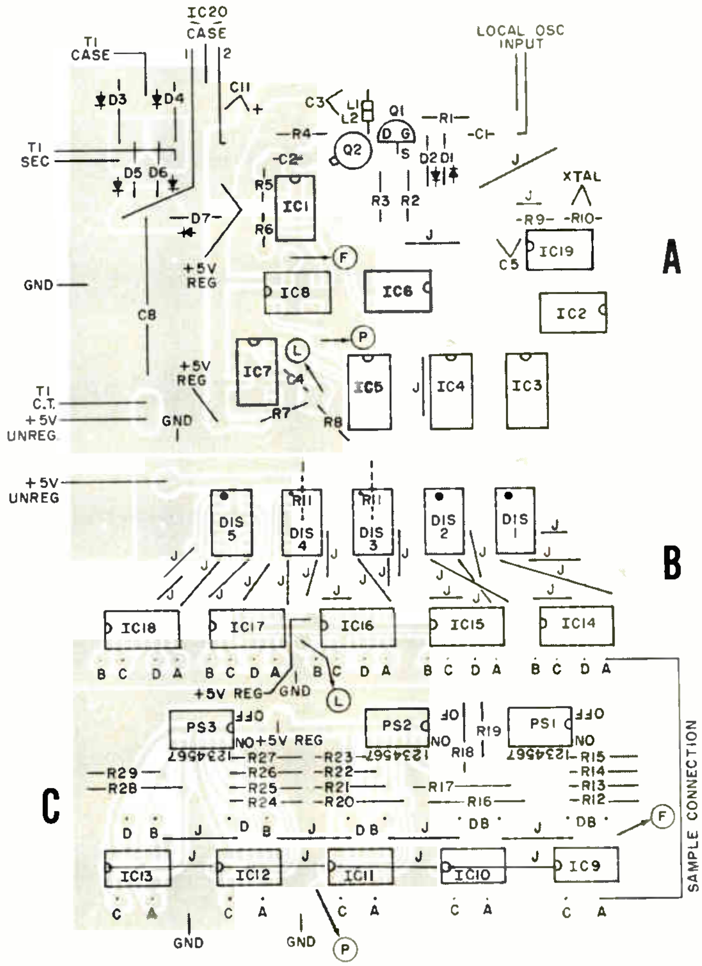

Fig. 5. Parts placement guides for main (top), display (center), and counter (bottom) pc boards.

a combination full-wave and bridge rectifier using a single 12.6-volt, center-tapped transformer. Two dc outputs are provided. The bridge rectifier (*D3* through *D6*) delivers pulsating dc to *C8* which acts as a filter. The filtered dc (+16 volts) is then applied to *IC20*, an LM309K voltage regulator, which is protected against transients by *D7*, *C9* and *C10*. A well-regulated +5-volt dc output is thus provided for the TTL IC's and the input circuit.

Another +5-volt dc source is derived from the center tap of *T1*, *D3* and *D4*. The three components form a full-wave rectifier, but its output is unfiltered and unregulated. This output is used to power the seven-segment readouts (*DIS1* through *DIS5*). The unfiltered, pulsating dc has a ripple frequency of 120 Hz, which is great enough to prevent display flicker and results in a display brightness comparable to that obtained with a steady dc source. Removing the display current demand from the regulated supply substantially reduces the amount of heat generated in the power transformer and voltage regulator IC, but causes no adverse effects. Display segment current limiting is performed internally by the 9374 IC's which also contain internal latch memories. No external current limiting resistors or bistable latch IC's are required, as is often the case with other decoder/driver chips.

Construction. The project should be assembled using printed circuit boards and IC sockets or Molex Soldercons. Transistor sockets (standard and TO-3) are also recommended for *Q1*, *Q2*, and *IC20*. The author used three pc boards in his prototype (Fig. 3). The boards can be interconnected with short lengths of No. 20 stranded hookup wire. Suitable etching and drilling guides are shown in Figs. 4 and 5 (A, B, and C) for the Main, Display, and Counter boards, respectively. Use the minimum amount of heat necessary for good solder connections. Be sure to observe polarities and pin basings of discrete semiconductors, IC's, and electrolytic capacitors.

Figure 3 shows how the boards and power supply components were mounted in the project enclosure. The Counter and Main pc boards were secured to the bottom of the cabinet using ¾-inch (1.9 cm) threaded metal spacers, while the Display board was mounted behind a bezel on the front of the case using ½-inch (1.3-cm) threaded metal spacers. Voltage regulator *IC20* must be properly heat sinked and mounted on the exterior of the enclosure's rear panel. Use heat sink compound to insure proper heat transfer, and be sure to connect a length of hookup wire between the regulator socket's center ground bus and the Main pc board's ground. Also, make sure that *IC20's* mounting screws are in firm contact with the IC's case and the TO-3 socket's ground bus. The author also recommends grounding the power transformer's case.

Because TTL IC's are high-current switching devices, the steep edges of their output waveforms contain large amounts of r-f energy. Unless certain precautions are taken, this r-f will produce high noise levels at the receiver output. First, a metal case must be used—but it must also be perforated or vented to allow heat to dissipate. Second, both the project's and receiver's enclosures must be tied to a good earth ground. Third, both sides of the ac power line must be bypassed with 0.01-μF disc ceramic capacitors (*C6* and *C7*).

Checkout and Use. A typical receiver's local oscillator is shown schematically in Fig. 6. Whether the receiver uses a FET, tube, or transistor oscillator, the point where the local oscillator signal must be tapped off is the same—at the capacitor coupling the output of the oscillator to the mixer. The author suggests that the signal be sampled on the local oscillator side of the coupling capacitor. For the following three popular SW receivers, the appropriate points are: Realistic DX-160, junction of *C12* and *R32* (drain of *Q8*); Lafayette HA-600A, junction of *C6* and *R21*; Heathkit GR-78, junction of *C308*, *R203*, and *R204*. (Note: if you are using a tube-type receiver, *beware of high voltage!*) The connection should be made with small-diameter coaxial cable such as RG-58-U. You might find it desirable to mount an RCA phono jack on the back of receiver and bring the coax from the local oscillator output to this point. Then you can interconnect the display and receiver with a short coaxial jumper terminated with an RCA phono plug. Alternatively, you can terminate one end of the jumper with small alligator clips, as

TABLE A
CONVERTING DECIMAL NUMBERS TO BCD

Number	BCD 8	4	2	1
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1

TABLE B
COUNTER BOARD PROGRAMMING ASSIGNMENTS

Programming section	PS3		PS2		PS1
Programming input number	7654321		7654321		7654321
BCD designation	81-8241		8241-82		41-8241
Actual programming*	1111001		0011100		1010010
Counter controlled	IC13	IC12	IC11	IC10	IC9
Frequency displayed (receiver off)	9	9	.5	4	4 MHz

*0 = no jumper or open switch (OFF),
1 = jumper or closed switch (ON).

was done with the prototype (Fig. 3). The clip would then be attached to the proper tie point within the receiver.

The counters will be programmed with DIP switches (seven spst switches mounted in a DIP) or with wire jumpers on the counter board. If you are using DIP switches, make sure that all switches are in the OFF position. If wire jumpers are to be used, do not install any of them yet.

Turn the power switch (*S1*) on. The display should read 0.000 with the second zero to the left of the decimal point blanked off. Insert No. 22 solid jumpers across the IC sockets at the number 5 positions of *PS1* and *PS3* and at the number 3 position of *PS2* (see component placement guide). Or, if DIP switches are used, close the switches at these positions. Then momentarily insert a jumper across the other IC socket positions and verify that the corresponding counter responds according to Table B. For DIP switches, this is accomplished by turning the remaining switches on and off. As voltage is applied to each programming input, the BCD value of that input will be displayed on the corresponding LED readout.

After completing the checkout procedure turn the power off and connect the hot and ground sides of the coaxial jumper to receiver's local oscillator output and chassis, respectively. Turn on the receiver and tune it to WWV or

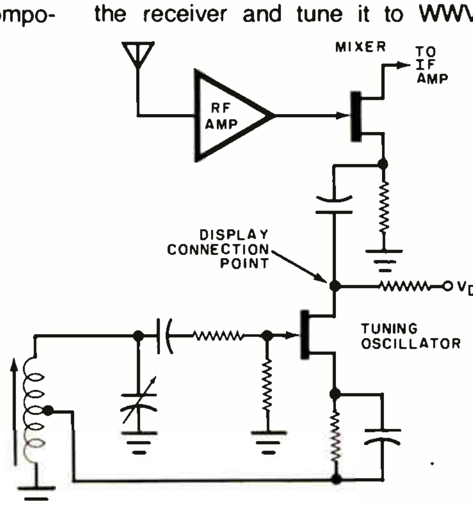

Fig. 6. Typical local oscillator circuit

WWVH at 5 MHz. Tune the receiver to the station's carrier as accurately as possible. You can best do this by turning on the bfo—if your receiver has one—and zero beating the carrier. If no bfo is available, tune in the carrier for maximum signal strength. Now turn the project on. The readout will display a frequency somewhat above or below that of WWV's carrier. Subtract the number display from 105.000 to obtain the number needed for counter programming. For example, if the display reads 5.456 MHz, subtract 5.456 from 105.000. You will obtain a remainder of 99.544, which is then programmed into the counters in BCD form as illustrated in TABLES A and B.

The display should now read 5.000 MHz. Programming can be verified by tuning in an AM broadcast station of known frequency for maximum signal strength. Observe the displayed frequency. If it is off by 1 kHz or so, adjust the programming of *IC9* so that the correct frequency is displayed. The project is now properly programmed for receivers with a fixed i-f for all bands and no further adjustments are needed. When the receiver is turned off but the project left on, the readout will display the number you have programmed into the counters.

Some multiple conversion receivers, such as the Heath GR-78, will require different programming for different bands. Thumbwheel switches with BCD outputs can be mounted on the front panel and used in place of jumpers or DIP switches. This will greatly speed programming.

The project is *not* suitable for use with those multiple conversion receivers having second (lower) i-f's with variable frequency (local) oscillators operating *below* the first i-f. In such a case, the tunable oscillator's output frequency is highest when the receiver is tuned to the lowest frequency within a given band. Conversely, the oscillator's output frequency is lowest when the receiver is tuned to the highest frequency within the band. However, receivers using this type of i-f generally have dial mechanisms with wide bandspread and frequency readout to the nearest one or five kilohertz. Therefore, they do not need the kind of improvement this project can provide.

For inexpensive SW receivers, however, this project is an enormous asset. Not only will it greatly enhance the user's enjoyment of shortwave listening, it will also make station tuning and logging a "breeze." ◇

Current "Foldback" Protects Power Supply & Load

BY JEROME MAY

How a 723 IC can be used for both load and supply regulation.

WHILE MOST modern power supplies are designed to protect themselves against overloads and short circuits, the protection often doesn't go far enough. In many modern projects—particularly those involving computers—the load on the power supply can cost a great deal more than the supply itself. A practical power supply for modern projects, then, should protect both itself and the load. With an inexpensive 723 precision voltage regulator IC and a handful of components, you can build such a "full-protection" power supply.

Unlike most other regulator IC's, the 723 can be programmed to automatically drop the output current to a small fraction of maximum under overload and short-circuit conditions. This "foldback" current is similar to conventional current limiting up to the maximum current rating of the supply. But while a conventional current limiter will keep right on pumping maximum current into the load, the foldback circuit will go to maximum and then signal the series-pass transistor in the 723 to drop the output current to a mere fraction of its capability.

The actions of both conventional and foldback limiting are graphically illustrated in Fig. 1. Note the downward slope of the short-circuit current, I_{SC}, for the foldback characteristic as opposed to the zero slope of the line for conventional current limiting.

The functional diagram of the 723 is shown in Fig. 2. Pin designations on the diagram are for the dual in-line (DIP) configuration of this IC. Below the diagram are the pin designations for the round (TO-100) configuration of this IC. Some of the IC's more important maximum specifications are: 40 V from +V and V_C to −V; 150 mA maximum current for internal series-pass transistor; 900 mW DIP (800 mW round) maximum power dissipation; 0.001-µF frequency-compensation capacitor; 0.03% regulation at load; input-output voltage differential, 30 V minimum. On the TO-100, pin 5 is connected to the case.

Regulation Differences. A basic current limiter using a 723 is shown in Fig. 3. This circuit can be programmed to operate in either a low- (2-to-7-) or high- (7-to-35-) volt range by proper selection of voltage-divider resistors *R1* and *R2*. (Note: To avoid confusion during calculations, two *R1-R2* divider networks are shown. The resistor values calculated will be the same in both divider networks.)

If only the high-voltage range is desired, switch *S1* goes to HI, and V_{REF} goes to the noninverting, or +, input of the error amplifier in the 723 through a 5000-ohm resistor (*R4*). The output current of the IC is sensed by *R3* and fed to the *Q2* current sense amplifier in the 723. When the potential across *R3* exceeds about 0.7 volt, *Q2* diverts any increase in base current from the error amplifier to *Q1* inside the IC. This limits the available current from the 723 to the IC's rated maximum. Unfortunately, if the load resistance goes to zero, this maximum current will still be pumped into the load.

Now, consider the foldback modification shown in Fig. 4. (This circuit is identical to the Fig. 3 circuit except that *R5* and *R6* have been added as shown.) The ratio of *R5/R6* shifts the operating point of *Q2* inside the 723 so that, when the voltage drop across *R3* biases on *Q2*, any increase in the drop across *R3* (beyond the point at which the transistor first starts to conduct) diverts increasing current away from the base of the 723's *Q1* transistor. Thus, the output current "folds back" after the maximum programmed current is obtained. Note, however, that because a finite voltage drop is required to keep the 723's *Q2* transistor conducting, the output current can never go to zero; it simply folds back to a small fraction of the maximum current the IC can deliver.

Calculations. To program a 723 for the current-foldback regulator, first determine values for *R1* and *R2* to fix the output voltage. To determine the foldback current ("knee" in Fig. 1), *R3* is calculated after selecting convenient values for *R5/R6*.

If the output is to be less than 7 volts, the *R1A-R2A* divider network goes directly to the 723's V_{REF} input with *S1* in the LO position as shown in Fig. 3. The basic formula from which to work is $V_O = V_{REF}\, R2A/(R1A + R2A)$, from which we obtain $R1A = R2A(V_{REF} - V_O)/V_O$ and $R2A = V_O R1A/V_{REF} - V_O)$. Assume that the desired V_O = 5 volts and that V_{REF} = 6.2 volts. Select an arbitrary value of several thousand ohms—say, 10,000 ohms — for *R2A*. Therefore, $R1A = 10{,}000(6.2 - 5)/5 = 2400$ ohms. Hence, for a 5-volt output, the values of *R1A* and *R2A* should be 2400 and 10,000 ohms, respectively.

Should you desire an output of greater than 7 volts, *S1* should be set to HI, which bypasses *R1A* and *R2A* by switching in *R4* and placing the *R1B-R2B* divider in the circuit. The basic for-

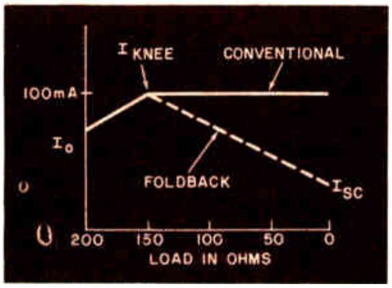

Fig. 1. Dashed line shows downward slope of short-circuit current for the foldback characteristic.

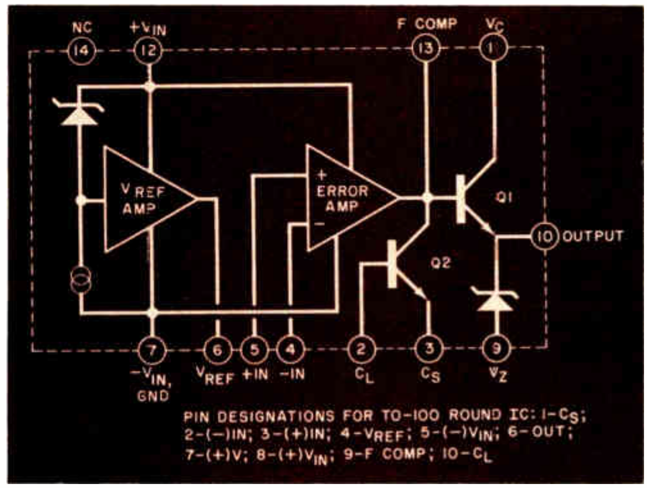

Fig. 2. Functional diagram of the DIP 723. Pin designations for TC-100 are also given.

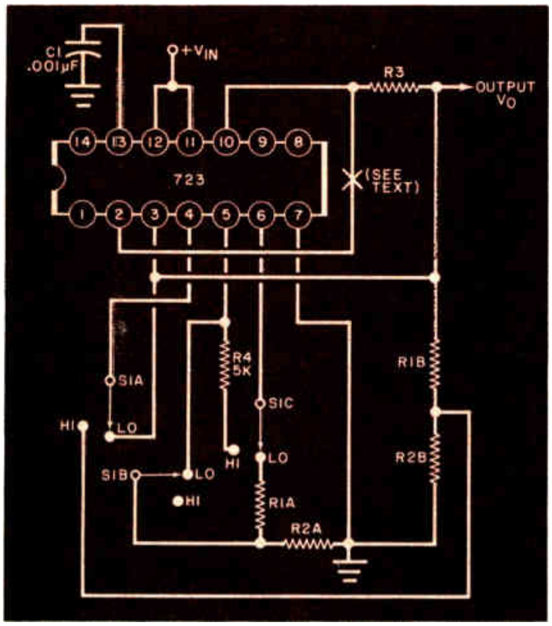

Fig. 3. Basic current limiter can operate in either a low (2 to 7 volts) or high (7 to 35) range by proper selection of resistors R1 and R2. See Fig. 4 for added circuit at point "X".

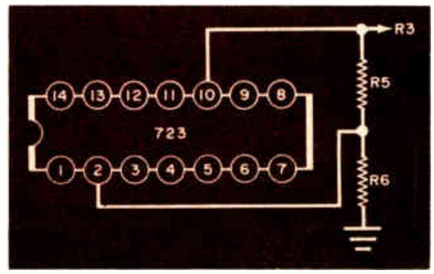

Fig. 4. Voltage divider at "X" in Fig. 3 shifts operating point.

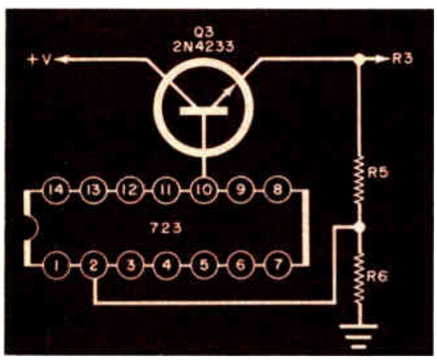

Fig. 5. Use of an npn series-pass transistor to increase capacity.

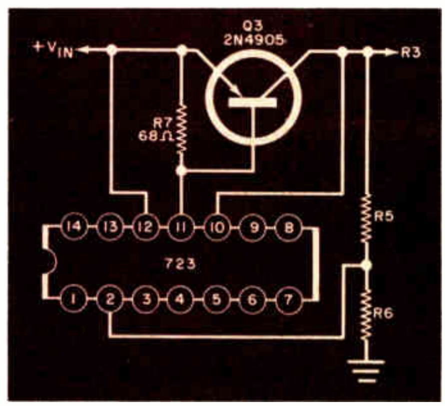

Fig. 6. If a pnp transistor is used as series-pass element, add a bias resistor.

mula here is $V_O = V_{REF}$ (*R1B* + *R2B*)/*R2B*. Therefore, *R1B* = *R2B*($V_O - V_{REF}$)/V_{REF} and *R2B* = V_{REF} *R1B*/($V_O - V_{REF}$). This time, let us assume that the output is to be 15 volts and that V_{REF} remains the same at 6.2 volts. Again arbitrarily selecting a value of 10,000 ohms for *R2B*, *R1B* = 10,000 (15 − 6.2)/6.2 = 14,193 ohms.

Now, select the maximum current the supply is to deliver to the load. For example, assume that at V_O = 15 volts, you want an I_{MAX} of 100 mA. Now, select values for *R5* and *R6* (Fig. 4 shows how these components connect into the basic circuit). Assume that *R5* and *R6* have values of 1000 and 10,000 ohms, respectively. (Note: The smaller the ratio of *R5/R6*, the lower will be the resistance for *R3* to provide the required limiting. Bear in mind that the short-circuit current will be reduced for larger values of *R3*.)

From the equation I_{MAX} = [V_O R5+0.7(R5 + R6)]/R3R6, we obtain R3 = [V_OR5 + 0.7 (R5 + R6)]/I_{MAX} R6. Therefore, R3 = [15(1000) + 0.7(1000 + 10,000)]/(0.1 × 10,000) = 22.7 ohms. Since the formula for short-circuit current is I_{SC} = 0.7(R5 + R6)/R3R6, I_{SC} = 0.7(1000 + 10,000)/(22.7 × 10,000) = 35 mA. This is about a third of the actual current the 723 supply is designed to deliver. The short-circuit current can be reduced, but then new values of the ratio R5/R6 will have to be selected to determine the 100-mA foldback point.

A current of 35 mA at 15 volts is a hefty half-watt to dissipate on an IC chip. Therefore, a better approach to the design of the supply would be to use an external series-pass transistor with adequate heat-sink protection. The circuit utilizing an npn series-pass transistor (*Q3*) is shown in Fig. 5. If all you have available is a pnp transistor, you can use it, along with an additional bias resistor (*R7*), as shown in Fig. 6. In either case, if the circuit is to be used to power a particular project, be sure the transistor's voltage, current, and power dissipation figures are capable of accommodating the load at full power. ◇

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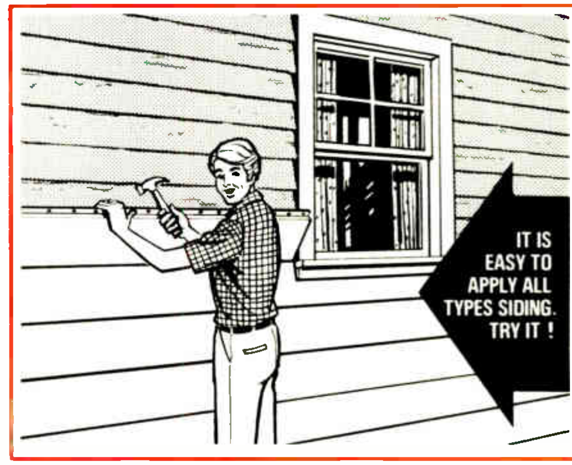

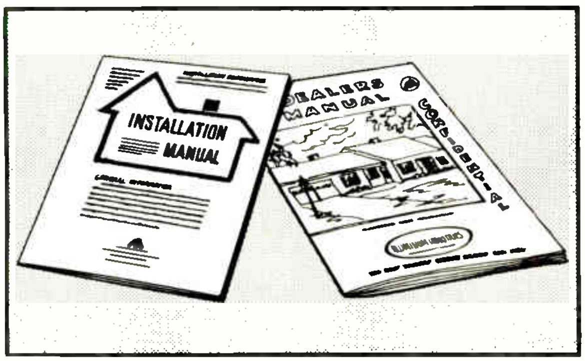

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CIRCLE NO 9 ON FREE INFORMATION CARD

Conference TALK TIMER

BY WALTER W. SCHOPP

Compact, versatile project has selectable time intervals.

IT IS a well-known fact that public speakers frequently run over their allotted time. This "Talk Timer" is an ideal device for keeping speakers within their time limits and getting a conference moving on schedule. Its use need not be confined to conferences, however. It can be used in any timing application in the kitchen, in the radio shack, near the telephone, etc.

When the unit is turned on and the RESET button is pressed, a green light glows for the TALK period (adjustable from 5 to 60 minutes). At the end of that time, a yellow light comes on, and the SUMMARIZE period (adjustable from 5 to 15 minutes) begins. When the total time is up, a red light comes on.

The project can be built easily at a total parts cost of about $30.

About the Circuit. The Talk Timer has a fairly low parts count due to the fact that two Exar XR-2400 IC's are used. Each chip contains a 555 timer and eight flip-flops (divide-by-two counters) in a 16-pin DIP. Each open-collector flip-flop output is accessible at a specific pin, and any number of them can be connected together. The result is a summed output signal with a period from RC to 255RC, where RC is the time constant of the timing resistor and capacitor.

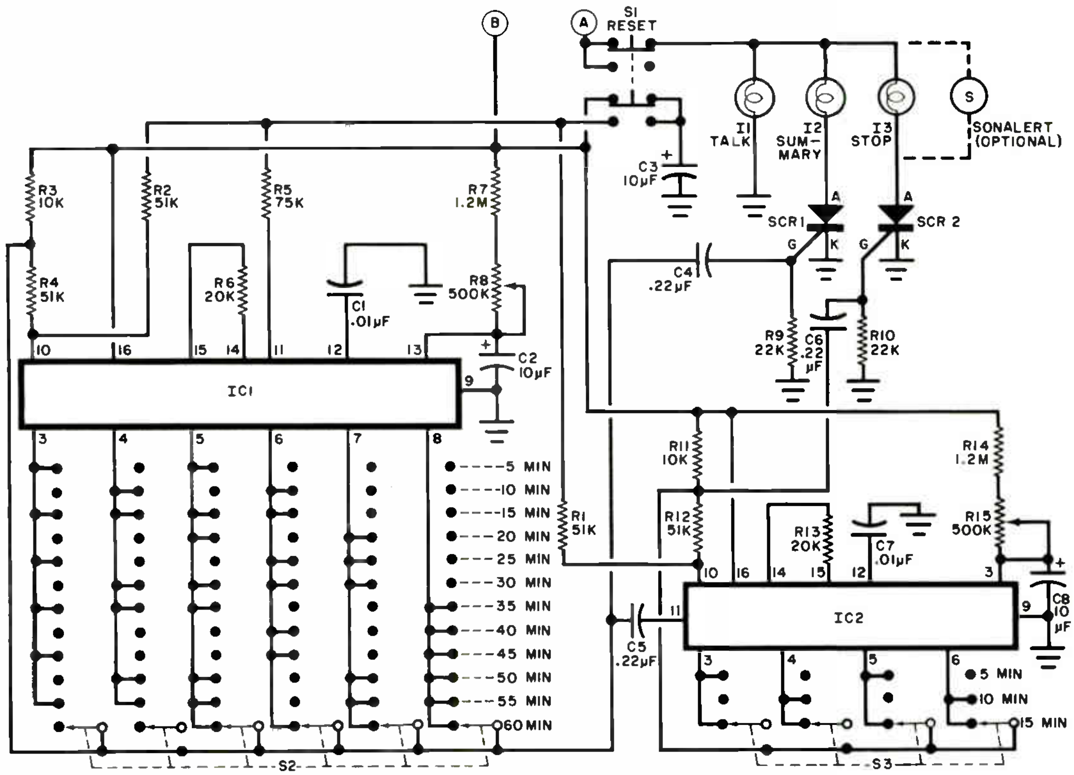
The schematic diagram of the Talk Timer is shown in Fig. 1. Duration of the "talk" period is controlled by *IC1*, and that of the "summarize" period by *IC2*. A 15-second time constant is used in each timer, determined by *R7*, *R8*, and *C2* for *IC1* and *R14*, *R15*, and *C8* for *IC2*. Because this time constant is fairly short, reasonably sized capacitors can be used. Also, adjustment of *R8* and *R15* is much easier for this interval than for one considerably longer. (The overall accuracy of each timer depends on that of its reference time constant.) For the "talk" period, the 4RC through 128RC outputs of *IC1* are selectively summed to give an output signal with a duration of 5 to 60 minutes in 5-minute increments. For the "summarize" period, the 4*RC* through 32*RC* outputs of *IC2* are combined to give an output signal of 5, 10, or 15 minutes.

When power is initially turned on, both timers are reset. All three lamps (*I1*-*I3*) glow, and the unit is ready for operation. When RESET switch *S1* is depressed, one pole momentarily disconnects *SCR1* and *SCR2* from the unregulated +7.5-volt supply (point A). This turns off the SCR's and lamps *I2* (SUMMARIZE) and *I3* (STOP). Lamp *I1* (TALK) will glow again when *S1* is released. The other pole of *S1* applies a pulse from capacitor *C3* to the reset terminal of *IC2* (pin 10) and to the reset and trigger (pin 16) terminals of *IC1*. Thus, *IC1* starts timing and its output goes low.

At the end of the selected "talk" period, the output of *IC1* goes high and causes *SCR1* and *I2* to conduct. Simultaneously, a pulse is applied to the trigger input of *IC2*. This IC then times out the SUMMARIZE period. At the end of that interval, *IC2*'s output goes high and turns on *SCR2*. This activates *I3* and the Sonalert (if used). The Talk Timer can then be reset for the next speaker by depressing *S1*. Also, the unit can be reset at any time during the TALK and SUMMARIZE intervals by pressing RESET.

A suitable power supply providing regulated and unregulated outputs is shown schematically in Fig. 2. For stability, the two timing chips are connected to the 6.8-volt regulated output (point B). The rest of the circuit (the SCR's and indicator lamps) is connected to the unregulated output.

Construction. Assembly techniques and parts placement are not critical. Printed circuit or perforated board can be used, with hard wire or wrapped wire



PARTS LIST

C1, C7—0.01-µF disc ceramic capacitor
C2, C3, C8—10-µF, 25-volt tantalum capacitor
C4 through C6—0.22-µF Mylar capacitor
I1 through I3—No. 44 or 47 pilot light
IC1, IC2—XR-2240CP programmable timer (Exar)
The following fixed resistors are ¼-watt, 10% tolerance components.
R1, R2, R4, R12—51,000 ohms
R3, R11—10,000 ohms
R5—75,000 ohms
R6, R13—20,000 ohms
R7, R14—1.2 megohms
R9, R10—22,000 ohms
R8, R15—500,000-ohm trimmer potentiometer
S1—Dpdt momentary pushbutton switch
S2—6-pole, 12-position nonshorting rotary switch (Centralab 2025 or equivalent)
S3—4-pole, 3-position nonshorting rotary switch (Centralab 2011 or equivalent)
SCR1, SCR2—1-ampere, 100-volt silicon controlled rectifier (Radio Shack 276-1059 or equivalent)
Misc.—Lensed lamp holders, printed circuit or perforated board, IC sockets or Molex Soldercons, suitable enclosure, switch knobs, Sonalert (optional), hookup wire, solder, etc.

Fig. 1. Two timer-counter IC's reduce parts count for the project.

connections. The use of sockets or Molex Soldercons is recommended for the IC's. Care should be taken when wiring *S2* and *S3*. The many contacts on these rotary switches make it easy to wire them incorrectly, and make it difficult to find the error after assembly. Lampholders with colored lenses should be used with *I1* (green), *I2* (yellow), and *I3* (red).

Adjustment. The only adjustments that need to be made are the settings of *R8* and *R15*. Using a dc-coupled oscilloscope or high-threshold logic probe, observe the signals at pin 1 of each IC. During the "talk" period, the waveform at pin 1 of *IC1* should change state every 15 seconds when *R8* is properly adjusted. During the "summarize" period, pin 1 of *IC2* will change state every 15 seconds when *R15* is set correctly. Try to adjust these *RC* time constants as precisely as possible, because the overall accuracy of the Talk Timer depends entirely on them.

No matter what your application may be, the Talk Timer is set up and operated in this manner—connect the project to the ac line, close power switch *S4*, select the desired talk and summary times with rotary switches *S2* and *S3*, respectively, and activate and reset the system using RESET switch *S1*. ◇

PARTS LIST

C9—2500-µF, 15-volt electrolytic capacitor
C10—0.001-µF disc ceramic capacitor
D1 through D4—1N4001 rectifier diode
D5—6.8-volt, 1-watt zener diode (1N3016B or equivalent)
R16—33-ohm, ½-watt resistor
S4—Spst toggle switch
T1—117V/6.3-volt, 1.2-ampere transformer
Misc.—Line cord, terminal strips, hookup wire, solder, machine hardware, etc.

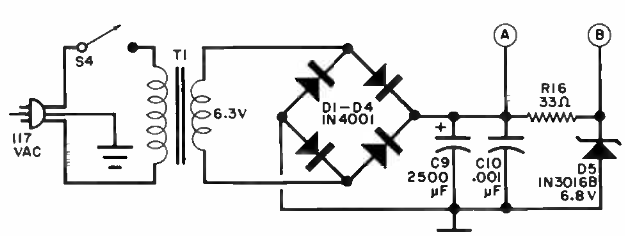
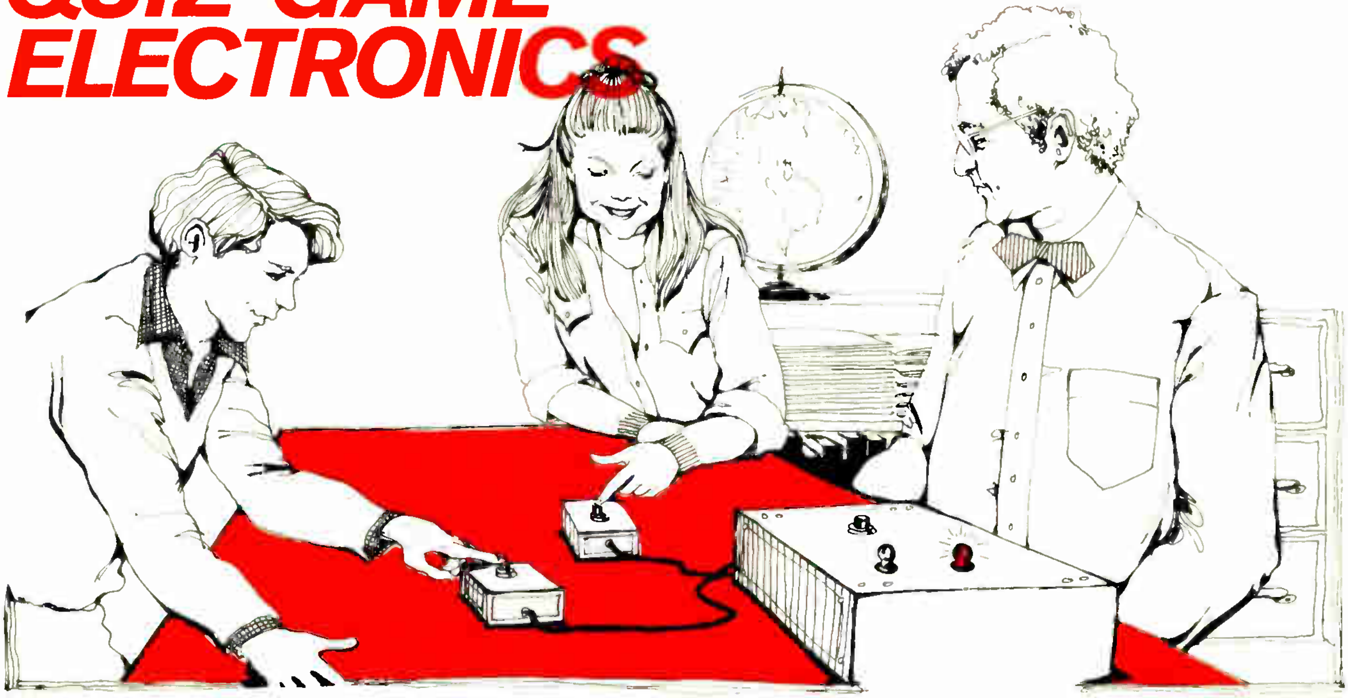


Fig. 2. Schematic of suitable power supply.

QUIZ-GAME ELECTRONICS

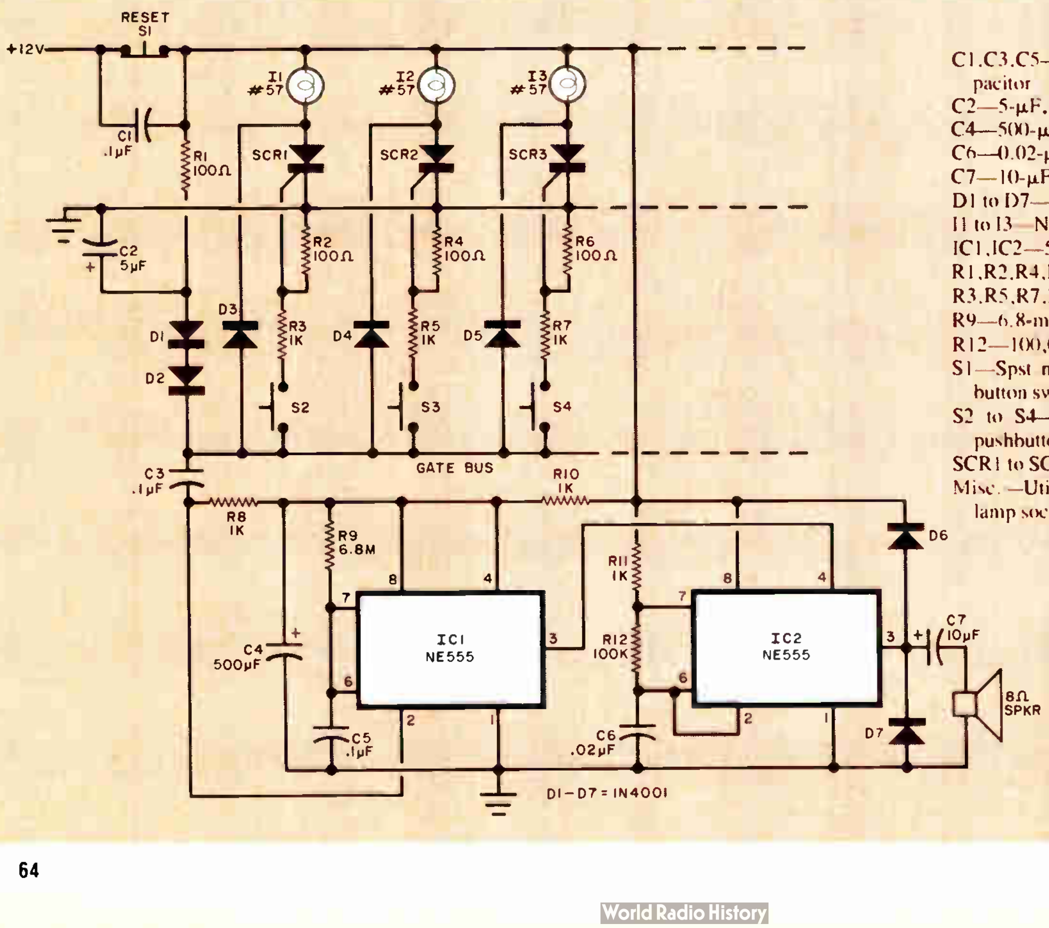
BY MICHAEL S. ROBBINS



Here's a player-response circuit that will enable you to imitate quiz shows at home or with larger audiences.

POPULAR TV quiz shows use electrical or electronic apparatus to determine which contestant makes the first response, thereby getting first crack at a question. Here's a simple circuit that will enable high school and college groups to emulate the quiz shows. It can be used for fun at home, too.

The circuit shown will energize a lamp to identify which player pushes his button first, sound an audible alarm, and lock out the buttons of the other players.



PARTS LIST

C1,C3,C5—0.1-µF, 50-volt disc ceramic capacitor
C2—5-µF, 25-volt electrolytic capacitor
C4—500-µF, 25-volt electrolytic capacitor
C6—0.02-µF, 50-volt disc ceramic capacitor
C7—10-µF, 25-volt electrolytic capacitor
D1 to D7—1N4001 diode
I1 to I3—No. 57 pilot lamp
IC1,IC2—555 IC timer
R1,R2,R4,R6—100-ohm resistor
R3,R5,R7,R8,R10,R11—1000-ohm resistor
R9—6.8-megohm resistor
R12—100,000-ohm resistor
S1—Spst normally closed, momentary pushbutton switch
S2 to S4—Spst normally open, momentary pushbutton switch
SCR1 to SCR4—HEP R1221 or equivalent
Misc.—Utility boxes, pc or perforated board, lamp sockets, wire, solder, hardware, etc.

Schematic diagram for the game circuit. By adding SCR networks, the circuit can be expanded to include any number of players.

The solid-state design is inexpensive to build and can be expanded to include any number of players and a combination of alarms could be used.

Circuit Operation. The heart of the system is an inexpensive SCR. When a contestant presses his button, the gate of his particular SCR (one for each player) is connected to the positive gate bus. The SCR turns on and the indicator is lit. Since the voltage across the SCR is nearly zero during conduction, the normally positive gate bus will be pulled down to almost 0 volts through the diode which ties the bus to the SCR's anode. When this happens, the bus will not be able to supply enough gate current to turn any other SCR on. Thus the other players' buttons are locked out until the referee resets the circuit.

This dip in voltage on the bus activates *IC1*, a 555 unit operating as a one-shot. A one-second pulse from *IC1*'s output activates *IC2*, a 555 in the astable mode, producing a tone in the speaker for the same length of time. Since the output of *IC2* is a square wave, an appreciable inductive "kick" can appear across the speaker coil. Two clipping diodes are connected across the output of *IC2* to protect the transistors inside the 555 from excessive voltage spikes.

Once a pulse of current flows into an SCR, it will conduct indefinitely (the player need not keep his button continuously depressed) until the anode current falls below the holding current, I_H. When this happens, the SCR turns off. In this circuit, the indicator lamp will continue to glow and all other pushbuttons will be locked out until the referee pushes the RESET button, *S1*.

The duration and pitch of the tone may be adjusted by changing the values of the timing components associated with *IC1* and *IC2*. For example, changing *R9* from 6.8 megohms to 1 megohm will shorten the duration to about 0.2 seconds, while substituting a 10-megohm resistor will extend the interval to about two seconds. Replacing the 100,000-ohm *R12* with a 500,000-ohm resistor will raise the frequency of the tone from 350 Hz to about 1000 Hz. Since tastes vary, you might install potentiometers in place of these two fixed resistances, and adjust them to produce the desired pitch/duration combination.

Any small 8-ohm speaker will be sufficient for this application. Power can be obtained from any source capable of producing 500 mA at 9 to 12 volts dc. A lantern battery or a small full-wave power supply will work fine.

Construction. The system can be constructed in several different configurations. One of the most versatile arrangements is to mount each contestant's pushbutton, indicator lamp, and SCR network in a small utility box, which is placed before him. All of the boxes are connected together by a three-conductor cable. The tone generator, RESET button, and power supply can then be installed in a utility box mounted at the referee's position.

An alternative arrangement is to mount all of the circuitry behind a panel on which the indicator lamps are installed. Twisted-pair or zip cord can be used to connect the circuitry to pushbuttons at the contestants' and referee's positions. Other configurations might be suggested by your own particular situation.

Parts placement is not critical, so the circuitry can be assembled on a printed circuit board or a piece of perforated board, mounted in any small, convenient utility box.

All you need now to use the system are contestants, brain teasers and prizes to be won! ◇

Solid State

TIMERS AND COUNTERS

By Lou Garner

A NUMBER of semiconductor manufacturers offer special devices designed specifically for use in timing and counting systems quite aside from watch and clock IC's. A typical family may include from two to four or more devices. The 8240, 8250, and 8260, for example, are a family of monolithic programmable timer circuits manufactured by *Intersil, Inc.* (10900 N. Tantau Ave., Cupertino, CA 95014) which can be used in a variety of interesting and exciting projects. Supplied in 16-pin DIP's, TTL compatible, and capable of operation on dc sources of 4 to 18 volts, these devices are suitable for use in process control, appliance and darkroom programmable timers; inventory checking, loading, filling and summing counters; music synthesis, harmonic synchronization and other frequency generation applications; analog-to-digital and digital-to-analog converters; sample and hold circuits; and pattern and waveform generators.

Terminal (pin) connections for the 8240, 8250 and 8260 family are identified in Fig. 1. Each device comprises an accurate low-drift oscillator, a counter section of cascaded master-slave flip-flops and suitable logic and control circuitry. The integral time-base oscillator can be set with an external R-C network or, if preferred, disabled, with the time base supplied by an external clock. The counter outputs are open-collector transistors which can be programmed easily at the external pins using wire connections or standard thumbwheel switches. With additional logic circuitry, timing can be programmed by a computer or microprocessor, thus permitting the devices to be used in complex automated control systems.

The 8260 is designed specifically to time accurate delays in seconds, minutes and hours. It has a maximum count of 59 and a carry-out gate, permitting several units to be cascaded for operation as a clock synchronized by the 60-Hz ac power line. With a maximum count of 99, the 8250 is optimized for decimal counting and delay, and can be programmed by standard binary coded decimal (BCD) thumbwheel switches. Each device has a counting capability of two decades, permitting selection of time delays from 1 RC to 99 RC (RC representing the external timing network), while a carry-out gate allows an expansion to as many decades as is needed. Finally, the 8240 employs conventional binary counting, using eight flip-flops to divide down the base frequency and providing 8 suboctaves of the fundamental simultaneously when operated in the astable mode. When used in the monostable mode, the output collectors can be wired for AND logic to give any combination of pulse widths needed from 1 RC to 255 RC. All three devices offer a typical accuracy of ±5% and a low drift of only ±100 ppm/°C (typical).

Typical practical applications for the 8240/50/60 family are illustrated schematically in Figs. 2 through 5. These are but a sampling of the circuits featured in the 16-page technical bulletin for the devices as well as Intersil's 23-page *Timer/Counter Applications Brochure.* All of the designs employ standard components and, with neither layout nor lead dress overly critical, may be duplicated quite easily in the home laboratory or workshop using conventional construction techniques, provided good wiring practice is observed. Intersil devices are stocked primarily by franchised industrial distributors such as *Arrow, Kierulff, Schweber, Weatherford,* and *Semiconductor Specialists.*

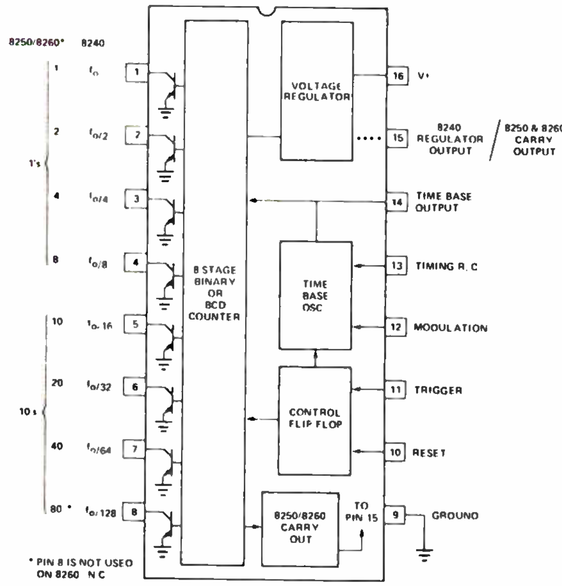
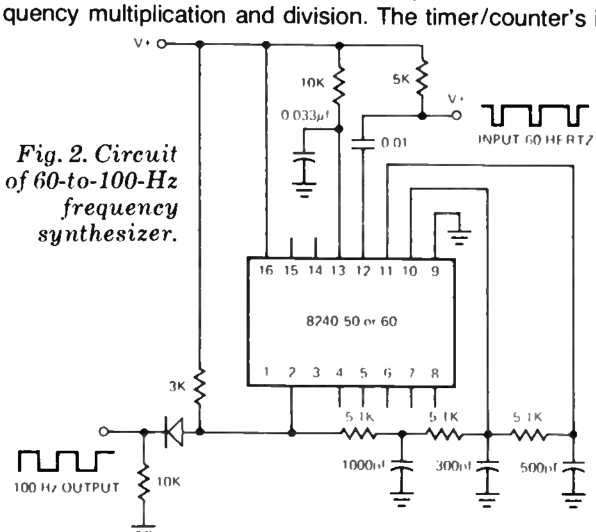


Fig. 1. Pin connections for 8240/50/60.

An unusual, but valuable, application for a timer/counter is shown in Fig. 2—synthesis of a signal bearing a fractional harmonic relationship to an accurate reference frequency. Here, a 100-Hz output signal is developed which is synchronized with and stabilized by a 60-Hz signal derived from the ac power line. In operation, this is achieved by a combination of frequency multiplication and division. The timer/counter's inter-

Fig. 2. Circuit of 60-to-100-Hz frequency synthesizer.



nal time base oscillator is set to a multiple of the reference frequency by means of the R-C timing network connected to pin 13 and is synchronized with it as in any harmonic generator. This signal is then divided by the counter chain. In the circuit shown, the 60-Hz reference frequency is multiplied by 5 and divided by 3 to develop the 100-Hz output signal. Frequency synthesizers may be used in a variety of projects—such as special-purpose test generators, clocks for control and process logic systems, tone sources for electronic musical instruments or remote control applications, or references for timing instrumentation.

With a few simple modifications and the addition of a voltage comparator and a flip-flop, a staircase generator may be adapted for use as an analog-to-digital converter, as shown in Fig. 3. If an 8240 is used, the digital output is an 8-bit binary signal, while a type 8250 (with a corresponding change in resistor array ratios) provides a 2-digit BCD output. In operation, an input strobe pulse first resets then triggers the 8240/50 and, at the same time, sets the flip-flop which enables the counter. The staircase signal developed by the 741 op amp counts down until it reaches the analog input voltage level, at which time the type 111 comparator changes state, resetting the flip-flop and stopping the count. The digital word at the timer/counter's eight outputs is the complementary binary (or BCD) equivalent of the analog input. The maximum conversion time is approximately 2.6 ms.

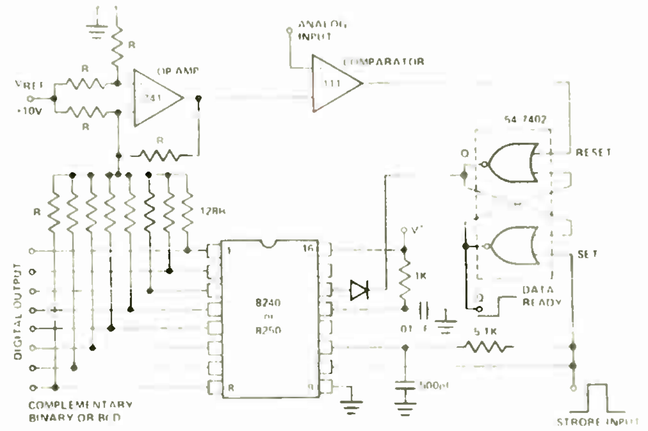


Fig. 3. Analog-to-digital converter circuit.

Using three cascaded 8250's and featuring an optional readout display, the programmable event counter circuit given in Fig. 4 can be used in numerous applications. Typically, it can serve to count and limit the number of moves in a game, for loading or package filling to preset quantities, for inventory control, and, with suitable sensors, even for limiting the number of individuals entering (or leaving) a restricted area, such as an auditorium, dance hall, or production plant. Extremely versatile, its applications are limited only by the imagination and skill of the designer and by the peripheral circuits or devices (such as alarms, solenoids, relays, valves, or motors) with which it is used. In operation, the six decade counter is preset (programmed) to the maximum desired count by means of six BCD thumbwheel switches. Action is initiated when the START COUNT pushbutton switch is closed, enabling both the programmed and the readout display counters, the latter a type 7208. Thereafter, the circuit begins counting the desired items or events, receiving its information in the form of negative-going pulses from its input line. The signal count pulses may be derived from microswitches, photoelectric sources, temperature transducers, pressure switches or other devices, depending on the specific application. The output is developed as a 0-to-5-volt step function; at the start of count-

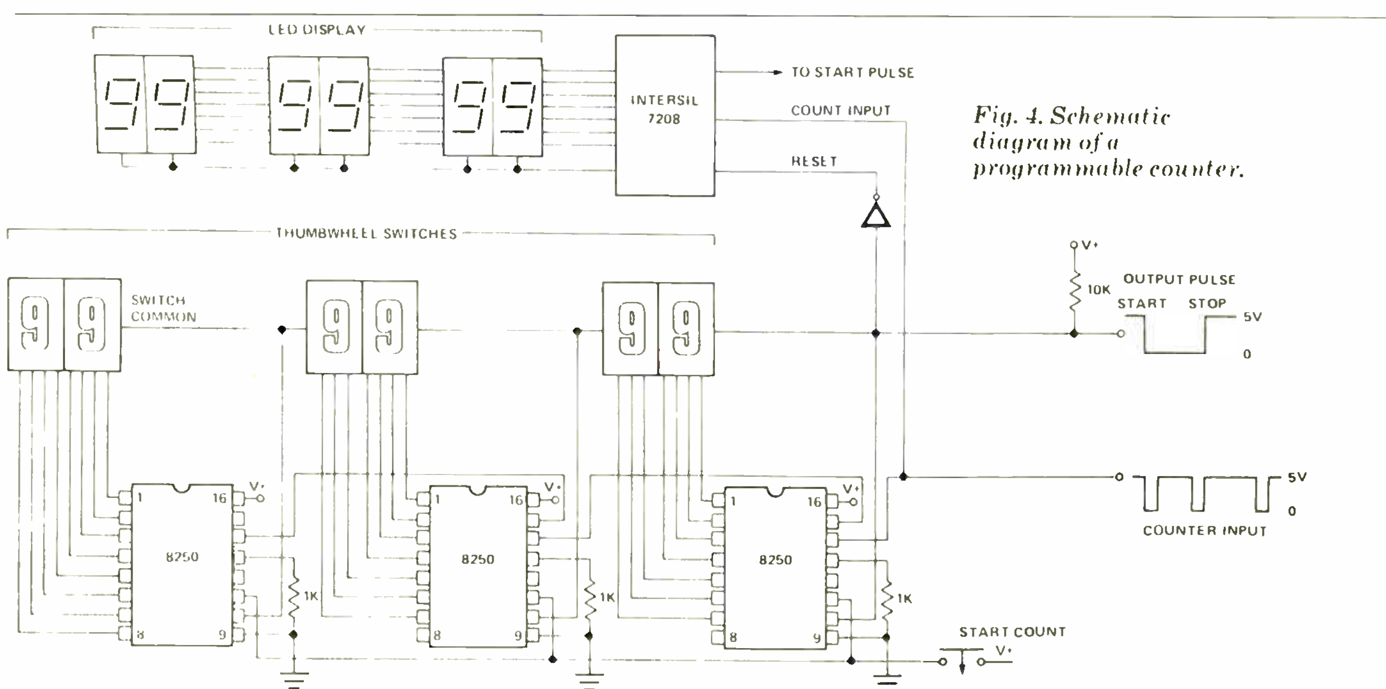


Fig. 4. Schematic diagram of a programmable counter.

ing, the output level drops from 5 volts (positive) to 0, remaining at this level until the count is complete. The accumulating count is shown on the six-digit LED display until the count preset by the thumbwheel switches is reached, at which time the output level changes state (returns to a five-volt value), resetting the system. The change in output voltage level can be applied to additional control circuitry to close (or open) a relay, actuate a motor or solenoid, set off an alarm, or initiate whatever action is required by the individual installation.

Reader's Circuit. One of our many friends north of the border, Doug Wood (9 Peter Ave., Guelph, Ontario, Can., N1E 1TS), has been experimenting with light-controlled relays and feels that one of his designs may be of interest to other readers. Suitable for use in a variety of remote switching applications, his circuit, shown in Fig. 5, features a pair of light-activated SCR's and two sensitive-reed relays. Doug writes that he has used it as a TV "commercial killer" and for switching a radio receiver, operating the circuit by means of a flash-

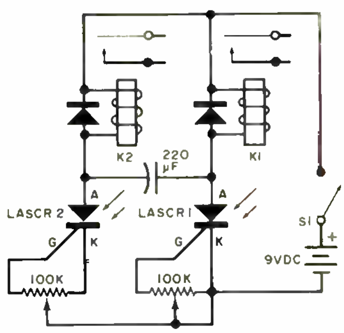


Fig. 5. Circuit for a remote light-operated switch.

light or camera flash unit. Generally, the more powerful the light source used as a trigger, the greater the control range.

Doug has interconnected two conventional LASCR control circuits with a 220-µF commutation capacitor to form what is essentially a light-activated flip-flop. In operation, the two circuits are activated alternately to provide the required switching action. Consider, for example, that *LASCR2* is conducting, energizing *K2* and permitting the commutation capacitor to charge through *K1* so that LASCR1's anode is at the dc source voltage. If light is now applied to *LASCR1*, this device will switch to a conducting state, discharging the commutation capacitor and momentarily removing *LASCR2*'s anode voltage, causing this device to switch to an "open" or nonconducting state. When this happens, *K2* is de-energized, *K1* is energized, and the commutation capacitor is charged in the *reverse* direction. The circuit will then continue to operate in this state until light is applied to *LASCR2*, at which time the action reverses, with *K2* energized and *K1* de-energized. The small diodes across the relay coils serve to damp switching transients and suppress voltage spikes, while the variable resistors in the LASCR gate-cathode circuits act as sensitivity controls.

With neither parts placement nor the wiring arrangement especially critical, the circuit may be duplicated using any preferred construction technique. Doug does suggest, however, that the LASCR's be mounted inside fiberboard, plastic or metal tubes (preferably with flat black interiors) to insure a directional response characteristic and avoid false triggering by extraneous light. The LASCR's are inexpensive low-voltage types (typically, *Radio Shack* No. 276-1096), and the diodes are general-purpose silicon rectifiers, such as type 1N4001. Standard 100k potentiometers are used as the sensitivity controls. The commutation capacitor should be a nonpolarized type; if this type is not available, one can be made up by connecting two 400- to 500-µF, 10-to-15-volt dc electrolytics in series back-to-back. Although Doug used reed relays for *K1* and *K2* in his model (typically, *Radio Shack* No. 275-230), conventional relays may be used if preferred (such as CALECTRO type D1-966). The ON-OFF switch, *S1*, is a spst toggle, slide or rotary type. Operating power is supplied by a 9-volt battery or line-operated dc power supply.

After the circuit assembly is completed and double-checked for possible errors, the unit's operation can be tested by using a sharply focused flashlight to trigger first one, then the other, LASCR, listening for the relay "clicks" signifying contact opening and closure. Next, the relay (*K1* and *K2*) contacts are connected to switch the external load, taking care to observe the relay contacts' maximum ratings. If heavy power loads are to be switched, it may be necessary to add additional "booster" relays. Finally, the control unit is mounted in its desired operating position and the sensitivity controls are adjusted for optimum performance. The ideal settings are those which insure

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positive actuation by the controlling light source but avoid false triggering by variations in ambient light levels.

Device and Product News. Motorola has introduced a bipolar LSI circuit that should be of interest to advanced experimenters working with microprocessor systems. The new device, called a Priority Interrupt Controller (PIC), allows priority control on the interrupt inputs to a microprocessor and has been dually designated the MC8507/MC-6828 to indicate that its performance has been optimized for the M6800 microprocessor system. However, it also may be used in non-M6800 applications. Basically, the PIC eliminates the software interrupt polling routing in systems containing eight or multiples of eight I/O devices, such as the Peripheral Interface Adapter (PIA), Asynchronous Communications Interface Adapter (ACIA), Synchronous Serial Data Adapter (SSDA), and so on. Functionally, the PIC can change the interrupt vector, reserved in memory for hardware interrupts, into one-of-eight alternate vectors assigned to the I/O service routines. The PIC modifies the low-order bytes of the reserved interrupt address. The MC8507/MC6828 is offered in both ceramic and plastic 24-pin DIP's.

On the other hand, if you're working with conventional logic circuits used in critical areas, you may want to investigate two new IC's announced recently by *Teledyne Semiconductor* (Mountain View, CA 94040). Designed for applications in high (electrical) noise areas, the HiNIL 306 and 307 both contain two 2-input NOR gates and two 3-input NOR gates. The 306 features active pullup outputs and 10-mA output drive currents, which permits it to drive lines up to 10 feet without loss of noise immunity. The 307 has open collectors so the outputs can be collector OR'd. Both devices operate on 10 to 16 V dc. Typical applications include CMOS input interface, industrial controls, medical instrumentation, and marine electronics. The HiNIL 306 and 307 are available in standard 16-pin DIP's in both plastic and ceramic versions.

National Semiconductor Corporation (2900 Semiconductor Drive, Santa Clara, CA 95051), has combined classical circuit techniques with an ion-implanted p-channel MOS process to create a new low-cost 8-bit analog-to-digital converter. Designated type MM5357, the new A/D converter contains a chain of 256 identical resistors connected in series, 255 analog switches, a high-impedance input comparator, output latches, and control logic on a single monolithic chip. In operation, conversion is performed using the successive approximation technique, whereby an unknown analog voltage is compared to the voltages at the resistor tie points by means of analog switches. A 10-volt reference applied across the resistor chain sets 256 precision voltages against which the unknown input voltage is compared by the analog switches under control of the on-chip logic. Requiring +5 and −12 V dc sources and dissipating approximately 170 mW, the MM5357 is supplied in an 18-pin Epoxy-B DIP.

National Semiconductor also has developed a new series of monolithic frequency-to-voltage converters with a combination high-gain op-amp-and-comparator. Identified as the LM2907 and LM2917 tachometer speed switches, they are specifically designed to operate relays, lamps, and other components when the input frequency reaches or exceeds a selected rate, and are especially suited for speedometers, tachometers and automotive lock and clutch controls where over-or-under speed sensing is required. The devices use a combination op-amp-and-comparator with a floating transistor as output, and can furnish either a supply-referenced load of 50 mA or a swing-to-ground for zero frequency. ◇

Experimenter's Corner

By Forrest M. Mims

FLIP-FLOPS AND DECADE COUNTERS—PART 1

Counting circuits perform many important roles in digital electronics. They are used to measure frequency, compute time, divide pulse streams by a fixed constant, generate signal sequences, and perform many other useful operations.

The common flip-flop is a fundamental counter circuit. The best way to understand a flip-flop is to build an ultra-simple flip-flop from a pair of inverters. But first, let's establish a couple of important definitions.

In digital electronics an electrical signal is either *high* or *low*. These two states are used to represent the binary bits 1 and 0. In positive logic, 1 is high and 0 is low. Negative logic means 1 is low and 0 is high. Since digital logic IC's commonly operate from a single-ended power supply, a high state represents a voltage near the supply voltage. A low state represents a voltage near 0 volt or ground.

With these basic definitions in mind, we can easily design a simple flip-flop from two of the six inverters in a 7404 hex inverter. As you may already know, the signal at the input of an inverter is changed from high to low (or from low to high) at the output. All we have to do to make a simple flip-flop is connect the inverters in crisscross fashion as shown in Fig. 1. When the output of the upper inverter is high, the output of the lower inverter is low. Similarly, when the output of the upper inverter is low, the output of the lower inverter is high. We therefore have a circuit which can occupy one of two stable states. That, of course, is the simplest definition of the flip-flop.

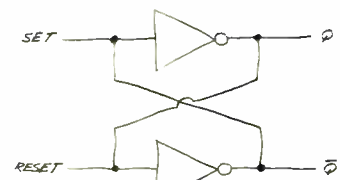


Fig. 1. The basic flip-flop.

Figure 2 shows a practical version of this ultra-simple flip-flop with an LED state indicator at both outputs. The resistor limits current through the LED's to a safe 10 milliamperes or so. You can assemble the circuit on a molded plastic solderless breadboard (a *must* for experimenters and design engineers alike) in a few minutes. If you don't have a 5-volt supply, use a fresh 6-volt battery and drop the voltage to about 5 volts with a 1N914 diode connected so that it is forward biased between the battery's positive terminal and the circuit.

When power is applied to the circuit, one of the LED's will glow. Momentarily grounding the SET input will cause only the Q output LED to flow. If the RESET input is momentarily grounded, only the Q LED will glow. Note that the LED continues to glow after the input signal is removed. This memory or latching action is the key to the operation of many kinds of complex logic circuits.

The ultra-simple flip-flop in Fig. 2 is not practical for counting applications. However, it's possible to make a binary counter by using gates instead of inverters, and by adding a couple of gates which allow the circuit to flip or flop only on command from an external clock pulse.

The 7473 Dual J-K Flip-Flop. We can actually assemble a clocked flip-flop from the four gates in a 7400 quad NAND Gate, but a far more convenient approach is to use a ready-made version such as the 7473 dual J-K flip-flop. This flip-flop will toggle back and forth between its two output states when connected to a 555 clock circuit as shown in Fig. 3.

The circuit in Fig. 3 makes a nice dual LED flasher—but it also demonstrates the important flip-flop applications of counting and dividing. You can see this by assembling the circuit on a solderless breadboard (which I urge you to do), and disconnecting the cathode of the LED at the $\bar{Q}$ output (pin 13 of the 7473) and connecting it to the clock output of the 555 (pin 3). Now, if you slow down the clock frequency to a few Hertz by adjusting the 100K pot, you will see that the LED at the Q output of the flip-flop flashes at exactly half the rate of the LED connected to the clock. In other words, the flip-flop is functioning as a divide-by-two counter.

All kinds of possibilities open up if we connect the unused Q output of the flip-flop to the clock input of the second flip-flop in the 7473. Figure 4 shows how to wire things together on your solderless breadboard. Obviously the second flip-

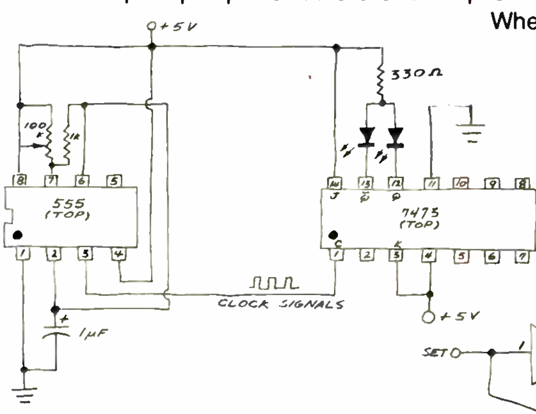


Fig. 3. 7473 flip-flop with 555 clock circuit.

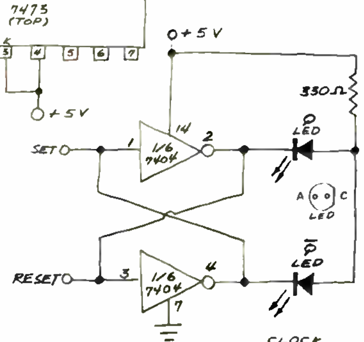


Fig. 2. Practical version of two-inverter flip-plop.

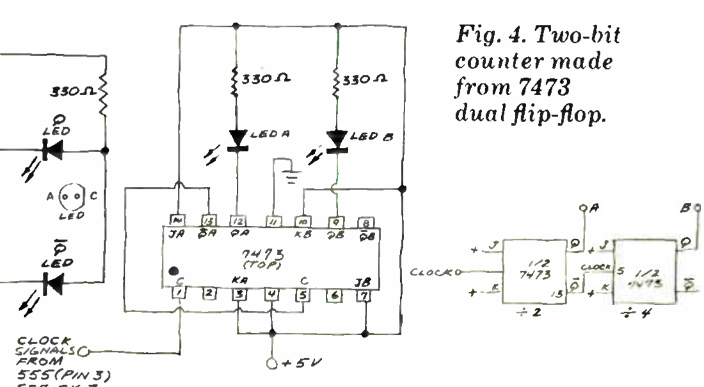


Fig. 4. Two-bit counter made from 7473 dual flip-flop.

flop in this new circuit will receive only half as many clock pulses as the first flip-flop. Therefore its Q LED will flash at only one-fourth the rate of the clock frequency. So now we have a divide-by-four counter. And this gives us a two-bit binary counter circuit.

To see how the circuit operates as a two-bit counter, remove the *CLOCK* LED and arrange the two flip-flop LED's so the one which is connected to the second flip-flop (the slow one) is to the left of the other one. By slowing down the clock you'll see this flash sequence (off = 0; on = 1):

LED B	*LED A*
0	0
0	1
1	0
1	1
0	1

(etc.)

This binary sequence, of course, corresponds to the decimal count 0 . . . 1 . . . 2 . . . 3 . . . 0 . . . etc. The circuit is called a two-bit counter since it recycles when the count exceeds two bits.

A really useful counter can be made by cascading four flip-flops to give four-bit capability. This would permit a decimal count of from 0 to 15. By means of external connections which automatically reset the counter when a desired count has been reached, a range of count intervals could then be achieved.

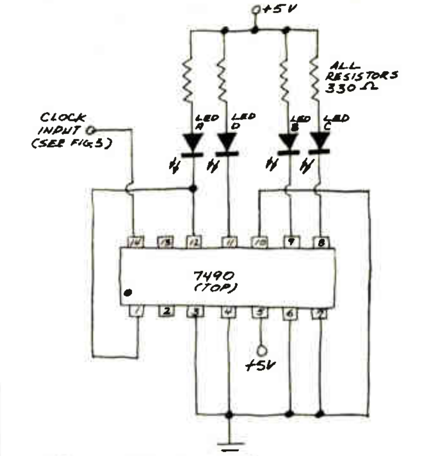


Fig. 5. 7490 four-bit counter.

Several quad flip-flop (four-bit) counter chips are available so there is no need to use separate gate or flip-flop packages. Since a 0 to 9 count has more applications than a full 0 to 15 count (at least for us decimal-oriented human beings!) let's take a look at the 7490 Decade Counter.

7490 Decade Counter. As its name implies, the 7490 Decade Counter is primarily intended for 0 to 9 counting. To provide a range of applications, one of its internal flip-flops is not connected to the others. This gives two separate counters in one package: a divide-by-two and a divide-by-five. Connecting the A output (pin 12) to the *CLOCK* input of the divide-by-two flip-flop (pin 14) forms a chain of four flip-flops which counts from 0000 to 1001 (0 to 9) before recycling.

Figure 5 shows how to connect the 7490 to the 555 clock of Fig. 3. When the circuit is running, you will obtain the following count sequence:

D	*C*	*B*	*A*	
0	0	0	0	(0)
0	0	0	1	(1)
0	0	1	0	(2)
0	0	1	1	(3)
0	1	0	0	(4)
0	1	0	1	(5)
0	1	1	0	(6)
0	1	1	1	(7)
1	0	0	0	(8)
1	0	0	1	(9)
0	0	0	0	(0)
0	0	0	1	(1)

(etc.)

In simplest terms, the four flip-flops in the 7490 count from 0 to 9 and then recycle. ◇

Hobby Scene Q&A

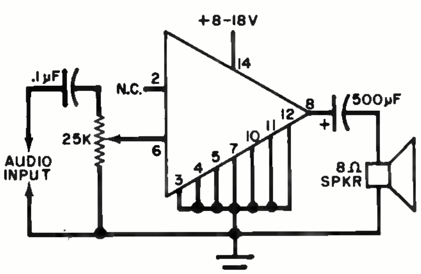
By John McVeigh

Have a problem or question on circuitry, components, parts availability, etc? Send it to the Hobby Scene Editor, POPULAR ELECTRONICS, One Park Ave., New York, NY 10016. Though all letters can't be answered individually, those with wide interest will be published.

LOW-POWER AUDIO AMP

Q. ***Can you show me a schematic for an audio amp to boost signals from my crystal set?—Rick Laird, Omaha, NE***

A. The LM380 audio amplifier is well suited for this application. It has a high input impedance, requires a single-ended power supply, and will deliver up to 2.5 watts or more of output power to an 8-ohm speaker. Note that seven pins of the IC are tied together and grounded. They should be connected to a heat sink (such as a large copper "land" on a pc board) at least six square inches (38.7 cm^2).



40-CHANNEL CB MODIFICATION

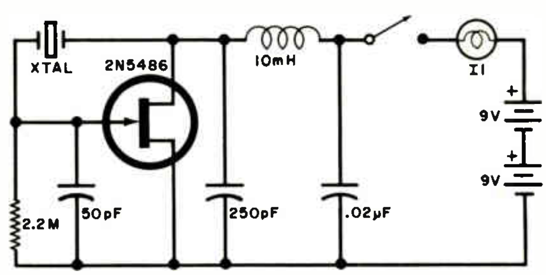
Q. ***I own a Royce Model 1-602A 23-channel mobile transceiver and would like to have it modified to cover the expanded Citizens Band. Can I do this?—Don J. Chillstrom, Wickenburg, AZ.***

A. As a general rule, 23-channel transcievers will not be able to be adapted to cover the 17 new channels. In fact, the FCC has specifically prohibited the use of external add-on circuits to expand channel coverage. However, there is one twist. Some manufacturers of PLL-synthesis transceivers are offering to "re-manufacture" rigs to cover the full 40 channels. The use of phase-locked loops in frequency generation makes this rather simple. The principal modification involves adding more combinations to the $\div N$ part of the synthesizer. The FCC has not objected to this program. Your transceiver uses crystal synthesis, and therefore cannot be so modified. Note, however, that it is permissable to use *receiving* converters with any receiver. Such a converter could be teamed up with your car radio for full-band coverage. A representative circuit appeared in the October 1976 issue of POPULAR ELECTRONICS.

CRYSTAL CHECKER

Q. ***Do you have a simple circuit for checking crystals in the 2- to 6-MHz range?—William J. Bills, Maitland, FL.***

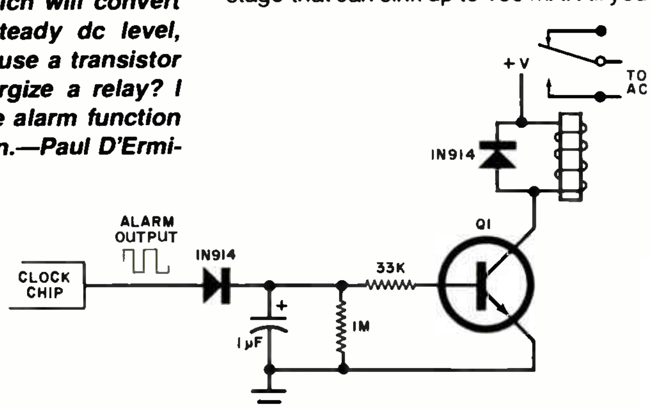
A. This tester can be used with crystals over the 0.1-to-10-MHz range. The lamp (a GE 1869, 10-volt, 14-mA type or equivalent) will light when the crystal is not in the circuit or is bad and when the switch is closed. When a good crystal is installed, the circuit oscillates and current through the lamp drops below 10 mA. The lamp will then dim or go out.



TONE-ACTIVATED RELAY

Q. ***I have built a digital clock using a Mostek MK50252N chip which incorporates a "beeper" alarm. Is there a circuit I can add which will convert the beeps into a steady dc level, which will in turn cause a transistor to conduct and energize a relay? I would like to use the alarm function to turn appliances on.—Paul D'Ermilie, Staten Island, NY.***

A. One way of performing this function is to use a tone decoder IC like the 567. This chip has been featured in the Experimenter's Corner and has an output stage that can sink up to 100 mA. All you would have to do is select the proper values of resistance and capacitance for response at the output frequency of the alarm. Here's another solution. In the circuit shown, the diode produces pulsating dc which is smoothed out by the RC combination with a time constant of about one second. (Values can be changed for a different time constant). When the capacitor charges up sufficiently, it will source base current for the switching transistor, which will turn on and energize the relay. When the beeper stops, the transistor will cut off. Any general-purpose switching transistor can be used. Be sure that the relay coil is compatible with the transistor, and that its contacts can handle the current demand of the appliances.



Product Test Reports

HEATHKIT MODEL IM-2202 DIGITAL MULTIMETER KIT

3½ digits with gas-discharge display for field and bench testing.

THE COST of owning a high-accuracy digital multimeter has dropped considerably over the past couple of years. Today, you can buy for less than $250 a DMM with features and accuracy that rival laboratory-grade instruments of only a few years ago. One instrument that reflects this trend is the Model IM-2202 DMM from Heathkit. Its low price brings to the user a 3½-digit display, 0.5% to 0.2%, ±1-digit accuracy on dc, and the capability of measuring ac and dc voltage and current and resistance over wide ranges. In addition, the DMM has built-in ac and rechargeable nickel-cadmium cell dc power supplies that make it equally suitable for bench and field servicing.

The Model IM-2202 DMM measures 8¼"W × 8"D × 3"H (21 × 20.3 × 7.6 cm) with its handle folded to the rear and weighs 7 lb (3.2 kg). Available only in kit form, it sells for $199.95.

Technical Details. The DMM's white control panel labelled in black is clean and functional. Arranged in a column along the left side of the panel are three banana jacks labelled from top to bottom MA, C (common), and V/Ω for the test-cable inputs. To the right of the jacks is the display window, below which is a bank of four pushbutton switches that are labelled AC, DC/Ω, V/Ω, and MA. The right third of the panel is occupied by a large range/function switch that also has positions for power OFF and BATT (battery check, specified on the panel at 4.6 volts minimum). Accessible through a small hole in the upper right corner of the panel is the screwdriver-adjustable ZERO control.

There are five dc-voltage ranges that go to 100 mV and 1, 10, 100, and 1000 volts full-scale. The input resistance is 50 megohms on the 100-mV range, 500 megohms on the 1000-volt range, and 10 megohms on the remaining ranges. The accuracy of the instrument is specified at 0.5%, ±1 digit using the built-in references and 0.2%, ±1 digit using laboratory standards. The DMM can safely handle an overload of 300 volts on the 100-mV and 1-volt ranges and 1000 volts on the three highest ranges.

The ac voltage ranges are the same as for the dc-voltage function, except that on the 1000-volt range the maximum specified input is 750 volts. Input impedance is 10 megohms, paralleled by 120 pF on the two lowest ranges and 60 pF on the upper ranges. The overload capability is 250 volts on the 100-mV and 1-volt ranges and 750 volts on all other ranges. The accuracy of the instrument is 1.0%, ±1 digit over a frequency range of from 40 to 1000 Hz (except 40 to 10,000 Hz on the 100-mV and 1-volt ranges) using the built-in references. Using laboratory references, the accuracy is 0.5%, ±1 digit from 40 to 1000 Hz, except to 2000 Hz on the 750-volt range.

Current in both the ac and the dc function can be measured to 100 μA and 1, 10, 100, and 1000 mA full-scale. The voltage drop in dc is 100 mV on the 100-μA and 1-mA ranges, 150 mV on the 10- and 100-mA ranges, and 300 mV on the highest range. On ac, the drop is 100 mV on the three lowest ranges, 150 mV on the 100-mA range, and 300 mA on the 1000-mA range. Accuracy on dc is 0.5% (except 1% on the 1000-mA range), ±1 digit with the built-in references and 0.2% (except 0.5% on the 1000-mA range) with laboratory standards. Ac accuracy is 1.0% (1.5% on the 1000-mA range), ±1 digit from 40 to 10,000 Hz on the built-in references and 0.5% (1.0% on the 1000-mA range), ±1 digit from 40 to 10,000 Hz. The input is coupled through a 3-ampere fuse to shunt diodes for overload protection with inputs exceeding about 1.2 volts.

There are also five resistance ranges that go to 100, 1000, 10,000, 100,000 ohms and 1 megohm full-scale. Test current is 1.0 mA on the first two ranges, 0.1 mA on the 10,000-ohm range, 1.0 μA on the 100,000-ohm range, and 10 μA on the highest range. The open-circuit potential at the test probes is 12 volts. Accuracy is 2%, ±1 digit using the built-in references. Positive input protection to 400 volts is provided by a blocking diode, while negative input protection is provided by a 0.03-ampere fuse and a shunt diode.

The DMM has a maximum display count of 1999, and its overrange capability is 100% on all but the 1000-volt dc and 750-volt ac ranges. Normal-mode rejection is stated as 35 dB or better, while common-mode rejection is 80 dB or better. The instrument can be operated 1500 volts above power line ground during line operation. The stated operating temperature is from 10° C to 40° C.

The instrument can be operated on either 110 to 130 or 220 to 260 volts 50 or 60 Hz line power, depending on an internal setting. It consumes 5 watts of power during battery charging.

The displays used are large ½" (12.7-mm) seven-segment orange gas-discharge types. Both + and − are displayed when taking dc measurements, depending on the polarity at the input to the DMM. An over range condition is indicated in the display by a flashing 1 in the half-digit location. The meter also features dual-slope A/D (analog-to-digital) conversion, automatic blanking of leading zeros, rechargeable nickel-cadmium cells that come standard, a carrying handle that doubles as a convenient tilt stand, and nonskid rubber feet.

About the Kit. Although this is a relatively complex digital multimeter, the kit is fairly easy to assemble owing to the well-written and well-illustrated assembly manual that comes with it. But for a handful of components, all parts mount on three printed circuit boards, including the function selecting pushbutton switches and the rotary range/function switch.

High-quality components and materials are used throughout the instrument. The printed circuit boards are epoxy-fiberglass, two of the three are double-sided with plated-through holes, and all three are silk-screened to show component values and orientation. Except for three resistors, all resistors are 5% tolerance or better. All hardware lines up exactly so that bolting together is a breeze.

There is very little in the way of tedious point-to-point wiring with this kit. The DMM uses a factory-prepared cable harness and switches that mount directly on the input circuit board. This reduces considerably the time required to assemble the kit and virtually eliminates the wiring errors that often crop up when using point-to-point wiring in a complex kit.

During assembly, we ran into one minor snag. We could not obtain the proper display indication on the highest resistance range during calibration. However, when we changed one component (supplied by Heath), everything worked out fine. All told, it took us approximately 17 hours to assemble and calibrate the DMM.

User Comment. We calibrated the DMM using both its built-in references and laboratory references. Using the built-in references, the instrument's accuracy on all ranges and functions equalled or bettered the published specifications. When we used laboratory references, the accuracy we obtained was well within the published specifications. Needless to say, this DMM provides greater accuracy than needed for less than laboratory-grade testing.

There are several things about this DMM that appealed to us. First off, it is very easy to operate. The range/function switch is large and easy to handle and its position labelling is clear and unambiguous. Pushbutton function selection is convenient. And the large gas-discharge displays are easy to read from any angle, up close, and at a distance. Even the test cable plugs have built-in convenience. When they are plugged into the front panel, the plugs still allow another instrument, such as an oscilloscope, to be plugged into them.

Though the Model IM-2202 is not as compact as some take-along battery-powered field-service DMM's, its larger size and weight offer the advantage of higher accuracy than usual. The intermediate size of the instrument also assures that it will not get lost on a crowded workbench or accidentally brushed off the bench onto a hard floor.

In both test-bench and field-service environments, the DMM acquitted itself admirably. After having used it for several months under all kinds of servicing conditions, we checked out its calibration. There was no significant change, and in most cases no detectable change.

The Model IM-2202 is a good-looking instrument that should fill the needs of most professionals and amateurs. It is also very reasonably priced for a highly accurate instrument that can be operated on both ac and dc power and comes standard with nickel-cadmium cells and recharging circuitry.

CIRCLE NO 104 ON FREE INFORMATION CARD

SHARP MODEL CB-800A CB MOBILE AM TRANSCEIVER

23-channel digital LED-display rig with excellent overload characteristics.

WITH new 40-channel CB rigs moving into the market place, this probably represents the last 23-channel mobile CB unit we will test. Nonetheless, 23-channel CB transceivers represent good value for the money; in some cases, unbelievable bargains. And the manufacturer of the CB transceiver examined here advises that this 23-channel unit will remain in its product line for a while.

The Model CB-800A AM CB transceiver from Sharp uses digital frequency synthesis and features a LED numeric display to indicate the channel in use. As a special feature, when the transceiver is set to Channel 9, the display flashes to tell the user that this emergency channel is in use. The transceiver has an unusually low price of only $149.95 to provide these latest technical features.

The usual lineup of controls and features are offered by the transceiver. These include: volume and variable squelch controls, S/r-f meter, switchable automatic noise limiter, Delta tune, PA operation, external-speaker jack, detachable dynamic microphone, full legal power output, TVI traps, 10.8-to-15.6-volt dc, negative- or positive-ground power requirements, voltage regulation, line filtering, and reverse-polarity protection.

The mobile transceiver measures 7⅞"D × 5¾"W × 2¼"H (20 × 14.6 × 5.7 cm).

General Description. The double-conversion receiver has i-f's located at 11.275 MHz and 455 kHz. A diode-protected r-f stage and two mixer stages are arranged in common-emitter configurations. A ceramic filter in the emitter circuit of the second mixer, plus two cascaded ceramic filters at the output of the mixer provide the 455-kHz selectivity. The i-f section, detector, second-conversion oscillator, and an agc amplifier for the i-f strip are incorporated into a single IC chip. Two outboard transistors provide another amplified agc loop for the r-f and first mixer stages and the squelch section. A series-gate anl following the detector drives an audio amplifier stage. The audio stage, in turn, drives an IC that contains the remainder of the audio section, including the output amplifier.

The digital frequency synthesis system employs a phase-locked loop (PLL). A single IC includes a 10.240-MHz crystal oscillator and a network that divides by 1024 to furnish the 10-kHz standard reference signal. A FET voltage-controlled oscillator (vco) that operates in the 38.240-to-38.530-MHz range provides the heterodyning signal to produce the 11.275-MHz i-f at the first mixer. The comparison reference from the vco is obtained by mixing the output from the vco with the 36-960-MHz crystal-controlled signal to produce difference frequencies in the range of 1.280 to 1.570

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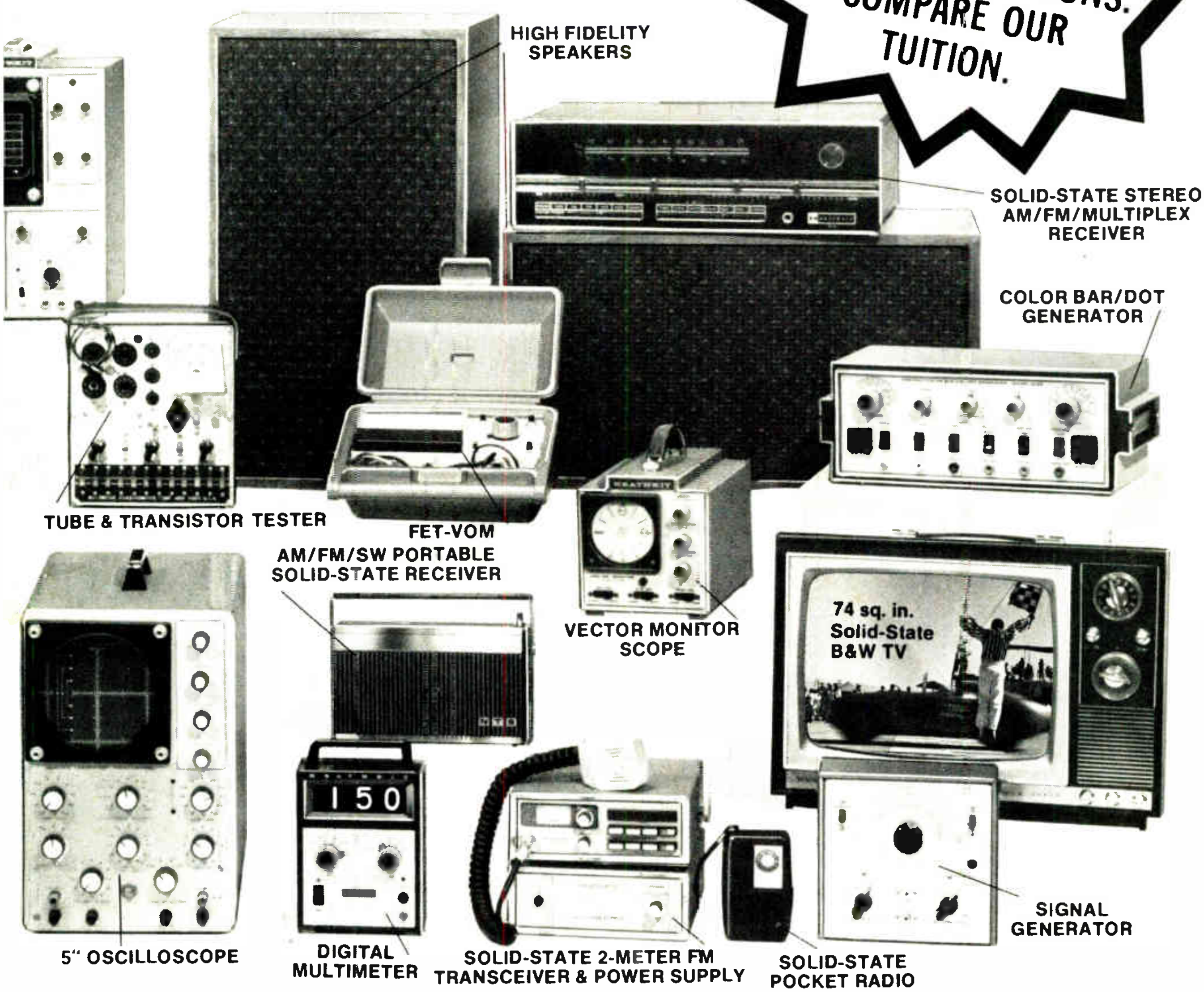

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MHz. The difference frequencies are reduced to the 10-kHz vco comparison signal through an IC that can be programmed to divide by a number between 128 and 157. The two reference signals are applied to an IC phase comparator that properly tunes the vco and PLL according to the desired channel selected by the channel-selector switch. The second-conversion crystal oscillator operates at a frequency of 11.730 MHz.

The outputs of the vco and an 11.275-MHz crystal oscillator are combined in a mixer in the transmitter. Spurious responses are minimized by bandpass filter circuits. The rest of the transmitter consists of a buffer amplifier and driver and power amplifiers. The output of the power amplifier goes through a dual-Pi filter for matching to 50-ohm loads. TVI traps tuned to 54 and 51 MHz minimize second- and third-harmonic radiation. As is usually the case, speech amplification and collector-modulation of the driver and power amplifier stages in the transmitter are obtained from the receiver's audio-amplifier section. Automatic modulation control (amc) is included here. Antenna and other circuit transfers are accomplished with a relay.

The channel LED display is activated through the selector switch and a diode-switching array. Flashing of the display on Channel 9 is controlled by a multivibrator.

Measurements. The sensitivity of the receiver measured 0.5 μV (rated 0.7 μV) for 10 dB (S + N)/N with 1000 Hz at 30% modulation. The overall audio response at 6 dB down was nominally 500 to 2625 Hz. The maximum available sine-wave power output was 2 watts at 2.5% THD with a 1000-Hz tone and an 8-ohm load. On PA, the output measured 2.5 watts.

Primary image rejection for signals near 49.6 MHz was greater than 80 dB, while secondary-image rejection for signals 910 kHz lower than the CB signal was 64 dB. I-f signal rejection was 60 to 64 dB, depending on the channel in use. Additional unwanted signals were 56 dB down for frequencies approximately 200 kHz below the CB signal. Other unwanted signals were a minimum of 60 dB down. Adjacent-channel rejection at 1 dB desensitization was 55 dB on both sides of each channel.

The agc held the audio output change to within 7 dB with an 80-dB input-signal change at 1 to 10,000 μV. The meter indicated S9 with a nominal 3.5-μV signal. The squelch threshold range for normal output was 0.3 to 10,000 μV.

Operating the transceiver at 13.8 volts dc, the transmitter's output measured 3.75 watts, depending on the channel in use. During modulation, amc compression began near 85% modulation and held to 15 dB compression beyond this point with close to 100% modulation at 4.5% THD. Adjacent-channel splatter was down 50 dB with a 1000-Hz test tone. With voice operation, the splatter held to at least 55 dB down. The overall 6-dB down response was nominally 275 to 4500 Hz. The transmitter's frequency tolerance was within 5 Hz of +105 Hz on any channel.

User Comment. The transceiver is neatly styled, with a black case and panel and satinized silver-colored trim. The chrome-finished control knobs add a nice accent. Small lever switches handle the anl and Delta-tune functions. (Delta tune shifts the receiver's frequency a fixed amount of about ±1000 Hz). The VOLUME and SQUELCH controls are rotary potentiometers, the positions of which can be readily observed and felt.

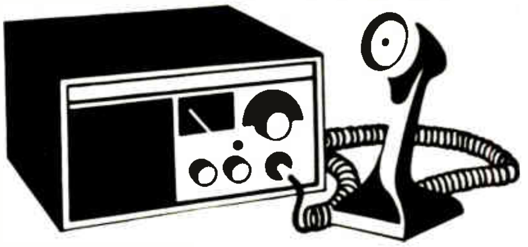
The LED display and S/r-f meter are located behind an oblong window. However, the meter is very small and can be difficult to read under some conditions. When the transceiver is switched to PA operation, the letters "PA" appear in the LED display. (Under very high ambient-light conditions, all the segments of the LED's sometimes reflect light, which can obscure the channel numerals.)

The anl system was highly effective on very short and rapid noise spikes, although its performance was not as good on slow repetitive and broader pulses. Nevertheless, the overall performance in a noisy vehicle was good. Due to an elaborate line-filter setup, we were not bothered with vehicle noises induced in the 12-volt supply line. The noise suppression was superior to that used in other mobile transceivers.

We were particularly impressed by the overload characteristics of the receiver, which by measurement did not exhibit distortion with signal inputs of 100,000 μV. Furthermore, no distortion or blocking effects were audibly noted from a CB transmitter located 30′ (9.1 m) removed from the transceiver's antenna.

Another plus for this transceiver is that its receiver audio response falls off fairly rapidly below 1000 Hz. This results in a somewhat high-pitched sound that lacks boominess. It gives the advantage of better-than-usual intelligibility from a bottom-facing speaker in mobile installations.

CIRCLE NO. 105 ON FREE INFORMATION CARD



CB Scene

By Ray Newhall, KWI6010

PURAC—A VOICE FOR CB'ERS

THE THIRD quarterly general meeting of the Personal Use Radio Advisory Committee (PURAC) to the FCC was held in Norfolk, Virginia, on October 28. The FCC hosted the gathering in a theater near their Field Operations branch offices. More than 100 representatives of CB industry, clubs, and leading publications; law enforcement agencies; the broadcasting industry; insurance companies; hams, and individual CB'ers were there to discuss their common problems, to hear the FCC's problems and to advise the FCC on the future course of personal-use radio communications.

In the past, FCC communications with radio users have always consisted of their "legal eagles" talking with other "legal eagles," and they understood each other. Now with such extensive use of CB by the general public, the FCC has found that it cannot effectively communicate with the public so it sent out a call for help from the CB industry and the CB'ers themselves. Public response at the first three meetings was better than the FCC had hoped. PURAC has become the vehicle by which any interested CB'er can work actively on a task group of his choice to help make CB a more viable, useful means of personal communications. He can talk with the FCC "wheels" face-to-face and be heard.

PURAC, chaired by John Johnson of the FCC, is organized into ten "task areas," each headed by a "Task Coordinator". An FCC representative has also been assigned to work actively in each of the task areas. The task/study areas are as follows:

1. *Operator Training Programs:* Recommend syllabus, methods and training programs for CB operators. Task Coordinator: Dave Garner

2. *Technical Standards:* Recommend material for, and organization of, the Technical Regulations sub-part of Part 95. Task Coordinator: Lee Bergren

3. *Part 95 Readability:* Recommend reorganization and rewrite of Part 95 to improve readability. Coordinator: Randy Knowles

4. *Disseminating Information:* Recommend systems for distributing information on CB topics to the CB public in the fastest, most economical, most accurate manner. Coordinator: Bill Bradford

5. *User Rule Compliance:* Recommend approaches and methods for improving user rule compliance. Coordinator: Stuart Lipoff

6. *Electromagnetic Compatibility:* Recommend susceptibility requirements and interference limits necessary to achieve electromagnetic compatibility between CB units and other electronic devices. Coordinator: John Sodolski

7. *Public Safety Uses of Personal Radio:* Recommend improvements in Part 95 to enhance the contributions of CB to public safety. Coordinator: Nathan Maryn

8. *Equipment Theft:* Recommend methods for reducing the number of CB sets stolen from users. Coordinator: Manny Hoffman

9. *Local Interference Problems:* Recommend remedial solutions for on-going complaints of interference created by CB transceivers. Coordinator: Stu Meyer

10. *Personal Use Radio Communication Needs:* Advise on current and future two-way radio communication needs of the general public, and recommend segments of the radio spectrum to meet those needs. Coordinator: Ted Andros

Each task/study group is staffed by volunteers who have offered their time to contribute to one or more sub-committee tasks. POPULAR ELECTRONICS has pledged to work actively on many Task Groups. This columnist will be pleased to assist any reader who wants to take part in PURAC activities by putting him in touch with the appropriate Task Coordinator. We will also pass-on well-considered, constructive suggestions from our readers. The next general meeting of PURAC will be held in Washington, D.C., on January 27, 1977.

PURAC Progress Report. It is far too early to expect major results from PURAC, since the first two general meetings were concerned primarily with organization, ground rules, and the subjects to which PURAC should address itself. Also, major shifts in attitude and performance in a bureaucracy such as the FCC are slow in coming, and rules-making procedures take even longer. None-the-less, some changes have already taken place as a result of PURAC:

- Engraved serial numbers will be required on all CB rigs manufactured since January 1, 1977. This does not itself solve the theft problem, but it is a step in the right direction.
- This writer had the opportunity to preview a TV tape on CB and its problems produced by a group of TV stations as a means of educating the public about CB and its relation to the TVI problem.
- By the time you read this, there will be a newly reorganized edition of Part 95 available. It separates the technical requirements from operating regulations, so that all information a CB'er needs to know is in one spot. (The new issue does not yet reflect all rules changes.) Although this first revision is still in "legalese," Task Group 3 is currently rewriting it in English for a future edition. These new editions do *not* obsolete the editions in circulation in January, 1977, because they do not represent substantial changes in content.

The FCC has now issued more than 12 million CB licenses, and there are more than 18 million CB transmitters in use, according to FCC estimates. The FCC recently conducted test samplings in a number of areas across the nation and determined that fewer than 10% of the CB'ers are now operating without licenses, but that still represents well over a million operators who would rather risk a $10,000 fine than pay 80¢ per year for the right to operate legally.

Following the 40-channel announcement in July, license applications fell-off about 8% to 10% for each of the next three months, and were down to a level of about 300,000 per month by October. FCC expects them to increase again shortly after the beginning of 1977.

Incidentally, the average turn-around time for issuing licenses during the period from July through September was under 17 days, and the FCC now believes it can continue to issue them in that time frame even though the demand may increase. There was one instance late last spring when a whole block of licenses were erroneously sent to the wrong Zip Codes and were lost by the Postal Service. It was necessary for them to be reissued and remailed.

Nearly 10% of all applications for Class D licenses must be returned to the applicants. The FCC urges CB'ers to read Form 505 carefully. Each month, 20,000 applications are returned because the wrong fee was enclosed. (The *license fee of $4.00* for a Class D license has been in effect since March 1976, and the license is valid for a five-year period.) Each month, 10,000 license applications are returned because the applicant is too young. An applicant *must be 18* years of age to be granted a Class D CB license, though the restriction that the applicant must be a U.S. citizen has been removed.

Much of the business of the third general meeting of PURAC concerned the growing problems of CB-related electromagnetic interference. In addition to the obvious increase in noise, skip, and adjacent channel interference on CB itself, of more concern is the staggering increase in CB-caused TVI (television interference) and interference with solid-state audio equipment.

The leading causes of TVI are:

1. Harmonic radiation from CB units.
2. Use of illegal linears.
3. TV and audio equipment deficiencies.
4. Attempted "fringe" reception by the TV viewer.

We are not too concerned with the last two causes listed because CB is not at fault (more about this later). However, we *must* be concerned with the first two because they represent about one third of all TVI problems and they are the fault of CB users and equipment. The new rules make it the *legal* responsibility of the CB'er to correct this type of interference wherever a complaint has been filed.

Harmonic radiations occur at multiples of the operating or fundamental frequency. For CB, these would occur at 54 MHz (TV Channel 2), 81 MHz (TV Channel 5), 108 MHz, etc. The new regulations have attempted to reduce harmonic radiations generated by rigs built after January 1, 1977 by requiring that harmonics be suppressed at least 60 dB down from the power output of the fundamental frequency (the old specification required about 49 dB suppression). Thus new transceivers will be limited to 4 microwatts of harmonic output. The TV manufacturers wanted CB harmonics suppressed by 100 dB, but FCC set these comments aside with the warning that CB manufacturers had better prepare now for stiffer limitations in the future.

How can the CB'er tell whether TVI is caused by his rig or the TV receiver? It is very simple once the CB'er understands harmonic radiation. If the TV exhibits TVI only on channel 2 or channel 5 when the transmitter is keyed, it is probably the fault of the CB rig. If TVI shows up on other channels as well, the fault is probably that the TV receiver cannot filter out strong signals at 27 MHz.

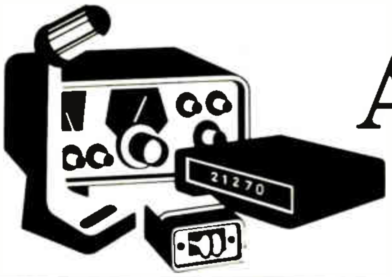
However, there is seldom a single cause of TVI. The FCC warns that, in most cases of bad interference, there are usually at least two system malfunctions before TVI becomes a problem. If the cause can be traced to the CB rig, then the CB'er *must* either correct it or cease operations. If the TV receiver is at fault, most TV manufacturers will supply corrective information and free parts, if necessary. Even though the fault is in the TV, it is in the interest of the CB'er to work with his neighbor to help him solve the problem.

Actually, harmonic radiation problems do not always originate in the CB transmitter, but they may also be introduced by any device which is inserted into the antenna lead line, such as an SWR meter or a coaxial switch. A linear amplifier in the line, even when *turned-off*, may increase the harmonic radiation by 9 dB or more. The increase in harmonic radiation when the linear is turned on may be much more than that.

On the point of linears, the FCC has determined that nearly all TV receivers within 500 feet of an operating linear will experience serious TVI, and nearly half the TV sets within a quarter mile will be affected. These figures are for linears which operate properly. Those which are not properly matched can cause even greater problems, but they are easily detected by FCC monitoring equipment. The FCC is aware that some stations are operating linears. Accordingly, the FCC has pledged to get them off the air, and if the illegal operators do not get rid of them voluntarily, it is prepared to seize their equipment and take the outlaws to court.

Consumer Electronics Legislation. At the present time, the FCC does not have any control power to set electromagnetic immunity standards for TV or other electronic communication or home entertainment devices which are not intended to transmit r-f emissions.

The Communications Reform Act of 1976, the so-called "Bell Bill" because it was largely written by telephone company lawyers and strengthened the monopolistic position of the communications utility companies, ran out of time when Congress adjourned. But it is bound to be revived by the 95th Congress. Extensive hearings are planned by both House and Senate committees. We believe that any such reform review should consider *all* our country's communications problems. ◇



Amateur Radio

By Herbert S. Brier

SPEECH PROCESSORS

YOU HAVE probably noticed that speech processors are being used more and more by radio amateurs. This recent trend prompted me to procure a logarithmic speech processor and see exactly what such a device can do to an SSB signal. My last involvement with speech processors was in the good-old AM days, when a good processor made a moderate improvement in the readability of weak voice signals. When the signals were subject to selective fading, processed signals often sounded louder but were actually *less* readable than when the processor was turned off. Consequently, our expectations for the new processor were not of the highest. However, after using it on the air for many months, we are convinced that the new generation of speech processors actually does what the designers claim—improve SSB signal readability up to six dB when conditions are worst. On the other hand, when signals are loud and clear, the majority of operators—especially locals—prefer the sound of unprocessed signals.

Historically, from the beginning of telephone and radiotelephone communications, engineers have worked to improve the efficiency of voice circuits. In ordinary conversation, the human voice can occupy a nominal bandwidth of 56 to 5700 Hz and a dynamic range up to 85 dB. Because the bandwidth of any signal is directly related to the highest frequency transmitted, extensive tests were conducted to determine the highest voice frequencies that had to be transmitted to preserve the readability of the reproduced speech. This was found to be nominally 3000 Hz. It was also found that frequencies below 500 Hz or so could be attenuated without reducing readability appreciably, although eliminating too many of them made the speech sound tinny.

As a result of such studies, international and domestic telecommunications regulations specify a 3000-Hz bandwidth for voice circuits. Many users prefer to transmit frequencies between 400 and 2500 Hz; others prefer 400 to 2800 Hz. Tailoring the modulating frequencies transmitted by a SSB transmitter is simple. Select the desired filter bandwidth—2100 Hz, for example. Then displace the (suppressed) carrier frequency by an amount equal to say, the lowest modulating frequency above the high-frequency knee of the filter selectivity curve (for lower sideband transmissions). Shift the carrier frequency by the same amount *below* the low-frequency knee for upper sideband transmissions.

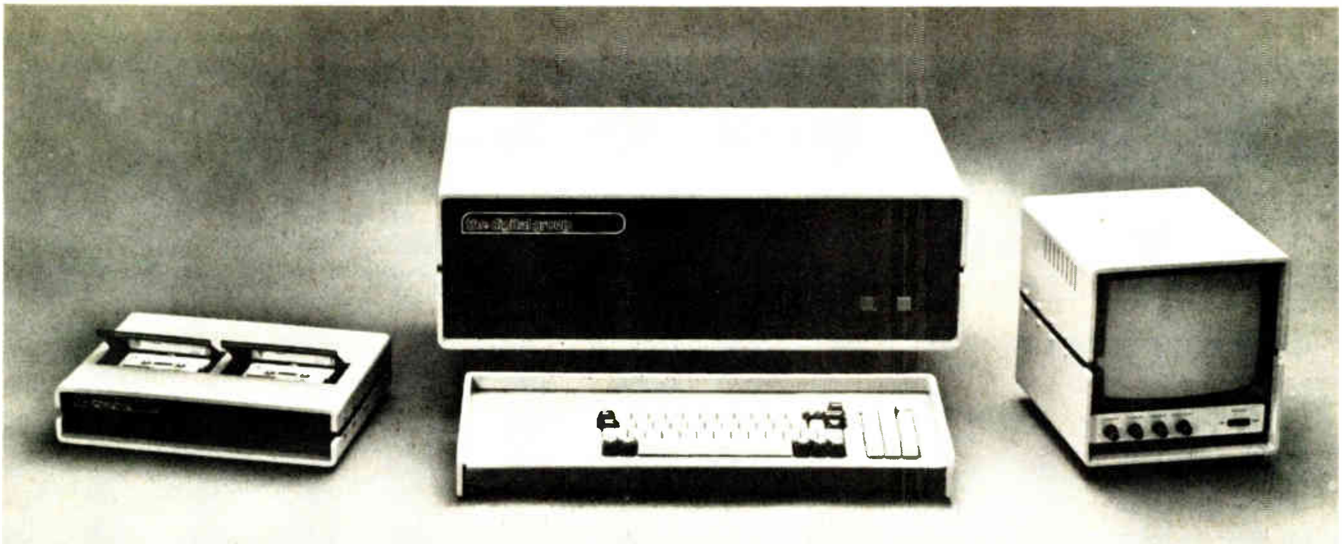
Amptitude Variations. It has been found that voice frequencies logarithmically centered around 100 Hz contain most of the speech energy and vary widely in amplitude but contribute little to the readability of the speech. In contrast, the frequencies between 300 and 3000 Hz do not contain much energy and do not vary much in amplitude but contain most of the spoken intelligence. Viewing the output signal of a voice-modulated SSB transmitter on an oscilloscope reveals that the lower voice components produce the highest modulation peaks, with the high-frequency peaks about 12 dB lower. Early speech processors increased the transmitter's speech amplifier gain to bring the amplitude of the higher frequency components up to the desired level. Those processors also chopped off the amplitude of all voice peaks to the threshold voltage of a stage. Feeding the clipped signals through a low-pass filter with a cutoff frequency of 3000 Hz kept the high-frequency harmonics generated by the clipper from modulating the transmitter. Unfortunately, the low-order harmonics of the clipped low frequencies still remained in the voice passband, making the processed speech sound "different" but barely more readable than unprocessed speech.

Logarithmic Speech Processors. The wide availability of versatile IC amplifiers has given new life to transmitter speech processors. In the logarithmic speech processor described in *QST* for August 1974, the microphone signal is first amplified 20 to 30 dB more than it would otherwise be. It is then passed through a high-pass filter with a low-frequency cutoff of approximately 50 Hz to remove most of the low-frequency, variable amplitude component. The signal is next fed to a logarithmic amplifier and clipper. The signal from the clipper—now a more-or-less constant-amplitude, 300-to-3000-Hz signal—goes through a low-pass filter with a 2950-Hz cut-off frequency to remove the high-frequency distortion products from the signal before it is applied to the microphone connector of the transmitter.

Another more-elaborate logarithmic speech processor (described in *QST* for March 1976) full-wave rectifies the audio signal before feeding it to the logarithmic amplifier and clipper. The output signal drives an exponential amplifier whose output modulates the transmitter. This processor also uses an input high-pass filter and an output low-pass filter.

Operating a Speech Processor. The first step in getting good results from a speech processor is to adjust the transmitter and its microphone gain control so that the transmitter r-f output peaks are not being clipped before the speech processor is placed in the line. Tune up the transmitter into a dummy load and turn the microphone gain control so that the maximum output peaks displayed on an oscilloscope just start to decrease in height. Next, turn on the processor with the microphone connected to the processor input and its output connected to the transmitter microphone jack. With the processor input and output controls full on, talk into the microphone while backing down the output control until the maximum pattern height on the oscilloscope is the same as after the mike gain adjustment. The processor input gain control is adjusted to match propagation conditions. In general, the better conditions are, the less processing should be used. When signals are strong and interference is weak, some operators turn off their processors entirely.

One of the most annoying characteristics of some speech processors is the loud roar that replaces the operator's voice when he stops talking. This roar is usually most evident when transmissions are controlled with a push-to-talk switch (PTT) rather than by VOX. We discovered by experiment that VOX operation with a short delay to cut off the roar generated by a noisy blower eliminated the criticism of the signal elicited by PTT operation. ◇



Cabinets clockwise from top: CPU, Dual-cassette drive, Keyboard, 9" Monitor

Meet The Digital Group

If you are seriously considering the purchase of a microcomputer system for personal or business use . . . or just beginning to feel the first twinges of interest in a fascinating hobby . . . the Digital Group is a company you should get acquainted with.

For many months now, we've been feverishly (and rather quietly) at work on our unique, high-quality product—a microcomputer system designed from the inside out to be the most comprehensive, easy-to-use and adaptable system you'll find anywhere. And our reputation has been getting around *fast*. In fact, you may have already heard a little something about us from a friend. We've found our own best salesmen are our many satisfied customers.

There's a good reason. Simply, the Digital Group has a lot to offer: state-of-the-art designs, a totally complete systems philosophy, unexcelled quality, reasonable software, affordable prices and the promise that our products will not become rapidly obsolete, even in this fast-moving, high-technology field.

The Advantages

Here are a few specific advantages of our product line:

- We offer interchangeable CPUs from different manufacturers (including the new "super chip"—the Z-80 from Zilog) which are interchangeable at the CPU card level. That way, your system won't become instantly obsolete with each new design breakthrough. The major portion of your investment in memory and I/O is protected.
- Digital Group systems are complete and fully featured, so there's no need to purchase bits and pieces from different manufacturers. We have everything you need, but almost any other equipment can be easily supported, too, thanks to the universal nature of our systems.
- Our systems are specifically designed to be easy to use. With our combination of TV, keyboard, and cassette recorder, you have a system that is quick, quiet, and inexpensive. To get going merely power on, load cassette and go!
- Design shortcuts have been avoided—all CPUs run at full maximum rated speed.
- All system components are available with our beautiful new custom cabinets. And every new product will maintain the same unmistakable Digital Group image.

The Features

Digital Group Systems—CPUs currently being delivered: Z-80 by Zilog 8080A/9080A 6800 6500 by MOS Technology

All are completely interchangeable at the CPU card level. Standard features with all systems:

- Video-based operating system
- Video/Cassette Interface Card
  512 character upper & lower case video interface
  100 character/second audio cassette interface
- CPU Card
  2K RAM, Direct Memory Access (DMA)
  Vectored Interrupts (up to 128)
  256 byte 1702A bootstrap loader
  All buffering, CPU dependencies, and housekeeping circuitry
- Input/Output Card
  Four 8-bit parallel input ports
  Four 8-bit parallel output ports
- Motherboard

Prices for standard systems including the above features start at $475 for Z-80, $425 for 8080 or 6800, $375 for 6500.

More

Many options, peripherals, expansion capabilities and accessories are already available. They include rapid computer-controlled cassette drives for mass storage, memory, I/O, monitors, prom boards, multiple power supplies, prototyping cards and others. Software packages include BASICs, Assemblers, Disassemblers, Text Editors, games, ham radio applications, software training cassettes, system packages and more (even biorhythm).

Sounds neat—now what?

Now that you know a little about who we are and what we're doing, we need to know more about you. In order for us to get more information to you, please take a few seconds and fill in our mailing list coupon. We think you'll be pleased with what you get back.

the digital group

P.O. Box 6528
Denver, Colorado 80206
(303) 777-7133

OK, I'd like to get to know you guys better.
Send me the whole package!

Name ____________________

Address ____________________

City/State/Zip ____________________

CIRCLE NO 21 ON FREE INFORMATION CARD

Computer Bits

By Stephen B. Gray

COMPUTER STORES

THE FIRST hobby-computer store opened in Los Angeles in July 1975. Now, a year and a half later, there are well over 100 of them across the country. Why such a rapid rise? As one store owner observed, a computer store "provides the place, the people and the knowledge to help out the hobbyist." It provides the hobbyist with a place to look over different computers, to ask questions, and often the chance to try out a computer, hands-on. In this way, he can look before he leaps.

A Typical Store. At one time there were two basic types of stores. Both sold a variety of peripherals, but one sold only MITS Altair computers, while the other sold several other makes. The former type of store can concentrate on a single line of computers, and develop an expertise in the sales, operation and service of a minimum number of mainframe machines. Now, however, as different models pour into the marketplace, some stores that previously sold only the 8800b and 680b computers also carry others. A substantial number, though, still prefer to concentrate on the two Altair models, offerring a host of peripherals to go with them.

If you walk into a typical computer store today, you'll find at least one operating computer connected to a Teletype or to a keyboard terminal and a TV monitor or receiver, or to a complete CRT terminal. Sometimes a peripheral or two are also on-line, such as a cassette-storage device, or a graphics terminal or printer. Other computers are on counters or in display cases, along with memory boards, Teletype paper and tape, extender boards, power supplies, TV monitors, interface boards, printers, terminals, breadboards, keyboards, etc. Not every store will have all these, but many do.

Test equipment is also on the shelves, including logic probes, logic monitors, perhaps a pulse generator, and maybe even a frequency counter. Some tools may also be on display, such as for wire-wrapping, soldering and desoldering. There are computer stores that also carry basic tools such as pliers, screwdrivers, soldering irons, etc.

A good supply of parts is essential, since half of the hobby computers built from kits don't work when first turned on. Not all of that is caused by solder bridges and miswiring. So, to repair the damage, the hobbyist may need IC's, LED's, and IC sockets, which most stores carry, along with breadboarding hardware, hookup wire, etc.

Books and Software. Many stores devote a large amount of space to books. As one store manager put it, "We carry books about everything on computers and data processing except the social issues." That store has books on hardware design, digital techniques, flowcharting, even on multiple regression and telecommunications. They have programming texts on assembler, BASIC, APL, FORTRAN, ALGOL, and several other languages. They also carry software books, offering assembly-language programs (such as the Scelbi series on the 8080 and 8008) and BASIC programs (including "101 BASIC Computer Games"). In addition to programs being offered as listings in these books, the store also has many programs on PROM memory chips, on paper tape, and on cassette.

Magazine racks are used by many stores to display up to half a dozen different hobby magazines. And there's always a bulletin board, with notices of meetings, "For Sale" ads for computer hardware, listings of computer courses, etc.

You may also find T-shirts, lettered with slogans such as "Does Not Compute," "Real Time Operator," or "Baud Rated."

Chains. Most of the stores are independently owned. There are several chains, one with over a dozen stores, mainly in California, another with half a dozen in the Northeast. Late last year, an industrial electronics distributor announced plans to establish computer display counters in their twelve U.S. branches, with "working models of five microprocessor kits, three non-assembled kits, plus four additional microprocessor chips not in kit form. Two complete developmental systems will be available. In addition, books, power supplies, tape readers, and accessories in kit form will be carried."

The company's president says, "The industrial distributor has never really catered to the hobbyist, but always allowed cash sales because many engineers and buyers from industry bought small quantities for their personal use. With the advent of the microprocessor, a whole new market of "Computerists" has developed. These people are engineers, programmers, and technicians from industry who are learning, designing, and programming microprocessor systems at home. They want a place to browse, read, have hands-on practice, and see what they are buying."

Repair Facilities. Some computer stores offer repair services. One store in New York fixes an item free if you bought it there and if it's still within the warrantee period. After that, the charge is $10 to $12 an hour. The alternative is to send your computer or pc board or peripheral to the manufacturer, and if the warrantee has expired, you pay $15 to $22 an hour, plus shipping. The most common problems with computers built from kits are solder bridges and miswiring. If the kit has otherwise been put together correctly, and if the store has a good digital electronics technician, you might save time and money by having your computer, or board, or whatever, repaired right there. One store manager expects his repair business to increase as more and more people with little or no electronics knowledge or ability try to build a computer, so he's expanding his service department.

If you can't get your computer to work, and don't know if it's the fault of the CPU board, or a memory board, or the rest of the computer, you can narrow it down by taking the two or three boards into a computer store that has a machine like yours in operation. They'll plug in your boards, one at a time, after first checking for shorts that might cause trouble, and you'll soon have a better idea of where the problem is. There's no charge for this informal checkout, unless you want the store to go further in localizing the problem. However, since there are usually several hobbyists in a computer store at almost any time of the day, especially during the lunch hour and after work, you might get some very useful advice from someone who had the same problem.

Idea Exchange. Because computer stores are often meeting places for computer "freaks," they are good places to go to listen in, if you're a beginner, and to join in the conversation, once you've learned the ropes. You can learn what others think of this or that computer or pc board or program, you can often find out from the store manager what new products are about to become available, and you can often watch one of the store assistants checking out a new piece of equipment. You can also often watch other hobbyists using the store's computer to check out some new program or peripheral, and thus help you decide if it's something you want to get into.

In short, there's no better place than a good computer store to see what's available, to find out what's going to be on the market, to chat with others afflicted with computeritis, and to get help. ◇

The Computer Mart (New York) typifies hobbyist stores around country.

Unique full-function 8-digit wrist calculator... available only as a kit.

A wrist calculator is the ultimate in common-sense portable calculating power. Even a pocket calculator goes where your pocket goes—take your jacket off, and you're lost!

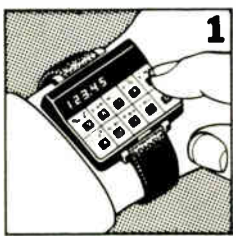
But a wrist-calculator is only worth having if it offers a genuinely comprehensive range of functions, with a full-size 8-digit display.

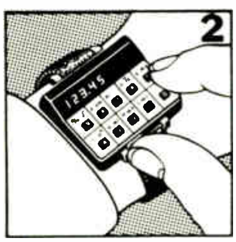
This one does. What's more, because it *is* a kit, supplied *direct* from the manufacturer, it costs only a very reasonable $19.95. And for that, you get not only a high-calibre calculator, but the fascination of building it yourself.

How to make 10 keys do the work of 27

The Sinclair Instrument wrist calculator offers the full range of arithmetic functions. It uses normal algebraic logic ('enter it as you write it'). But in addition, it offers a % key; plus the convenience functions $\sqrt{x}$, $1/x$, x^2; plus a full 5-function *memory*.

All this, from just 10 keys! The secret? An ingenious, simple three-position switch. It works like this.





1. The switch in its normal, central position. With the switch centered, numbers—which make up the vast majority of key-strokes—are tapped in the normal way.

2. Hold the switch to the left to use the functions to the left above the keys...

3. and hold it to the right to use the functions to the right above the keys.

The display uses 8 full-size red LED digits, and the calculator runs on readily-available hearing-aid batteries to give weeks of normal use.

Assembling the Sinclair Instrument wrist calculator

The wrist calculator kit comes to you complete and ready for assembly. All you need is a reasonable degree of skill with a fine-point soldering iron. It takes about three hours to assemble. If anything goes wrong, Sinclair Instrument will replace any damaged components free: we want you to enjoy assembling the kit, and to end up with a valuable and useful calculator.

Actual Size

Contents
Case and display window.
Strap.
Printed circuit board.
Switches.
Special direct-drive chip (no interface chip needed).
Display.
Batteries.

Everything is packaged in a neat plastic box, and accompanied by full instructions. The only thing you need is a fine-point soldering iron.

All components are fully guaranteed, and any which are damaged during assembly will be replaced free.

The wrist-calculator kit is available only direct from Sinclair Instrument. Take advantage of this 10 day money-back offer.

Send the coupon today.

Sinclair Instruments Inc.
6 Commercial Street
Hicksville, N.Y. 11801

To: **Sinclair Instruments Inc.**
6 Commercial Street
Hicksville, NY 11801 PE 2

Please send me

____ Sinclair wrist calculator kit(s) at $19.95 $____

Sales tax (NY residents) ____

Shipping & handling ($2.50 per unit) ____

Enclosed is check/MO (payable to Sinclair Instruments Inc.) TOTAL $____

Name ____

Address ____

City ____

State ____ Zip ____

I understand that you will refund the purchase price of the kit in full if I return it in saleable conditiion within 10 days of receipt.

NOAA WEATHER RADIO OPERATING LOCATIONS

The National Oceanic and Atmospheric Administration (NOAA) National Weather Service is the sole government-operated radio system for communicating attack or weather disaster warnings directly to the public—as well as regular weather reports. A vhf high-band receiver or scanning monitor is required to pick up these broadcasts.

Transmitter Site	Call Letters	Frequency (MHz)
Alabama		
*Birmingham	KIH-54	162.55
*Cheha	KIH-58	162.475
*Dozier	KIH-59	162.55
*Florence	KIH-57	162.475
Huntsville	KIH-20	162.40
*Louisville	KIH-56	162.475
Mobile	KEC-61	162.55
*Montgomery	KIH-55	162.40
*Tuscaloosa	KIH-60	162.40
Alaska		
Anchorage	KEC-43	162.55
Seward	KEC-81	162.55
Arizona		
Phoenix	KEC-94	162.55
California		
Coachella	KIG-78	162.40
Crescent City, Calif./ Brookings, Ore.	KIH-37	162.55
Eureka	KEC-82	162.40
Los Angeles	KWO-37	162.55
Monterey	KEC-49	162.40
Point Arena	KIH-30	162.40
Sacramento	KEC-57	162.40
San Diego	KEC-62	162.40
San Francisco	KHB-49	162.55
San Luis Obispo	KIH-31	162.55
Santa Barbara	KIH-34	162.40
Colorado		
Denver	KEC-76	162.55
Connecticut		
New London	KHB-47	162.40
Florida		
Daytona Beach	KIH-26	162.40
Jacksonville	KHB-39	162.55
Key West	KIH-25	162.40
Miami	KHB-34	162.55
Panama City	KGG-67	162.55
Pensacola	KEC-86	162.40
Tallahassee	KIH-24	162.40
Tampa	KHB-32	162.55
West Palm Beach	KEC-50	162.40
Georgia		
Atlanta	KEC-80	162.55
Savannah	KEC-85	162.40
Hawaii		
Hilo	KBA-99	162.55
Honolulu	KBA-99	162.55
Kokee	KBA-99	162.40
Mt. Haleakala	KBA-99	162.40
Illinois		
Chicago	KWO-39	162.55
Indiana		
Evansville	KIG-76	162.55
Indianapolis	KEC-74	162.55
Iowa		
Des Moines	KEC-75	162.55
Kansas		
Wichita	KEC-59	162.55
Kentucky		
Ashland	KIH-39	162.55
Bowling Green	KIH-45	162.40
Covington	KIH-42	162.55
Hazard	KIH-40	162.475
Lexington	KIH-41	162.40
Louisville	KIH-43	162.475
Mayfield	KIH-46	162.475
Somerset	KIH-44	162.55
Louisiana		
Baton Rouge	KHB-46	162.40
Lake Charles	KHB-42	162.55
Morgan City	KIH-23	162.475
New Orleans	KHB-43	162.55
Maine		
Ellsworth	KEC-93	162.40
Portland	KDO-95	162.55
Maryland		
Baltimore	KEC-83	162.40
Salisbury	KEC-92	162.40
Massachusetts		
Boston	KHB-35	162.40
Hyannis	KEC-73	162.55
Michigan		
Alpena	KIG-83	162.55
Clio	KIH-29	162.40
Detroit	KEC-63	162.55
Grand Rapids	KIG-63	162.55
Marquette	KIG-66	162.55
Sault Sainte Marie	KIG-74	162.55
Traverse City	KIH-22	162.55
Minnesota		
Duluth	KIG-64	162.55
Minneapolis	KEC-65	162.55
Mississippi		
*Ackerman	KIH-51	162.475
*Booneville	KIH-53	162.55
*Bude	KIH-48	162.55
Gulfport	KIH-21	162.40
*Iverness	KIH-50	162.55
Jackson	KIH-38	162.40
*McHenry	KIH-47	162.475

*Oxford	KIH-52	162.40
*Rose Hill	KIH-49	162.55
*Beaufort	WXJ-23	162.475
*Columbia	WXJ-20	162.40
*Florence	WXJ-22	162.55
*Greenville	WXJ-21	162.55
Missouri		
Kansas City	KID-77	162.55
St. Joseph	KEC-77	162.40
St. Louis	KDO-89	162.55
Nebraska		
*Omaha	KIH-61	162.40
New Jersey		
Atlantic City	KHB-38	162.40
New Mexico		
Albuquerque	KIG-84	162.40
New York		
Buffalo	KEB-98	162.55
New York City	KWO-35	162.55
Rochester	KHA-53	162.40
North Carolina		
Cape Hatteras	KIG-77	162.55
New Bern	KEC-84	162.40
Wilmington	KHB-31	162.55
Ohio		
Akron	KDO-94	162.40
Cleveland	KHB-59	162.55
Columbus	KIG-86	162.55
Sandusky	KHB-97	162.40
Oklahoma		
Tulsa	KIH-27	162.55
Oregon		
Astoria	KEC-91	162.40
Coos Bay	KIH-32	162.40
Eugene	KEC-42	162.40
Newport	KIH-33	162.55
Portland	KIG-98	162.55
Pennsylvania		
Erie	KEC-58	162.40
Philadelphia	KIH-28	162.475
Pittsburgh	KIH-35	162.55
South Carolina		
Charleston	KHB-29	162.55
Myrtle Beach	KEC-95	162.40
Tennessee		
Nashville	KIG-79	162.55
Texas		
Brownsville	KHB-33	162.55
Corpus Christi	KHB-41	162.55
Dallas	KEC-56	162.40
Fort Worth	KEC-55	162.55
Galveston	KHB-40	162.55
Houston	KGG-68	162.40
Pharr	KHB-33	162.40
Utah		
Salt Lake City	KEC-78	162.55
Vermont		
Burlington	KIG-60	162.40
Virginia		
Manassas	KHB-36	162.55
Norfolk	KHB-37	162.55
Washington		
Neah Bay	KIH-36	162.55
Seattle	KHB-60	162.55
Yakima	KIG-75	162.55
Wisconsin		
Green Bay	KIG-65	162.55
Milwaukee	KEC-60	162.40

*Stations expected to be in operation by end of 1977.

Operation Assist

If you need information on outdated or rare equipment—a schematic parts list etc.—another reader might be able to assist. Simply send a postcard to Operation Assist, POPULAR ELECTRONICS, 1 Park Ave., New York, NY 10016. For those who can help readers, please respond directly to them. They'll appreciate it. (Only those items regarding equipment not available from normal sources are published.)

Blaupunkt Verona type 20103 hi-fi radio. Any service material, especially dial cord restringing info. Lewyn F. Cutten, Jr., 102 W. Idaho St., Ellensburg, WA 98926.

Hallicrafters S-20-R shortwave receiver. Any information or owner's manual or photocopy. Bradley Richelson, 8 Randolph St., Plymouth, NH 03264.

RCA military receiver Model RAL-6, type CRV-46156. Serial 172. Rect. Power Unit # CRV-20131. Circa December 29, 1941. Covers 0.3 to 23 MHz. Schematic diagrams or any other info. George Tobin, New Gloucester, ME 04260.

Superior Instruments Co. Model TV-11 Tube Tester, Model 76 CR bridge and signal tracer, Model 77 VTVM. Instruction manuals and schematics. John Schreyer, W2KQV, 610 Bay 25 St., Far Rockaway, NY 11691.

Philco-Tropic Model 39-750. Schematic and/or service manual and parts source. Irving Leiboff, 667 E. 34 St., Brooklyn, NY 11203.

Hammarlund Model SP-600J receiver. Alignment information. W. Harwood, Box 563, Hudson Hope, BC, Canada V1C 1V0.

Paco Model C-20 Resis-Capacity Ratio Bridge. Instruction manual and schematic. Jose Varas, 515 4th St., Union City, NJ 07087.

Realistic Model 105 Tube Tester. Schematic and/or operations manual. Dr. Ali Allmaker, Woodcock Rd., Williamstown, MA 01267.

Jetronic Model AN-USM-81 oscilloscope. Need schematic and instruction manual. Ben Goble, Rockmont College, 8801 W. Alameda Ave., Lakewood, CO 80226.

Radson Model RT-70A radio telephone. Operation manual and wiring diagram. John K. Jakvis, DR 520, Schertz, TX 78154.

Panoramic Model LP-1 sonic analyzer. Need schematic, manual or source of information. Gregory A. Marks, 1737 Sanford, Ann Arbor, MI 48103.

De Vry 5" oscilloscope and transistor voltmeter. Construction manual or schematics needed. Paul Etchason, 406 W. Monroe, Kokomo, IN 46901.

Arkay FL-10 amplifier. Need service or operating manual and schematic. Edwin L. Dews, 703 Tammy, San Antonio, TX 78216.

Friden Model 132 electronic calculator. Schematic and/or service manual. Steven Eubanks, 8833 Westlawn Blvd., Olmsted Falls, OH 44138.

Kaar Model TR 327 Citizens Band radio. Schematic and alignment data. M. W. Murphy, Rt. 2 Box 554, Hayden Lake, ID 83835.

RCA Model 816K superheterodyne receiver. Need any available information. Jim Burrell, Rte. 2, Sallis, MS 39160.

Bendix RT-221AE-28 aircraft transceiver. Need service manual or schematic. George Kapsokavadis, 23 Kolotroni St., Kerkya, Greece.

Knightkit VTVM. Need schematic and calibration instructions. Don Bradley, P. O. Box 1213, Uallejo, CA 94590.

Friden Model 5023 computyper. Operating and service manuals. John G. Peters, 1905 Victory Blvd., Unit 11, Glendale, CA 91201.

Ultronic Systems Videomaster 7700 computer terminal. Need service manual, modem requirements and any available data. Charles E. Gerhardt, 2134 Springhill, Dallas, TX 75228.

Hallicrafter Model S-40B receiver. Schematic or any available information. Ron J. Jones, 4871 Kingridge Dr., San Jose, CA 95124.

Alexander Model ALX CR900 battery-ac tape recorder. Need schematic and service manual. Mr. Bailey, 426 Slocum Ave., Neptune, NJ 07753.

WHY THE BOX?

Perfect listening.

All Stax Earspeakers™ connect through an adaptor box to your power amp, integrated amp or receiver, just like speakers. The box permits a vastly superior electrostatic principle to be used in Stax personal listening instruments.

Results? Incredible transients. Response curves that match the human ear perfectly. And no "flaking" of preamp circuitry that occurs with those non-box "headphones" that plug into the front panel.

Why the box? Because you can tell the difference.

STAX: The inventor of the electrostatic earspeaker.

Distributed in the U.S. by:

American Audioport
Columbia, MO 65201

CIRCLE NO 65 ON FREE INFORMATION CARD

Electronics Library

DIGITAL EQUIPMENT SERVICING GUIDE

by Robert G. Middleton

This book was written for the technician whose troubleshooting experience has been limited to linear circuits such as in radio and TV circuits. A great many digital circuits are described here, along with information on how they work, what can go wrong with them, and how to detect and repair the problems. The seven chapters cover basic technology, gates, adders, subtractors, counters, display devices, digital logic in electronic instruments, and digital frequency display.

Published by Howard W. Sams & Co., 4300 W. 62nd St., Indianapolis, IN 46206. 104 pages. $5.95 soft cover.

THE RECORDING STUDIO HANDBOOK

by John M. Woram

Eighteen chapters cover the techniques of creative sound recording and just about every aspect of modern recording technology. The book is in eight sections, on basics (the decibel, sound), microphones and loudspeakers, signal-processing devices (equalizers, compressors, phasing, etc.), magnetic recording, noise and noise reduction, recording consoles, recording techniques (recording session, mixdown session), and appendices that include an extensive bibliography.

Published by Sagamore Publishing Co., 1120 Old Country Rd., Plainview, NY 11803. 496 pages. $35.00 hard cover.

THE CB OPERATOR'S KIT

by the Editors of Consumers Guide

Packed in a waterproof plastic pouch that fits conveniently into an auto's glove compartment, the kit includes a "CB Operator's Manual & Log," a road map of the US, 10-code card, and a CB decal with space for the operator's call number and handle. The book discusses how CB radio works, how to get your license, basic rules for operation, installing a CB radio in your car, theft prevention, using the channels, the many uses of CB, a coast-to-coast trip using CB, dictionary of CB jargon, and the FCC rules and regulations. A log section provides space to record calls made, while another section is for keeping track of "CB Buddies." The map shows, by state and highway, the channels most frequently used by truckers, emergency personnel and police, and on the back is a list of almost 100 "town handles," from Monkey Town to Cowboy City, plus a large 10-33 sign for display in emergencies.

Published by Simon and Schuster, 630 Fifth Ave., New York NY 10020. 192 pages. $5.95 soft cover.

ELECTRONICS MARKET PLACE

NON-DISPLAY CLASSIFIED: COMMERCIAL RATE: For firms or individuals offering commercial products or services, $2.25 per word (including name and address). Minimum order $33.75. Payment must accompany copy except when ads are placed by accredited advertising agencies. Frequency discount; 5% for 6 months; 10% for 12 months paid in advance. **READER RATE:** For individuals with a personal item to buy or sell, $1.35 per word (including name and address.) No minimum! Payment must accompany copy. **DISPLAY CLASSIFIED:** 1" by 1 column (2-1/4" wide), $260.00. 2" by 1 column, $520.00. 3" by 1 column, $780.00. Advertiser to supply film positives. For frequency rates, please inquire.

GENERAL INFORMATION: First word in all ads set in caps at no extra charge. All copy subject to publisher's approval. All advertisers using Post Office Boxes in their addresses **MUST** supply publisher with permanent address and telephone number before ad can be run. Advertisements will not be published which advertise or promote the use of devices for the surreptitious interception of communications. Ads are not acknowledged. They will appear in first issue to go to press after closing date. Closing Date: 1st of the 2nd month preceding cover date (for example, March issue closes January 1st. Send order and remittance to **POPULAR ELECTRONICS**, One Park Avenue, New York, New York 10016, Attention: Hal Cymes.

FOR SALE

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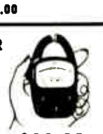

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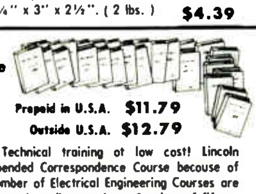

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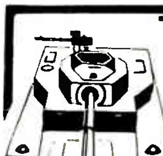

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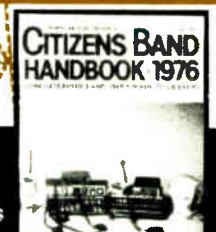

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1mf to 300mf in mixture of voltages. 100% marked 'n good. 2E3226

BARREL KIT #119 PRECISION RESISTORS 100 for $1.98
PREFORMED! Designed for printed circuit work. 1/4, 1/2 w. Marked values, 1 and 2% values. 2 ozs. 2E3205

BARREL KIT #118 MINI SCRS 50 for $1.98
UNBELIEVABLE! TO-92 plastic SCRS in barrels . . . rite from factory. Includes all voltages up thru 200 prv. 2E3135

BARREL KIT #115 MOLEX SOCKETS 200 for $1.98 100% good Cat. No. 2E3144
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BARREL KIT #112 MICRO MINI LEDS 40 for $1.98
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BARREL KIT #109 TERMINAL STRIPS 100 for $1.98
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BARREL KIT #104 SLIDE VOLUME CONTROLS 10 for $1.98
Cat. No. 2E3057

BARREL KIT #101 RESISTOR SPECIAL 200 for $1.98
Includes: 1/8, 1/4, 1/2, 1, 2-watters, carbon. 8 oz. 100% good. 2E3054

BARREL KIT #99 PHOTO ELECTRIC CELLS 10 for $1.98
Asst. GE types, CDS types. Mixed by factory. Big job for us to separate. 100% good. Cat. No 2E3052

BARREL KIT #93 HALF WATTERS 200 for $1.98
Resistor factory tried to fool us by mixing 100% color-coded resistors in barrel. But value is there. 4 oz. 2E3046 Untested

BARREL KIT #92 3 AMP EPOXY RECTIFIERS Untested **100 for $1.98**
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BARREL #91 SILVER MICAS 100 for $1.98
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BARREL KIT #88 LITRONICS LED READOUTS 10 for $1.98
747's, 727's, singles, triples, etc. .33 to 0.6. Bot from factory, all mixed have fun! No. 2E2861

BARREL KIT #87 NATIONAL IC BONANZA 100 for $1.98
Types 8000, 7400 series, DTL's, ROMs, registers, clock & calc. chips, linears etc Cat. No. 2E2860 Untested.

BARREL KIT #86 HOBBY LEDS 40 for $1.98 Untested
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BARREL KIT #83 15 for $1.98 LM-340T VOLT REG
Factory rejected them for length of leads. May include 5, 6, 8, 12, 15, 18, 24 volts Power tab Cat. 2E2635

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BARREL KIT #76 1-WATT ZENERS 100 for $1.98
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BARREL KIT #75 400MW ZENERS 100 for $1.98
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BARREL KIT #73 TRANSISTOR ELECTROS 50 for $1.98
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BARREL KIT #68 2 WATTERS 100 for $1.98 100% good.
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BARREL KIT #65 MIXED READOUTS 10 for $1.98
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BARREL KIT #62 MIXED IC'S 100 for $1.98
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BARREL KIT #61 POLYSTYRENE CAPS 100 for $1.98
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BARREL KIT #56 POWERS! POWERS! $1.98 100 for
Large distributor cleaned house. Barrels of power resistors 3 to 7 watts. Cat. No 2E2724

BARREL KIT #54 8 DIGIT READOUTS 10 for $1.98
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BARREL KIT #48 741 MINI DIP "BONANZA" 50 for $1.98
Barrels 'n barrels of 'em. This is a buyer's market. How many can we get tested. Cat. No. 2E2626

BARREL KIT #46 G.E. 3.5 WATT AMPLIFIERS 25 for $1.98
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BARREL KIT #40 PNP HIGH-POWER TRANSISTORS 20 for $1.98
Popular germanium TO-3 case 2E2618 100% good

BARREL KIT #39 2N3055 HOBBY TRANSISTORS 15 for $1.98
Fallouts of the famous 2N3055. 2E2617 100%

BARREL KIT #37 1 AMP "BULLETT" RECTIFIERS Untested **100 for $1.98**
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BARREL KIT #35 NEON LAMPS 30 for $1.98 100% good.
Famous NE-2's. All prime, but factory made millions and barrel'ed 'em. Your advantage Cat. No 2E2613

BARREL KIT #31 METALLIC RESISTORS 100 for $1.98
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BARREL KIT #30 PREFORMED RESISTORS 200 for $1.98
We got barrels of 1/4 and 1/2" watters for pc use. 100, 1/4, 100 1/2 watters. No. 2E2608 100% good

BARREL KIT #27 PREFORMED DISCS 100 for $1.98
Hi-Fi mfr's shelf inventory but he dumped 'em in barrels. Preformed, for PC use. Mixed values too! 2E2605

BARREL KIT #26 PLASTIC TRANSISTORS 100 for $1.98 Untested.
Type TO-92 (TO-18), all manufacturers, variety of 2N #'s. Cat. No 2E2604

BARREL KIT #25 METAL CAN TRANSISTORS 100 for $1.98
Includes TO-5, TO-1, TO-18, etc., assorted 2N numbers, unmarked etc. Cat. No 2E2603 Untested.

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SN7403N	.16	SN7447N	.69	SN74100N	.98	SN74165N	.99
SN7404N	.16	SN7448N	.76	SN74106N	.65	SN74173N	1.39
SN7405N	.18	SN7450N	.16	SN74107N	.33	SN74174N	.97
SN7406N	.20	SN7451N	.16	SN74112N	.65	SN74175N	.89
SN7407N	.25	SN7454N	.16	SN74113N	.65	SN74176N	.79
SN7408N	.25	SN7464N	.16	SN74114N	.65	SN74177N	.79
SN7409N	.18	SN7470N	.45	SN74121N	.38	SN74181N	2.05
SN7410N	.16	SN7472N	.34	SN74123N	.59	SN74184N	1.75
SN7411N	.25	SN7473N	.36	SN74125N	.59	SN74185N	1.75
SN7413N	.45	SN7474N	.31	SN74126N	.59	SN74190N	1.15
SN7417N	.32	SN7475N	.49	SN74132N	1.00	SN74191N	1.05
SN7420N	.16	SN7476N	.31	SN74141N	.88	SN74192N	.87
SN7421N	.29	SN7478N	.79	SN74145N	.69	SN74193N	.83
SN7423N	.35	SN7483N	.69	SN74148N	1.29	SN74195N	.73
SN7425N	.27	SN7485N	.86	SN74150N	.99	SN74196N	.88
SN7430N	.16	SN7489N	1.95	SN74151N	.70	SN74198N	1.49
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SN7440N	.16	SN7492N	.47	SN74155N	.70	SN74251N	1.09
SN7441N	.84	SN7493N	.47	SN74157N	.70	SN74284N	5.95
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★ LINEAR

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LM106H	2.50	LM320K 12	1.45	LM382N	.79	LM1458CN	.65	SG4501T	2.40
LM300H	.80	LM320K 15	1.45	LM555CN	.58	LM1496N	.95	SG4501N	2.40
LM301H	[illegible]	LM320T 5	1.75	LM556CN	[illegible]	LM2111N	1.95	SG3524	[illegible]
LM301CN	[illegible]	LM320T 12	1.75	LM558CN	1.45	LM2901N	1.95	RC4194T	6.95
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LM307H	[illegible]	LM339N	1.55	LM710N	.70	LM7534N	2.20	RC4558CN	[illegible]
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LM308CN	[illegible]	LM340K 8	1.95	LM711H	.39				
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LM312H	[illegible]	LM370H	1.65	LM741CH	.35				
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LM320K 5	[illegible]	LM380CN	1.05	LM747N	.75				
				LM748H	.39				
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CD4002	.25	CD4028	1.50	CD4081	.35
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CD4007	.25	CD4030	.60	CD4510	1.95
CD4008	1.95	CD4033	2.49	CD4517	1.40
CD4009	.48	CD4034	4.95	CD4516	1.95
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CD4011	.28	CD4040	2.10	CD4520	2.49
CD4012	.28	CD4042	1.45	CD4522	2.56
CD4013	.60	CD4043	1.45	CD4526	2.56
CD4014	1.95	CD4044	1.95	CD4527	2.70
CD4015	1.95	CD4049	.61	CD4528	1.50
CD4016	.59	CD4050	.61	CD4531	1.99
CD4017	1.25	CD4051	2.25	CD4543	2.25
CD4018	2.39	CD4066	1.20	CD4555	1.75
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CD4020	1.35	CD4069	.35	CD4581	4.95
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CD4023	.29	CD4071	.35	CD4585	2.45
CD4024	1.29	CD4072	.35	Also	
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7402N	10	7447N	99	74125N	79	74191N	$1.30
7403N	16	7448N	99	74126N	79	74192N	$1.10
7404N	19	7450N	26	74132N	70	74193N	$1.10
7405N	20	7451N	26	74141N	88	74194N	95
7406N	25	7453N	26	74145N	70	74195N	95
7407N	25	7454N	26	74147N	$1.59	74196N	95
7408N	21	7470N	45	74148N	$1.29	74197N	95
7409N	21	7472N	30	74150N	$1.15	74198N	$1.45
7410N	21	7473N	30	74151N	98	74199N	$1.85
7411N	21	7474N	30	74153N	98	74251N	$1.45
7412N	21	7475N	69	74154N	$1.15	74279N	$1.10
7413N	45	7476N	42	74155N	95	8093N	49
7414N	89	7480N	70	74156N	95	8094N	49
7416N	35	7482N	95	74157N	95	8095N	99
7417N	35	7483N	95	74160N	99	8096N	99
7420N	19	7485N	89	74161N	99	8097N	99
7421N	35	7486N	28	74162N	99	8098N	99
7423N	35	7489N	$1.88	74163N	98	75150N	$1.70
7425N	36	7490N	60	74164N	99	75450N	$1.10
7426N	35	7491N	70	74165N	99	75451N	58
7427N	35	7492N	59	74166N	$1.10	75452N	59
7428N	28	7493N	79	74170N	$4.20	75453N	59
7430N	21	7494N	79	74172N	$16.25	75454N	59
7432N	31	7495N	79	74173N	$1.40	75491N	70
7433N	30	7496N	79	74174N	$1.25	75492N	70
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	ADDRESS	Up to 64K Bytes
3. 8224 Clock driver	I/O	256 Directly Addressed
4. 8214 Interrupt controller	INTERRUPT	8 Level Priority Vectored Interrupt
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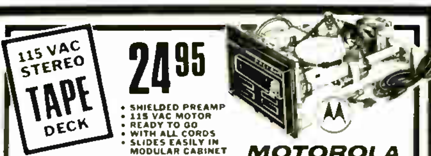

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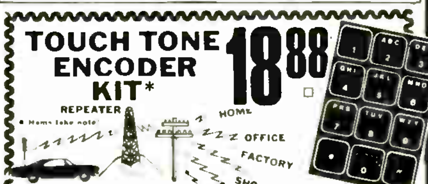

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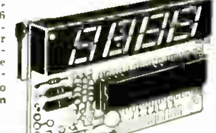

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7408	.25	7472	.39	74150	1.10
7409	.25	7473	.45	74151	1.25
7410	.20	7474	.45	74153	1.35
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7416	.43	7483	1.15	74157	1.30
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CA3035	2.45	N5558	.55	UA703C	.45
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1N914	.07	2N960	.90	2N2219A	.30	2N2913	.75	2N3740	1.00	2N4401	.16
		2N962	.95	2N2221	.25	2N2914	1.20	2N3771	1.75	2N4402	.16
2N173	1.75	2N967	.95	2N2221A	.30	2N2916A	3.65	2N3772	1.90	2N4403	.20
2N174	3.50	2N1136	1.75	2N2222	.25	2N3019	.50	2N3773	3.00	2N4409	.16
2N178	.90	2N1142	2.25	2N2222A	.30	2N3053	.30	2N3819	.40	2N4410	.16
2N327A	1.15	2N1300	1.00	2N2223	1.00	2N3054	.70	2N3823	.70	2N4416	.75
2N334	1.20	2N1301	1.10	2N2270	.40	2N3055	.75	2N3856	.20	2N5061	.30
2N336	.90	2N1302	1.25	2N2323	1.00	2N3227	1.00	2N3866	.85	2N5064	.50
2N338A	1.05	2N1303	.70	2N2324	1.35	2N3247	3.40	2N3903	.16	2N5130	.20
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2N404	.75	2N1305	.75	2N2326	2.85	2N3375	6.50	2N3905	.16	2N5138	.15
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2N508A	.45	2N1309	.90	2N2368	.25	2N3415	.18	2N3954A	3.75	2N5306	.20
2N555	.75	2N1552	3.25	2N2369	.25	2N3416	.19	2N3955	2.45	2N5354	.20
2N652A	1.25	2N1554	1.25	2N2484	.32	2N3417	.20	2N3957	1.25	2N5369	.20
2N677	6.00	2N1557	1.15	2N2712	.18	2N3442	1.85	2N4036	.75	2N5400	.40
2N706	.25	2N1560	2.80	2N2894	.40	2N3553	1.50	2N4037	.60	2N5401	.50
2N706B	.75	2N1805	.35	2N2903	3.30	2N3563	.20	2N4093	.85	2N5457	.35
2N711	.90	2N1813	.30	2N2904	.25	2N3565	.20	2N4124	.16	2N5458	.30
2N711B	1.10	2N1711	.30	2N2904A	.30	2N3638	.20	2N4126	.16	CIO3Y	.25
2N718	.25	2N1907	4.10	2N2905	.25	2N3642	.20	2N4141	.20	C106B1	.50
2N718A	.30	2N2060	1.85	2N2905A	.30	2N3643	.20	2N4142	.20		
2N720A	.50	2N2102	.40	2N2906	.25	2N3645	.20	2N4143	.20		

JAPANESE TRANSISTORS ★ CB, AUDIO, INDUSTRIAL

2SA52	.60	2SC206	1.00	2SC774	1.75	2SC1173	.95	2SD77	1.00
2SA316	.75	2SC240	1.10	2SC775	2.75	2SC1175	.65	2SD81	3.25
2SA473	.75	2SC291	.65	2SC776	3.00	2SC1209	.55	2SD88	1.50
2SA483	1.95	2SC292	3.00	2SC777	4.00	2SC1213	.75	2SD118	3.25
2SA489	.80	2SC320	.75	2SC778	4.00	2SC1226A	1.25	2SD130	1.25
2SA490	.70	2SC352	.75	2SC781	3.00	2SC1237	4.50	2SD141	2.25
2SA505	.70	2SC353	.75	2SC783	1.00	2SC1239	4.00	2SD151	2.25
2SA564	.50	2SC371	.70	2SC784	.70	2SC1243	1.50	2SD170	2.00
2SA628	.65	2SC372	.70	2SC785	1.00	2SC1293	.85	2SD180	2.75
2SA643	.85	2SC394	.70	2SC789	1.00	2SC1306	4.75	2SD201	1.95
2SA647	2.75	2SC458	.70	2SC793	2.50	2SC1307	5.75	2SD218	4.75
2SA673	.85	2SC460	.70	2SC796	3.15	2SC1308	4.75	2SD235	1.00
2SA679	3.75	2SC478	.80	2SC797	2.50	2SC1317	.60	2SD300	2.50
2SA682	.85	2SC481	1.85	2SC798	3.10	2SC1318	.70	2SD313	1.10
2SA699	1.30	2SC482	1.75	2SC799	4.25	2SC1325	4.95	2SD315	.75
2SA699A	1.45	2SC491	2.50	2SC802	3.75	2SC1327	.70	2SD316	2.50
2SA705	.55	2SC495	1.10	2SC803	4.00	2SC1338	1.75	2SD317	1.25
2SA815	.85	2SC497	1.60	2SC815	.75	2SC1346	.80	2SD318	.95
2SA816	.85	2SC502	1.50	2SC828	.75	2SC1347	.80	2SD325	1.25
		2SC515	.80	2SC829	.75	2SC1364	1.50	2SD341	.95
2SB22	.65	2SC517	4.25	2SC830	1.60	2SC1377	5.50	2SD350	3.25
2SB54	.70	2SC535	.75	2SC838	.70	2SC1383	.75	2SD352	.80
2SB56	.70	2SC536	.65	2SC839	.85	2SC1384	.85	2SD380	5.70
2SB77	.70	2SC537	.70	2SC922	.55	2SC1409	1.25	2SD389	.75
2SB128	2.25	2SC563	2.50	2SC929	.70	2SC1410	1.25	2SD390	.75
2SB152	4.50	2SC607	1.25	2SC930	.65	2SC1447	1.25		
2SB173	.55	2SC614	3.80	2SC938	.65	2SC1448	1.25	2SF8	3.00
2SB175	.55	2SC615	3.90	2SC943	1.50	2SC1449	1.30	2SCF8	3.50
2SB178	1.00	2SC616	4.15	2SC945	.65	2SC1475	1.50	2SCF8	1.25
2SB186	.60	2SC617	4.25	2SC959	3.15	2SC1507	1.25	HEPS3001	3.25
2SB187	.60	2SC620	.80	2SC960	2.75	2SC1509	1.25	JSP7001	.75
2SB235	7.00	2SC627	1.75	2SC984	1.50	2SC1569	1.25	MRF8004	3.00
2SB303	.65	2SC642	3.50	2SC996	4.90	2SC1674	1.75	MPS8000	1.25
2SB324	1.00	2SC643	3.75	2SC1010	.80	2SC1675	1.75	MPS8001	1.25
2SB337	2.10	2SC644	.70	2SC1012	.80	2SC1678	5.50	MPSU02	.50
2SB367	1.60	2SC681	2.50	2SC1013	1.50	2SC1679	4.75	MPSU31	4.00
2SB370	.65	2SC684	2.10	2SC1014	1.50	2SC1756	1.25	SK3047	3.75
2SB405	.85	2SC687	2.50	2SC1017	1.50	2SC1760	2.15	SK3048	3.25
2SB407	1.65	2SC696	3.00	2SC1018	1.50	2SC1816	4.50	SK3049	4.75
2SB415	.85	2SC699	4.75	2SC1030	4.75	2SC1908	.70	SK3054	1.25
2SB461	1.25	2SC710	.70	2SC1051	2.50	2SC1909	4.75	2SK19	.75
2SB463	1.65	2SC711	.70	2SC1060	.75	2SC1957	1.50	2SK30	1.00
2SB471	1.75	2SC712	.70	2SC1061	1.65	2SC1973	1.50	2SK33	1.20
2SB474	1.50	2SC713	.70	2SC1069	3.50	2SC1974	4.90	2SK41	1.75
2SB476	1.25	2SC731	3.00	2SC1079	3.75	2SC1975	4.90	3SK22Y	2.75
2SB481	2.10	2SC732	.70	2SC1080	3.75	2SC2028	1.10	3SK40	2.75
2SB492	1.25	2SC733	.70	2SC1096	1.20	2SC2029	4.75	3SK45	2.75
2SB495	.95	2SC735	.70	2SC1098	1.15	2SC2074	3.00	3SK49	2.75
2SB507	.90	2SC739	.70	2SC1115	2.75			4004	3.00
2SB511	.70	2SC715	.70	2SC1166	.70	2SD45	2.00	4005	3.00
2SB531	3.00	2SC756	3.00	2SC1167	4.25	2SD65	.75	40080	1.25
2SB556	3.50	2SC762	1.90	2SC1170	4.00	2SD68	.90	40081	1.50
2SB135	.95	2SC773	.85	2SC1172B	4.25	2SD72	1.00	40082	3.00

SILICON UNIJUNCTIONS

2N2160	.65	MU4892	.50
2N2646	.45	MU4893	.50
2N2647	.55	MU4894	.50
2N4851	.75	2N6027	.55
2N4852	.75	2N6028	.70
2N4870	.50	D5E37	.35
2N4871	.50	MU10	.35
MU4891	.50	MU20	.40

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Nylon Screws, Nuts & Rivets (Complete Kit, 50 pc's)	1.99
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MK20 T03 Complete Mounting Kit	5/.99
MK25 T066 Complete Mounting Kit	5/.99
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IC Socket 14 Pin DIL Pkg. of 1	.25ea.
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IN4006	1.10	10.00
IN4007	1.20	11.00

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CY3A	4 000 MHz	HC18 U	$4 95
CY7A	5 000 MHz	HC18 U	$4 95
CY12A	10 000 MHz	HC18 U	$4 95
CY14A	14 31818 MHz	HC18U	$4 95
CY19A	18 000 MHz	HC18 U	$4 95
CY22A	20 000 MHz	HC18 U	$4 95
CY30B	32 000 MHz	HC18 U	$4 95

XR-2260KB Kit $27.95 XR-2206KA Kit $17.95

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WAVEFORM GENERATORS — TIMERS — MISCELLANEOUS — STEREO DECODERS — PHASE LOCKED LOOPS

XR 2206CP 4 49

XR 2211CP $6 70

XR 2240CP 3 25

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156 Spacing-Tin-Double Read-Out

Bifurcated Contacts — Fits .054 to .070 P C Cards

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18 36	PINS (Solder Eyelet)	$2.49
22 44	PINS (Solder Eyelet)	$2.95
50 100 (.100 Spacing)	PINS (Solder Eyelet)	$6.95

25 PIN-D SUBMINATURE

DB25	PLUG	$3.25
DB25	SOCKET	$4.95

3½ DIGIT DVM KIT

This 0-2 VDC .05 per cent digital voltmeter features the Motorola 3½ digit DVM chip set. It has a .4" LED display and operates from a single +5V power supply. The unit is provided complete with an injection molded black plastic case complete with Bezel. An optional power supply is available which fits into the same case as the 0-2V DVM allowing 117 VAC operation.

A. 0-2V DVM with Case $49.95

B. 5V Power Supply $14.95

VECTOR WIRING PENCIL

$9.95

REPLACEMENT WIRE — BOBBINS FOR WIRING PENCIL

W36 3 A Pkg 3	250 ft 36 AWG GREEN	$2 40
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1/16 VECTOR BOARD

0.1 Hole Spacing — P Pattern — Price

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205-CB		$ .25
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HEXADECIMAL ENCODER 19-KEY PAD

- 1 - 0
- ABCDEF
- Return Key
- Optional Key (Period)
- — Key

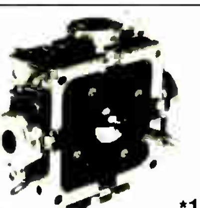
$10.95 each

63 KEY KEYBOARD

$19.95

HD0165 16 LINE TO FOUR BIT PARALLEL KEYBOARD ENCODER $7 95

JOYSTICK



These joysticks feature four * potentiometers that vary resistance proportional to the angle of the stick. Sturdy metal construction with plastics components only at the movable joint. Perfect for electronic games and instrumentation.

*5K Pots $6.95

*100K Pots $7.95

MICROPROCESSOR COMPONENTS

8080A	CPU	$19 95	MC6800L	8 Bit MPU	$35 00
8212	8 Bit Input Output	4.95	MC6820L	Periph Interface Adapter	15 00
8216	Bi-Directional Bus Driver	6 95	MC6810AP1	128 x 8 Static RAM	6 00
8224	Clock Generator Driver	12 95	MC6830L7	1024 x 8 Bit ROM	18 00
8228	System Controller - Bus Driver	12 95			

CPU S — RAM S

8008	8 BIT CPU	$19 95

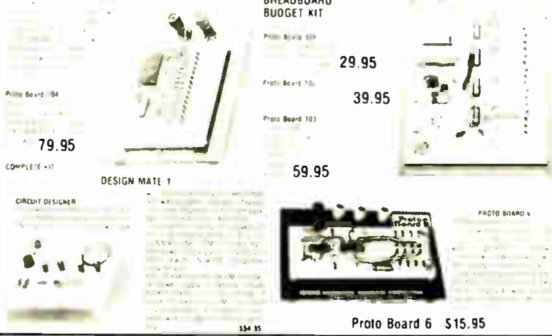
SR S — UART S — ROM S — PROMS

BIPOLAR PROM SPECIAL

6330-1	256 Bit (32 x 8) Open Collector	2 95	6306 1	2048 Bit (512 x 4) Three State	9 95
6331 1	256 Bit (32 x 8) Three State	2 95	6340 1	2048 Bit (512 x 8) Open Collector	19 95
6300 1	1024 Bit (256 x 4) Open Collector	3 49	6341 1	2048 Bit (512 x 8) Three State	19 95
6301-1	1024 Bit (256 x 4) Three State	3 49	6352 1	4096 Bit (1024 x 4) Open Collector	19 95
6305 1	2048 Bit (512 x 4) Open Collector	9 95	6353 1	4096 Bit (1024 x 4) Three State	19 95

Continental Specialties

Proto Board 100 $19.95 THE MINI BREADBOARD BUDGET KIT



29.95

39.95

79.95

DESIGN MATE 1

59.95

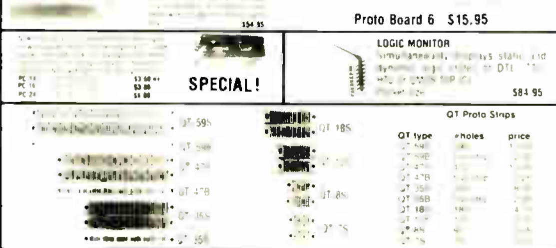
Proto Board 6 $15.95

SPECIAL!

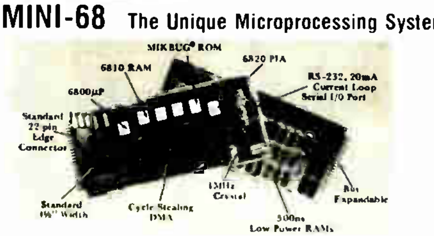
LOGIC MONITOR

$84 95

QT Proto Strips



GEMINI-68 The Unique Microprocessing System



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8K EPROM BOARD — Uses 5204 EPROMS by AMI or NATIONAL. Shipped with all decode and miscellaneous IC s, except the 5204 EPROMS. Part # Gemini 68 EPROM Board $ 89.95

NOT A KIT — ALL BOARDS ARE COMPLETELY ASSEMBLED, BURNED IN AND TESTED. COMES WITH COMPLETE DOCUMENTATION

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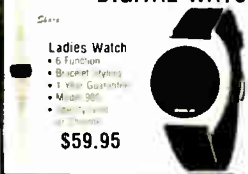

Ladies Watch — $59.95

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RADOFIN MODEL 8P

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FEATURES

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Kit — $39.95

Assembled — $49.95

Heavy Duty Carry Case $5.95

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Kit: $29.95

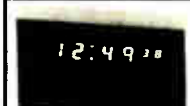
Assembled: $39.95

CASE ONLY (includes hardware, mounting bracket and bezel) $5.95

JE700 CLOCK

115 VAC

$17.95



This large digit clock ... hours & minutes ... features the MMS314 clock chip. It operates from 117 VAC and will operate in either a 12 or 24 hour mode. The clock is complete with a walnut grain case ... has fast set, slow set and hold time set features.

JE500 KIT - ALL COMPONENTS & CASE $34.95
WIRED & ASSEMBLED $39.95

DIGITAL CLOCK KIT — 3½ INCH DIGITS

4 DIGIT KIT $49.95	4 DIGIT ASSEMBLED $59.95
6 DIGIT KIT $69.95	6 DIGIT ASSEMBLED $79.95

This clock features big 3½" high digits for viewing in offices, auditoriums, etc. Each digit is formed by 31 bright 0.2" LED s. The clock operates from 117 VAC, has either 12 or 24 hr operation. The 6 digit version is 27" x 3½" x 1½" and the 4 digit is 18" x 3½" x 1½". Kits come complete with all components, case and transformer.

Specify 12 or 24 Hour When Ordering

JE803 PROBE

$9.95 Per Kit

printed circuit board

T²L 5V 1A Supply

This is a standard TTL power supply using the well known LM309K regulator IC to provide a solid 1 AMP of current at 5 volts.

$9.95 Per Kit

7400N TTL

SN7400N	16	SN7459A	25		
SN7401N	16	SN7460N	22	SN74154N	[illegible]
SN7402N	21	SN7470N	45	SN74155N	99
SN7403N	16	[illegible]	39	SN74156N	99
SN7404N	18	[illegible]	37	SN74157N	99
SN7405N	24	[illegible]	32	SN74160N	1 25
SN7406N	20	[illegible]	50	SN74161N	99
SN7407N	29	[illegible]	32	SN74163N	99
SN7408N	25	[illegible]	5 00	SN74164N	[illegible]
SN7409N	25	[illegible]	50	SN74165N	[illegible]
SN7410N	18	[illegible]	98	SN74166N	1 75
SN7411N	30	[illegible]	70	SN74167N	5 50
SN7412N	33	[illegible]	89	SN74170N	2 10
SN7413N	45	SN7486N	39	SN74172N	8 95
SN7414N	70	SN7488N	3 50	SN74173N	1 50
SN7416N	35	SN7489N	[illegible]	SN74174N	1 25
SN7417N	35	SN7490N	45	SN74175N	99
SN7420N	21	SN7491N	75	SN74176N	90
SN7421N	[illegible]	SN7492N	49	SN74177N	90
SN7422N	49	SN7493N	49	SN74180N	99
SN7423N	37	SN7494N	79	SN74181N	2 49
SN7425N	29	SN7495N	79	SN74182N	95
SN7426N	29	SN7496N	89	SN74184N	1 95
SN7427N	37	SN7497N	4 00	SN74185N	2 20
SN7429N	42	SN74100N	1 00	SN74186N	15 00
SN7430N	26	SN74107N	39	SN74187N	6 00
SN7432N	[illegible]	SN74121N	39	SN74188N	3 95
SN7437N	[illegible]	SN74122N	39	SN74190N	1 19
SN7438N	[illegible]	SN74123N	[illegible]	SN74191N	1 25
SN7439N	[illegible]	SN74125N	60	SN74192N	89
SN7440N	[illegible]	SN74126N	60	SN74193N	89
SN7441N	89	SN74132N	1 09	SN74194N	[illegible] 25
SN7442N	[illegible]	SN74136N	95	SN74195N	75
SN7443N	[illegible]	SN74141N	1 15	SN74196N	1 25
SN7444N	[illegible]	SN74142N	4 00	SN74197N	75
SN7445N	[illegible]	SN74143N	4 50	SN74198N	[illegible] 75
SN7446N	[illegible]	SN74144N	4 50	SN74199N	[illegible] 75
SN7447N	[illegible]	SN74145N	1 15	SN74200N	5 59
SN7448N	79	SN74147N	2 35	SN74279N	90
[illegible]	[illegible]	SN74148N	2 00	SN74251N	1 79
SN7451N	27	SN74150N	1 00	SN74284N	6 00
SN745[illegible]N	27	SN74151N	79	SN74285N	6 00
SN7454N	20	SN741[illegible]3N	89	SN74367N	75

MANY OTHERS AVAILABLE ON REQUEST
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CMOS

CD4001	[illegible]			74C04N	75
CD4001	[illegible]			74C10N	65
CD4002	[illegible]	[illegible]	1 85	74C20N	65
CD4006	50	CD4044	3 45	74C30N	65
CD4007	25	CD4044	1 90	74C42N	2 15
CD4009	59	CD4044	1 50	74C73N	[illegible] 50
CD4010	59	[illegible]	[illegible]	74C74	1 15
CD4011	25	CD4047	[illegible]	74C90N	3 00
CD4012	25	CD4049	[illegible]	74C95N	2 00
CD4013	47	CD4050	79	74C107	[illegible] 25
CD4016	56	[illegible]	2 95	74C151	2 90
CD4017	1 35	CD405[illegible]	2 95	74C154	4 00
CD4019	[illegible]	CD4060	[illegible]	74C157	2 15
CD4020	1 49	CD4066	[illegible]	74C160	3 25
CD4022	[illegible]	[illegible]	45	74C161	3 25
CD4023	[illegible] 5	[illegible]	45	74C163	3 00
CD4024	[illegible]	[illegible]	45	74C164	3 25
CD4025	[illegible]	CD451[illegible]	[illegible] 50	74C173	2 60
CD4027	69	CD4518	[illegible]	74C193	2 75
CD4028	[illegible] 65	CD4566	3.00	74C195	2 75
CD4029	[illegible]	[illegible]	39	MC4044	4 50
CD40[illegible]	[illegible]	[illegible]	52	MC14016	56

LINEAR

LM300H	80			LM1310N	2 95
LM301H	[illegible]			LM1351N	[illegible] 65
LM301CN	35			LM1414N	[illegible] 75
LM302H	75			LM1458C	65
LM304H	[illegible] 00	LM370N	[illegible]	LM1496N	95
LM305H	95	LM373N	3 25	LM1556V	1 85
LM307CN	35	LM377N	4 00	LM2111N	[illegible] 95
LM308H	[illegible] 00	LM380N	1 39	LM2901N	2 95
LM308CN	[illegible] 00		1 05	LM3065N	69
LM309H	[illegible] 10	LM381N	[illegible] 79	LM3900N	55
LM309K	99	LM382N	1 79	LM3905N	60
LM310CN	1 15	NE501K	8 00	LM3909	1 25
LM311H	90	NE510A	6 00	LM5556N	1 85
LM311N	90	NE531H	3 00	MC5558V	1 00
LM318CN	1 50	NE536T	6 00	LM7525N	90
LM319N	1 30	NE540L	6 00	LM7535N	1 25
LM320K 5	1 35	NE550N	79	8038B	4 95
LM320K 5 2	1 35	NE555V	[illegible]	LM75450	49
LM320K 12	1 35	NE560B	5 00	75451CN	39
LM320K 15	1 35	NE561B	5 00	75452CN	39
LM320T 5	1 75	NE562B	5 00	75453CN	39
LM320T 5 2	1 75	NE565H	1 25	75454CN	39
LM320T 8	1 75	NE565N	1 75	75491CN	79
LM320T 12	1 75	NE566CN	1 25	75492CN	89
LM320T 15	1 75	NE567H	1 95	75494CN	89
LM320T 18	1 75	NE567V	1 50	**RCA LINEAR**	
LM320T 24	1 75	LM703CN	45	CA3013	2 15
LM323K 5	9 95	LM709H	29	CA3032	2 56
LM324N	1 80	LM709N	29	CA3035	2 48
LM3[illegible]N	[illegible] 70	LM710N	79	CA3039	1 35
LM340K 5	[illegible] 95	LM711N	39	CA3046	1 30
LM340K 6	1 95	LM723H	55	CA3059	3 25
LM340K 8	1 95	LM723N	55	CA3060	3 25
LM340K 12	[illegible] 95	LM733N	1 00	CA3080	85
LM340K 15	[illegible] 95	LM739N	1 00	CA3081	2 00
LM340K 18	[illegible] 95	LM741CH	35	CA3082	2 00
LM340K 24	1 95	LM741CN	35	CA3083	1 60
LM340T 5	1 75	[illegible]	39	CA3086	85
LM340T 6	[illegible] 75	LM747H	79	CA3089	3 75
LM340T 8	1 75	LM747N	79	CA3091	10 20
LM340T 12	1 75	LM748H	39	CA3123	2 15
LM340T 15	1 75	LM748N	39	CA3130	1 39
LM340T 18	1 75	LM1303N	90	CA3140	1 25
LM340T 24	1 75	LM1304N	1 19	CA3600	1 75
LM350N	1 00	LM1305N	1 40	RC4194	5 95
LM351CN	65	LM1307N	85	RC4195	3 25

74LS00 TTL

74LS00	[illegible]			74LS139	1.95
74LS01	[illegible]			74LS151	1 55
74LS03	[illegible]	74LS74	[illegible]	74LS153	1 89
74LS04	[illegible]	74LS75	[illegible]	74LS157	1 55
74LS05	[illegible]	74LS76	49	74LS162	2 25
74LS08	29	74LS8[illegible]	[illegible]	74LS163	2 25
74LS10	[illegible]	[illegible]	[illegible]	74LS164	1 9[illegible]
74LS13	[illegible]	74LS86	[illegible]	74LS175	1.95
74LS14	[illegible]	[illegible]	1 25	74LS181	3 69
74LS20	[illegible]	[illegible]	[illegible]	74LS190	[illegible] 85
74LS26	[illegible]	[illegible]	[illegible]	74LS191	[illegible] 85
74LS27	[illegible]	[illegible]	[illegible]	74LS192	[illegible] 85
74LS30	[illegible]	[illegible]	[illegible]	74LS193	[illegible] 85
74LS3[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
74LS4[illegible]	[illegible]	74LS109	[illegible]	[illegible]	[illegible]
74LS5[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

CLOCK CHIPS

MM5[illegible]	[illegible]	$9 95
MM5[illegible]	[illegible]	4 95
MM5[illegible]	4 Digit BCD Output [illegible] PPS Output	4 95
MM5314	6 Digit [illegible] 24 Hour [illegible] 60 Hz	4 95
MM5[illegible]	4 Digit Alarm 1 PPS Output	6 95
MM5318	Video Clock [illegible] MM5841	9 95
CT7001	6 Digit Calendar Alarm 12/24 Hour	5 95

DATA HANDBOOKS

7400	Pin out & Description of 5400/7400 ICS	$2.95
CMOS	Pin out & Description of 4000 Series ICS	$2.95
Linear	Pin out & Functional Description	$2.95

ALL THREE HANDBOOKS $6.95

FAIRCHILD TECHNOLOGY KITS FAIRCHILD

TECHNOLOGY KIT

- Complete Specifications on back of each kit
- Packaged for WALL DISPLAY APPEARANCE
- Dealer's Inquires Invited — Price List Available

FAIRCHILD

DIGITS

FTK0001	0.5 High [illegible] Cathode Digit	$1 00
FTK0002	0.5 High Common Anode Digit	[illegible]
FTK0003	[illegible] High Common Cathode Digit	[illegible]
FTK0004	0.8 High Common Cathode Digit	[illegible] 00
FTK0005	0.8 High Common Anode Digit	[illegible] 00

0.8 HIGH DISPLAY ARRAYS

FTK0010	12 Hour [illegible] Digit Clock Display	[illegible] 00
FTK0011	24 Hour 4 Digit Clock Display	[illegible] 00

LED LAMPS

FTK0020	10 Red LED Lamps	[illegible] 00
FTK0021	5 Mixed Colored LED Lamps	[illegible]
FTK0022	10 LED Mounting Clips	[illegible]
FTK0023	6 Three Piece LED Mounting Adapters	[illegible]

PHOTO TRANSISTORS

FTK0030	[illegible]	[illegible]
FTK0031	[illegible]	[illegible]
FTK0032	[illegible]	[illegible]
FTK0033	[illegible]	[illegible]

PHOTO ARRAYS

FTK0040	9 Element Tape Reader Array	16 00
FTK0041	12 Element Card Reader Array	[illegible] 00
FTK0042	Reflective Optic Coupler	4 00

COUPLERS

FTK0050	3 General Purpose Optic Couplers	1 00
FTK0051	Darlington Optic Coupler	1 00

MOS CLOCK CIRCUITS

FTK0400	Digital Clock Calendar Circuit (FCM7001)	[illegible] 00
FTK0401	Digital Clock Calendar with BCD Outputs (FCM7002)	[illegible] 00
FTK0402	Direct Drive Digital Clock Circuit with AC Output (FCM[illegible])	5 00
FTK0403	Direct Drive Digital Clock Circuit with DC Output (FCM[illegible])	5 00
FTK0405	Direct Drive Digital Clock Calendar Circuit (FCM7015)	[illegible]

KITS

FTK0106	[illegible]	[illegible]

DISCRETE LEDS

.125 dia		.090 dia
XC209 Red [illegible]		[illegible]
XC209 Green [illegible]		[illegible]
XC209 Yellow [illegible]		[illegible]

.200 dia	.185 dia	.200 dia	.085 dia
XC22 Red [illegible]	XC526 Red [illegible]	XC556 Red [illegible]	[illegible]
XC22 Green [illegible]	XC526 Green [illegible]	XC556 Green [illegible]	[illegible]
XC22 Yellow [illegible]	XC526 Yellow [illegible]	XC556 Yellow [illegible]	[illegible]
XC22 Orange [illegible]	XC526 Orange [illegible]	XC556 Orange [illegible]	[illegible]
XC22 Clear [illegible]	XC526 Clear [illegible]	XC556 Clear [illegible]	

DISPLAY LEDS

TYPE	POLARITY	HT		TYPE	POLARITY	HT	
[illegible]	Common Anode	[illegible]	[illegible]	MAN 3620	Common Anode orange	[illegible]	[illegible]
[illegible]	[illegible] Dot Matrix	[illegible]	[illegible]	MAN 3640	Common Cathode orange	[illegible]	[illegible]
[illegible]	Common Cathode	[illegible]	[illegible]	MAN 4710	Common Anode red	[illegible]	[illegible]
[illegible]	Common Cathode	[illegible]	[illegible]	DL[illegible]	Common Anode red	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	DL704	Common Cathode	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

IC SOLDERTAIL — LOW PROFILE (TIN) SOCKETS

SOLDERTAIL STANDARD (TIN)

SOLDERTAIL STANDARD (GOLD)

WIRE WRAP SOCKETS (GOLD) LEVEL #3

10 pin	$ 45	41	[illegible]	24 pin	$1 05	95	85
14 pin	39	38	[illegible]	28 pin	1 40	1 25	1 10
16 pin	43	42	41	36 pin	1 59	1 45	1 30
18 pin	[illegible]	68	[illegible]	40 pin	1 75	1 55	1 40

PUSH BUTTON SWITCH

PB-123	$1 75
Maintained Action Switch	
PB 126	$1 75
Momentary Action Switch	

SPDT

MINATURE TOGGLE SWITCH

JMT-221	DPDT	on off on	$1 95
JMT-223	DPDT	on none on	$1 75
JMT-121	SPDT	on off on	$1 50
JMT-123	SPDT	on none on	$1 25

CLIPLITE

NEW LED MOUNTING SYSTEM — to be used with XC556 LEDS — SPECIFY COLORS — RED — GREEN — AMBER — YELLOW **4/$1.00**

50 PCS. RESISTOR ASSORTMENTS $1.75 PER ASST.

ASST. 1	5 ea	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1/4 WATT 5%	50 PCS
ASST. 2	5 ea	[illegible]	[illegible]	[illegible]	330 OHM	390 OHM	1/4 WATT 5%	50 PCS
ASST. 3	5 ea	[illegible]	[illegible]	[illegible]	2.2K	[illegible]	1/4 WATT 5%	50 PCS
ASST. 4	5 ea	[illegible]	[illegible]	[illegible]	5.6K	6.8K	1/4 WATT 5%	50 PCS
ASST. 5	5 ea	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1/4 WATT 5%	50 PCS
ASST. 6	5 ea	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1/4 WATT 5%	50 PCS
ASST. 7	5 ea	[illegible]	[illegible]	[illegible]	1.8M	[illegible]	1/4 WATT 5%	50 PCS

ASST. 8R Includes Resistor Assortments 1-7 (350 PCS.) **$10.95 ea.**

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- Wraps 30 AWG Wire onto Standard DIP Sockets (.025 inch)
- Complete with built-in bit and sleeve

$34.95 (batteries not included)

WIRE-WRAP KIT — WK-2-W

WRAP • STRIP • UNWRAP

- Tool for 30 AWG Wire
- Roll of 50 ft White 30 AWG Wire
- 50 pcs. each 1", 2", 3" & 4" lengths — pre-stripped white wire

$11.95

WIRE WRAP TOOL WSU-30

WRAP • STRIP • UNWRAP - $5.95

WIRE WRAP WIRE — 30 AWG

25 ft min $1 25 50 ft $1 95 100 ft $2 95 1000 ft $15 00
SPECIFY COLOR — White - Yellow - Red - Green - Blue - Black

THUMBWHEEL SWITCHES

THUMBWHEEL SWITCH ONLY

SERIES SI Front Mount Assembly — SERIES SR Rear Mount Assembly

ACCESSORIES

Part No	Description	Price	Part No	Description	Price
SI EP	End Plates, Pair	50	SR EP	End Plates, pair	[illegible]
SI DP	Divider Plate each	40	SR DP	Divider Plate each	[illegible]
SI BB	Blank Body each	40	SR BB	Blank Body each	[illegible]
SI HB	Half Body each	40	SR HB	Half Body each	[illegible]

DIP SWITCH

$1.95

ZENERS — DIODES — RECTIFIERS

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
1N746	[illegible]	400m	4/1 00	1N4001	[illegible]	1 AMP	[illegible]
1N751A	5 1	400m	4/1 00	1N4006	[illegible]	1 AMP	12/1 00
1N752	5 6	400m	4/1 00	1N4007	[illegible]	1 AMP	[illegible]
1N753	6 2	400m	4/1 00	1N60	[illegible]	[illegible]	[illegible]
1N754	6 8	400m	4/1 00	1N4148	75	[illegible]	[illegible]
1N959	8 2	400m	4/1 00	1N4154	25	[illegible]	[illegible]
1N965B	15	400m	4/1 00	1N4305	75	[illegible]	[illegible]
1N5232	5 6	500m	[illegible]	1N4734	5 6	1A	[illegible]
1N5234	6 2	500m	[illegible]	1N4735	6 2	1A	[illegible]
1N5235	6 8	500m	[illegible]	1N4736	6 8	1A	[illegible]
1N5236	7 5	500m	[illegible]	1N4738	[illegible]	1A	[illegible]
1N456	25	[illegible]	6/1 00	1N4742	[illegible]	1A	[illegible]
1N458	150	[illegible]	6/1 00	1N4744	[illegible]	1A	[illegible]
1N485A	180	10m	6/1 00	1N1183	[illegible]	35 AMP	[illegible]
1N4001	50 PIV	1 AMP	12/1 00	1N1184	[illegible]	35 AMP	[illegible]
1N4002	100 PIV	1 AMP	12/1 00	1N1185	150 PIV	35 AMP	[illegible]
1N4003	200 PIV	1 AMP	12/1 00	1N1186	200 PIV	35 AMP	[illegible]
1N4004	400 PIV	1 AMP	12/1 00	1N1188	400 PIV	35 AMP	[illegible]

SCR AND FW BRIDGE RECTIFIERS

C36D	15A @ 400V	SCR	$1 95
C38M	35A @ 200V	SCR	1 95
2N2328	1 6A @ 200V	SCR	50
MDA 980 1	12A @ 50V	FW BRIDGE REC	1 95
MDA 980 3	12A @ 200V	FW BRIDGE REC	1 95

TRANSISTORS

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N4123	10 $1 00		

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-49	50-100		1-9	10-49	50-100
10 pf	.05	.04	.03	.001µF	.05	.04	.035
22 pf	.05	.04	.03	.0047µF	.05	.04	.035
47 pf	.05	.04	.03	.01µF	.05	.04	.035
100 pf	.05	.04	.03	.022µF	.06	.05	.04
220 pf	.05	.04	.03	.047µF	.06	.05	.04
470 pf	.05	.04	.035	.1µF	.12	.09	.075

100 VOLT MYLAR FILM CAPACITORS

.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22

+20% DIPPED TANTALUMS (SOLID) CAPACITORS

.1 35V	.28	.23	.17	1.5 35V	.30	.26	.21
.15 35V	.28	.23	.17	2.2 25V	.31	.27	.22
.22 35V	.28	.23	.17	3.3 25V	.31	.27	.22
.33 35V	.28	.23	.17	4.7 25V	.32	.28	.23
.47 35V	.28	.23	.17	6.8 25V	.36	.31	.25
.68 35V	.28	.23	.17	10 25V	.40	.35	.29
1.0 35V	.28	.23	.17	15 25V	.63	.50	.40

MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS

Axial Lead				Radial Lead			
.47 50V	.15	.13	.10	.47 25V	.15	.13	.10
1.0 50V	.16	.14	.11	.47 50V	.16	.14	.11
3.3 50V	.15	.13	.10	1.0 16V	.15	.13	.10
4.7 25V	.16	.14	.12	1.0 25V	.16	.14	.11
10 25V	.15	.13	.10	1.0 50V	.16	.14	.11
10 50V	.16	.14	.12	4.7 16V	.15	.13	.10
22 25V	.17	.15	.12	4.7 25V	.15	.13	.10
22 50V	.24	.20	.18	4.7 50V	.16	.14	.11
47 25V	.19	.17	.15	10 16V	.14	.12	.09
47 50V	.25	.21	.19	10 25V	.15	.13	.10
100 25V	.24	.20	.18	10 50V	.16	.14	.12
100 50V	.35	.30	.28	47 50V	.24	.21	.19
220 25V	.32	.28	.25	100 16V	.19	.15	.14
220 50V	.45	.41	.38	100 25V	.24	.20	.18
470 25V	.33	.29	.27	100 50V	.35	.30	.28
1000 16V	.55	.50	.45	220 16V	.23	.17	.16
2200 16V	.70	.62	.55	470 25V	.31	.28	.26

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NATIONAL

MA1002A 12 Hour (AM PM) Version $10.50
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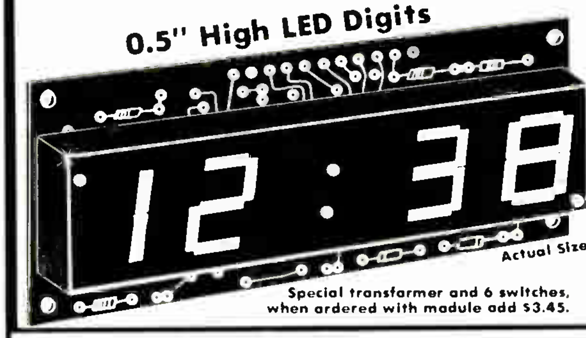

Special transformer and 6 switches, when ordered with module add $3.45.

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MA1002 & MA1010 Series Electronic Clock Modules

The MA1002 & MA1010 Series Electronic Clock Modules are assembled and pretested modules which combine a monolithic MOS-LSI integrated clock circuit, 4-digit LED display, power supply and other associated discrete components on a single printed circuit board to form a complete electronic clock movement. The user need add only a transformer and switches to construct a digital clock for application in clock-radios, alarm or instrument panel clocks. Timekeeping may be from 50 or 60 Hz inputs and 12 or 24 hour display formats may be chosen. Direct LED drive eliminates RF interference. Time setting is made easy through use of "Fast" and "Slow" scanning controls.

The MA1002A and MA1010A have a 12 hour display with an AM and PM indicator. The MA1002C and MA1010C have a 24 hour display.

Features include alarm "on" and "PM" indicators, "sleep" and "snooze" timers and variable brightness control capability. The modules are extremely compact, the MA1002 measuring 1.375" by 3.05", the MA1010 measuring 1.75" by 3.75". This small size is achieved by bonding the I.C. to the back of the circuit board.

It is highly recommended that the transformer be obtained with the clock module as it is a special dual secondary type not otherwise readily available.

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$24.95

1,032 SOLDERLESS PLUG-IN TIE POINTS
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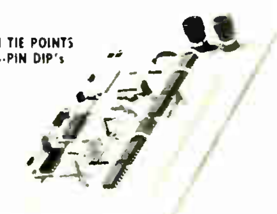
TWO 5-way binding posts
Size 4-9/16" by 7"
Kit form



WIRE WRAPPING WIRE

Red or Black Kynar insulated pre-cut and stripped 30 ga. wire 1" of insulation is removed from each end

Insulation Length	No. in Pkg.	Price per Pkg.
1.0"	100	$2.50
2.0"	100	$2.60
2.5"	100	$2.65
3.0"	100	$2.70
3.5"	100	[illegible]
4.0"	100	$2.80
4.5"	100	$2.90
5.0"	100	$3.00
6.0"	50	$1.60
7.0"	50	$1.70
8.0"	50	$1.80
9.0"	50	$1.90
10.0"	50	$2.00
15.0"	50	$2.50

SLIDE SWITCHES

Single Pole Single Throw
.15 1.20/10 10.00/C

Double Pole Double Throw
.23 2.00/10 19.00/C

BATTERY HOLDERS

1-AA . . . 26c
2-AA . . . 42c
1-C 35c
2-C 42c
1-D 35c
2-D 42c

BISHOP GRAPHICS Printed Circuit Drafting

Aids are now available from Digi-Key

RADIAL ELECTROLYTICS

.47 50V	.08	.65/10	22 50V	.12	1.00/10	330 25V	.23	1.86/10
1 50V	.08	.65/10	100 6.3V	.09	.75/10	470 10R	.21	1.71/10
2.2 50V	.08	.65/10	100 10V	.10	.77/10	470 16V	.23	1.81/10
3.3 50V	.08	.65/10	100 16V	.11	.85/10	470 25V	.29	2.35/10
4.7 35V	.08	.65/10	100 25V	.13	1.10/10	1000 10V	.24	1.96/10
4.7 50V	.08	.68/10	100 50V	.21	1.71/10	1000 16V	.29	2.35/10
10 16V	.08	.65/10	220 10V	.13	1.08/10	1000 25V	.42	3.33/10
10 25V	.08	.65/10	220 16V	.15	1.16/10	2200 10V	.42	3.33/10
10 50V	.10	.75/10	220 25V	.21	1.71/10	2200 16V	.54	4.30/10
22/16V	.08	.67/10	220 50V	.29	2.35/10	2200 25V	.58	4.67/10
22/25V	.09	.70/10	330 10V	.15	1.16/10	3300 16V	.89	7.14/10
			330 16V	.21	1.66/10			

AXIAL ELECTROLYTICS

.47 10V	.11	.90/10	33 25V	.14	1.15/10	330 16V	.29	2.35/10
1 30V	.11	.90/10	33 50V	.19	1.52/10	330 25V	.32	2.54/10
3.3 35V	.12	.95/10	47 16V	.14	1.15/10	470 16V	.32	2.55/10
3.3 50V	.12	1.00/10	47 25V	.17	1.30/10	470 25V	.37	3.00/10
4.7 25V	.11	.90/10	47 50V	.21	1.17/10	1000 10V	.33	2.65/10
4.7 35V	.12	.95/10	100 10V	.14	1.13/10	1000 16V	.39	3.15/10
4.7 50V	.12	1.00/10	100 16V	.17	1.30/10	1000 25V	.56	4.50/10
10 25V	.12	1.00/10	100 25V	.20	1.55/10	2200 10V	.50	3.96/10
10 50V	.14	1.15/10	100 50V	.29	2.30/10	2200 16V	.62	4.95/10
22 16V	.12	1.00/10	220 10V	.18	1.42/10	2200 25V	.79	6.35/10
22 25V	[illegible]	1.05/10	220 16V	.20	1.55/10	3300 16V	.95	7.63/10
22 50V	.17	1.32/10	220 25V	.29	2.35/10	4700 16V	1.09	8.70/10
33 16V	.12	1.00/10	220 50V	.40	3.23/10	10000 10V	1.15	9.19/10
			330 10V	.14	1.16/10			

INTEGRATED CIRCUITS — TTL, CMOS, LINEAR & MOS

7400	.21	7476	.32	74181	2.15	4012	.23	4520	1.14
7401	.21	7480	.70	74182	.79	4013	.40	4527	1.68
7402	.21	7482	.70	74184	2.19	4014	.96	4528	.88
7403	.21	7483	.70	74185	2.19	4015	.96	4585	1.23
7404	.21	7485	.89	74188	3.50	4016	.40	2102-1	1.99
7405	.21	7486	.28	74189	3.50	4017	1.05	8080A	24.95
7406	.25	7489	2.19	74190	1.23	4018	1.05	CA3046	.75
7407	.25	7490	.44	74191	1.23	4019	.23	LM2111N	1.25
7408	.21	7491	.70	74192	.88	4020	1.14	LM309K	1.80
7409	.21	7492	.44	74193	.88	4021	1.14	LM324A	1.28
7410	.21	7493	.44	74194	.88	4022	.96	LM340T-5	1.25
7411	.21	7494	.70	74195	.88	4023	.23	LM340T-6	1.25
7412	.21	7495	.70	74196	.88	4024	.84	LM340T-8	1.25
7413	.25	7496	.70	74197	.89	4025	.23	LM340T-12	1.25
7414	.89	74100	1.28	74198	1.49	4026	1.68	LM340T-15	1.25
7416	.25	74107	.30	74199	1.49	4027	.40	LM340T-18	1.25
7417	.25	74109	.33	74251	1.09	4028	.89	LM340T-24	1.25
7420	.21	74121	.35	74279	.55	4029	1.14	LM3900N	.88
7421	.25	74122	.44	74365	.67	4030	.23	LM3909N	.69
7423	.35	74123	.61	74366	.67	4033	1.51	MC1456V	1.00
7425	.35	74125	.40	74367	.67	4034	3.50	MC1458V	.53
7426	.25	74126	.40	74368	.67	4035	1.14	MC3302P	1.15
7427	.33	74132	.70	8093	.40	4040	1.14	NE536T	3.24
7428	.23	74141	.88	8094	.40	4041	.79	NE540L	2.04
7430	.21	74145	.70	9095	.67	4042	.79	NE555V	.48
7432	.25	74147	1.63	8096	.67	4043	.70	NE556A	.88
7433	.30	74148	1.30	8097	.67	4044	.70	NE560B	3.83
7437	.25	74150	1.16	8098	.67	4046	1.86	NE561B	3.83
7438	.25	74151	.70	75150	1.16	4049	.40	NE562B	3.83
7440	.21	74153	.65	75450	.88	4050	.40	NE565A	1.25
7442	.53	74154	1.03	75451	.61	4051	1.26	NE566V	1.28
7443	.63	74155	.70	75452	.61	4052	1.26	NE567V	1.36
7445	.70	74156	.70	75453	.61	4053	1.26	uA709CV	.44
7446	.70	74157	.70	75454	.61	4060	1.58	uA710CA	.44
7447	.70	74160	.88	75491	.81	4066	.79	uA711CA	.53
7448	.70	74161	.88	75492	.84	4071	.23	uA723CA	.60
7450	.21	74162	.88	75493	1.09	4072	.23	uA733CA	.75
7451	.21	74163	.88	75494	1.19	4073	.23	uA741CV	.44
7453	.21	74164	.96	82S25	2.19	4075	.23	uA747CA	.70
7454	.21	74165	1.15	4000	.23	4081	.23	uA748CV	.49
7459	.21	74166	1.26	4001	.23	4082	.23	uA7805CU	1.25
7460	.21	74170	2.64	4002	.23	4502	.79	uA7806CU	1.25
7470	.30	74173	1.42	4006	1.23	4510	1.14	uA7808CU	1.25
7472	.30	74174	.98	4007	.23	4511	1.05	uA7812CU	1.25
7473	.30	74175	.93	4008	.79	4514	2.80	uA7815CU	1.25
7474	.30	74176	.79	4009	.44	4515	2.80	uA7818CU	1.25
7475	.49	74177	.79	4010	.44	4516	1.23	uA7824CU	1.25
		74180	.70	4011	.23	4518	1.14		

WIRE WRAPPING WIRE IN BULK

Red or Black 30 ga. Kynar

100' $2.00 500' $8.50 1000' $15.00

PERF BOARD

0.1" spacing between holes

4½ x 6 $1.71
4½ x17 $4.25

TERMINALS

for above perf board
$1.50 C

LED LAMPS

NSL5053 T-1 ¾ .18 $15 C
NSL5056 T-1 ¾ .18 $15 C

LED DISPLAYS

FND357	CC	375	$1.75
FND500	CC	500	$1.75
FND 507	CA	500	$1.75
FND800	CC	800	$3.50
FND807	CA	800	$3.50

ENTIRE ROCKWELL CALCULATOR LINE ON DISCOUNT IN OUR LATEST CATALOG

MOLEX PINS

Make your own IC sockets on PC board

.85/C 8.20 M 38.20 5M 275.00 50M

SILICON DIODES

1N4001	.64/10	5.50/C	$49/M
1N4002	.66/10	5.60/C	$51/M
1N4003	.68/10	5.80/C	$52/M
1N4004	.70/10	5.95/C	$54/M
1N4005	.82/10	7.05/C	$63/M
1N4006	.90/10	7.75/C	$69/M
1N4007	[illegible]/10	8.[illegible]/C	$77/M
1N4148	.40/10	3.50/C	$29/M

Double Digit Discounts Save You Even More!

RESISTOR ASSORTMENTS

5 ea all 10% ¼ w val 10 thru 5.6 meg (350 pcs) $12.00
5 ea all 10% ½ w val 2.2 thru 22 meg (425 pcs) $12.00

½ WATT ZENER DIODES

1N5226B	3.3v	.15	$11/C	1N5236B	7.5v	.15	$11/C
1N5227B	3.6v	.15	$11/C	1N5237B	8.2v	.15	$11/C
1N5228B	3.9v	.15	$11/C	1N5238B	8.7v	.15	$11/C
1N5229B	4.3v	.15	$11/C	1N5239B	9.1v	.15	$11/C
1N5230B	4.7v	.15	$11/C	1N5240B	10v	.15	$11/C
1N5231B	5.1v	.15	$11/C	1N5241B	11v	.15	$11/C
1N5232B	5.6v	.15	$11/C	1N5242B	12v	.15	$11/C
1N5233B	6.0v	.15	$11/C	1N5243B	13v	.15	$11/C
1N5234B	6.2v	.15	$11/C	1N5244B	14v	.15	$11/C
1N5235V	6.8v	.15	$11/C	1N5245B	15v	.15	$11/C

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DATA BOOKS

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Transistors 288 p.	$3.00
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MPF102 .36 $30.60 C 2N5457 .48 $41.00 C MPSA13 .28 $24.00/C 2N3055 .99 $85.00 C

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$5.95

Wraps, Unwraps & Strips 30 ga. Wire

¼ & ½ WATT 5% CARBON FILM RESISTORS

5c each in multiples of 5 per value
$1.70/100 & $12.00/1000 of same value

1 ohm thru 1.0 megohm

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8 Pin Solder	.17	1.60/10
14 Pin Solder	.20	1.90/10
16 Pin Solder	.22	2.10/10
18 Pin Solder	.29	2.75/10
24 Pin Solder	.38	3.60/10
28 Pin Solder	.45	4.25/10
40 Pin Solder	.63	6.00/10
8 Pin W-W	.24	2.30/10
14 Pin W-W	.26	2.50/10
16 Pin W-W	.30	2.85/10
18 Pin W-W	.60	5.70/10
24 Pin W-W	.96	9.10/10
28 Pin W-W	1.12	10.00/10
40 Pin W-W	.92	8.75/10

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2-56 1/2 Screw	.99/C	7.65/M
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4-40 1/2 Screw	.60/C	4.05/M
6-32 1/4 Screw	.65/C	4.40/M
6-32 1/2 Screw	.75/C	4.85/M
8-32 3/8 Screw	.90/C	5.85/M
8-32 5/8 Screw	.99/C	7.00/M
2-56 Hex Nut	.55/C	3.60/M
4-40 Hex Nut	.55/C	3.75/M
6-32 Hex Nut	.60/C	4.00/M
8-32 Hex Nut	.60/C	4.15/M
No 2 Lockwasher	.85/C	5.75/M
No 4 Lockwasher	.45/C	3.00/M
No 6 Lockwasher	.45/C	3.00/M
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Merchandise	Discount	Merchandise	Discount
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6 Digit LED Clock Kit - 12/24 hr.

$9.95 ea. QTY. 12 OR MORE — **$10.95 ea.** QTY. 6-11 — **$11.95 ea.** QTY. 1-5

KIT INCLUDES
- INSTRUCTIONS
- QUALITY COMPONENTS
- 50 or 60 Hz OPERATION
- 12 or 24 HR OPERATION

6-LED Readouts (FND-359 Red, com. cathode)
1-MM5314 Clock Chip (24 pin)
13-Transistors
3-Switches
6-Capacitors
5-Diodes
9-Resistors
24-Molex pins for IC socket

LARGE **.4" DIGITS!**
ORDER KIT #850-4
AN INCREDIBLE VALUE!

"Kit #850-4 will furnish a complete set of clock components as listed. The only additional items required are a 7-12 VAC transformer, a circuit board and a cabinet, if desired."

Printed Circuit Board for kit #850-4 (etched & drilled fiberglass)	$2.95
Mini-Brite Red LED's (for colon in clock display) pkg. of 5	1.00
Molded Plug Transformer 115/10 VAC (with cord)	2.50

NOTE: Entire Clock may be assembled on one PC Board or Board may be cut to remote display. Kit #850-4 will fit Plexiglas Cabinet II.

MOBILE LED CLOCK

12 OR 24-HOUR OPERATION
12 VOLT AC or DC POWERED FOR FIXED OR MOBILE OPERATION.
SIX LARGE **.4" DIGITS!**

KIT OR ASSEMBLED — MODEL 2001

ACCURATE TIME WITH ADJUSTABLE XTAL TIME BASE

Approx. Size: 1¾"H x 4"W x 4½"D

BATTERY BACK UP FOR POWER FAILURE OR TRANSPORTING FROM HOUSE TO CAR ETC

- 6 JUMBO .4" RED LED'S BEHIND RED FILTER LENS WITH CHROME RIM.
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- BRIDGE POWER INPUT CIRCUITRY — TWO WIRE NO POLARITY HOOK-UP
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KIT #2001 COMPLETE KIT (Less 9V Battery) **29.95 EA** — 3 OR MORE **$27.95 EA** — 115 VAC Power Pack #AC-1 **$2.50 EA**

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This is a complete, top of the line, Kit for the person that wants the best. Some of the many features and options are: 12/24 time, 28-30-31 day calendar, alternates time (8 sec) and date (2 sec) or can display time only and date on demand, 24 hr alarm - 10 minute snooze, alarm set indicator, 50/60 HZ. line operation or use with Xtal time base (#TB-1), built in OSC for battery back-up / AC failure, Aux. timer, CHOICE OF DIGITS.

Kit #7001B	6 - .4" Digits	$39.95
Kit #7001C	4 - .6" Digits & 2-." [Seconds]	$42.95
Kit #7001X	6 - .6" Digits	$45.95

Kits are complete (less cabinet) including PC boards, power supply, IC socket, 9 switches, 16 transistors and all parts required for above features and options [All #7001 Kits Will Fit Cabinet I]

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NS8080AD
Micro Processor Chip
Prime National LSI
40 Pin socket
$ .50 with each 8080A!

450 ns MEMORY

Fairchild 1K Ram
low, low, low power.

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JUMBO RED LED's 12/$1.00 50/$3.95

PRINTED CIRCUIT BOARDS for CT-7001 Kits sold separately with assembly info. PC Boards are drilled Fiberglass, solder plated and screened with component layout. Specify for #7001B or #7001C (Set of 2) $7.95

JUMBO DIGIT CLOCK KIT

A complete Kit (less Cabinet) featuring: six .5" digits, MM5314 IC, 12/24 Hr. time, 50/60 HZ., Plug-Transformer, Line Cord, Switches, and all Parts.
[Ideal Fit in Cabinet II]
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Convert small digit LED clock to large .5" displays. Kit includes 6-.5" LED's, Multiplex PC Board & easy hook-up info.
Kit #JD-1CC For common Cathode
Kit #JD-1CA For common Anode
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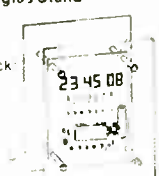
SEE THE WORKS Clock Kit
Clear Plexiglas Stand

- 6 Big .4" digits
- 12 or 24 hr. time
- 3 set switches (back)
- Plug transformer
- all parts included

Plexiglas is Pre cut & drilled
Size 6"H 4 3"W



A SUPER LOOKING CLOCK!
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4" Char. Ht 7 segment LED RED Com. Cath. Direct pin replacement for popular FND-70
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74S60	85
74S64	55
74S74	85
74S75	1 75
74S78	1 50
74S86	95
74S107	95
74S112	95
74S113	1 40
74S114	95
74S133	75
74S134	75
74S138	1 75
74S139	1 50
74S151	1 95
74S153	1 95
74S155	1 95
74S156	1 95
74S157	1 80
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709	TO 5
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741	M DIP
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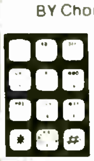

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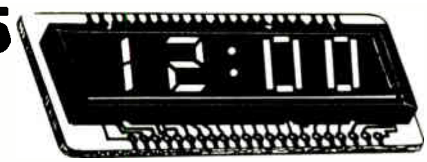

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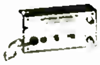

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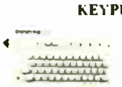

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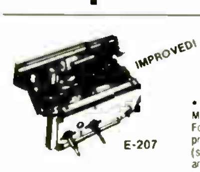

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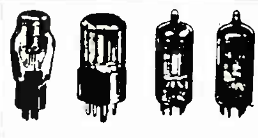

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6AR5	.81	6GM6	1.68
6AS8	2.48	6GM8	3.30
6AU4GTA	1.97	6GS7	1.38
6AU5GT	2.41	6GU7	1.67
6AU6A	1.31	6GW8	.98

ALL TUBES BRAND NEW MANU. BOXED 70% OFF

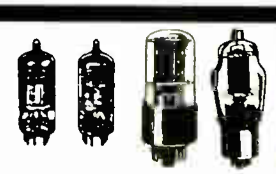
MINIMUM ORDER $7.50

MONEY BACK GUARANTEE

Terms: Minimum order $7.50. Include postage. Either full payment with order or 20% deposit, balance C.O.D.

6GX6	1.38	6JH8	2.51
6H6	2.71	6JM6A	2.16
6HA5	1.53	6JN6	2.03
6HB7	1.55	6JR6	3.54
6HE5	1.91	6JS6C	2.95
6HF5	3.78	6JT6	2.40
6HF8	2.16	6JT8	1.91
6HQ5	2.03	6JU6	2.84
6HS5	2.94	6JU8	1.77
6HS6	1.46	6JV8	1.80
6HS8	1.91	6JW8	1.35
6HV5	3.54	6K6GT	1.64
6HZ6	1.28	6K7GT	2.24
6J5	1.89	6K8	4.69
6J7	2.31	6KA8	1.95
6J10	2.45	6KD6	3.38
6JB6	2.42	6KE8	2.45
6JC6A	1.79	6KM6	3.38
6JD6	1.85	6KT8	2.18
6JE6C	3.35	6KV6A	2.67
6JG6A	2.67	6KZ8	1.64
6JH6	1.43	6L6	4.86

WRITE FOR FREE VALUE PACKED CATALOG



70% OFF LIST!

6L[illegible]	2.84	12BH7A	1.58
6LB6	3.23	12BY7	1.43
6LE8	2.27	12DQ6B	2.10
6LF6	3.20	12FX5	1.34
6LF8	2.34	12GN7	2.22
6LJ8	1.76	12HL7	1.95
6LM8	1.95	12JB6A	2.55
6LN8	1.05	12MD8	1.77
6LT8	1.64	12SL7	2.31
6LU8	1.92	13GF7A	2.09
6LX8	1.05	13Z10	2.55
6M11	2.76	14BL11	3.11
6MB8	1.52	15BD11A	2.25
6MD8	2.34	15CW5	.87
6SA7	2.04	15KY8A	2.91
6SG7	2.30	16A8	1.23
6SJ7	2.19	16LU8A	2.97
6SK7	2.03	17AY3A	1.52
6SL7GT	2.30	17BE3	1.52
6SN7GT	1.52	17BF11	2.39
6SQ7	2.01	17BR3	1.23
6T8A	1.92	17BS3	1.52
6T10	2.25	17CK3	1.31
6U8A	1.56	17CU5	1.26
6U10	1.62	17DW4	1.41
6V6	3.57	17JN6	2.16
6X4	1.46	17JQ6	1.85
6X5GT	1.47	17JZ8	1.43
6X9	1.82	19CG3	1.58
7F8	6.00	20AQ3	1.17
7V7	3.00	21GY5	2.01
8A8	.93	21HB5	1.92
8AC9	1.88	21JS6	4.30
8AR11	2.46	21JZ6	2.10
8B10	1.80	21LR8	1.89
8BA11	2.25	21LU8	1.86
8BM11	2.30	22JF6	2.66
8BQ11	1.98	22JR6	2.73
8BU11	2.30	22KM6	3.08
8CG7	1.12	23Z9	1.91
8JV8	1.86	24JE6C	3.20
8LT8	1.61	25CG3	1.38
9AQ8	2.31	29KQ6	3.53
9GH8	1.67	30AE3	1.17
9JW8	1.26	31JS6C	2.89
10CW5	1.02	31LQ6	3.05
10DX8	.98	31LZ6	3.38
10GK6	1.82	33GY7A	2.42
10GN8	1.92	35C5	1.31
10JT8	2.06	35W4	.89
10JY8	1.50	35Z5GT	1.41
10KR8	2.04	36KD6	3.36
11AF9	2.13	38HE7	2.92
11AR11	2.46	38HK7	2.86
11BM8	1.86	40KG6A	3.26
11FY7	1.52	42EC4A	1.59
11KV8	2.20	42KN6	2.75
11MS8	1.53	50B5	1.21
12AB5	1.41	50C5	1.23
12AT6	1.13	50EH5	1.47
12AT7	1.37	50GY7A	3.60
12AU7A	1.23	50L6GT	1.95
12AV6	1.02	80	1.88
12AX7A	1.13	6267	2.10
12AZ7A	1.74	6973	1.85
12B4A	1.77	7025A	1.13
12BA6	1.16	7189A	1.73
12BE6	1.22	7199	2.06

EDLIE ELECTRONICS, INC. 2700-KP HEMPSTEAD TPKE., LEVITTOWN, N. Y. 11756

CIRCLE NO. 23 ON FREE INFORMATION CARD

SOCKETS

LOW PROFILE, SOLDER, TIN

8 Pin	0.16	0.15	0.14	18 Pin	0.28	0.27	0.26	28 Pin	0.44	0.43	0.42
14 Pin	0.19	0.18	0.17	22 Pin	0.36	0.35	0.34	36 Pin	0.59	0.58	0.57
16 Pin	0.21	0.20	0.19	24 Pin	0.37	0.36	0.35	40 Pin	0.62	0.61	0.60

STANDARD, SOLDER, TIN

	1-24	25-49	50 100
14 Pin	0.27	0.25	0.24
16 Pin	0.30	0.27	0.25
18 Pin	0.35	0.32	0.30
24 Pin	0.49	0.45	0.42
28 Pin	0.99	0.90	0.81
36 Pin	1.39	1.26	1.15
40 Pin	1.59	1.45	1.30

STANDARD, SOLDER, GOLD

	1-24	25-49	50-100
8 Pin	0.30	0.27	0.24
14 Pin	0.35	0.32	0.29
16 Pin	0.38	0.35	0.32
18 Pin	0.52	0.47	0.43
24 Pin	0.70	0.63	0.57
28 Pin	1.10	1.00	0.90
36 Pin	1.75	1.40	1.26
40 Pin	1.75	1.59	1.45

WIREWRAP, GOLD (Level No.3)

	1 24	25 49	50-100
10 Pin	0.45	0.41	0.37
14 Pin	0.39	0.38	0.37
16 Pin	0.43	0.42	0.41
18 Pin	0.75	0.68	0.62
24 Pin	1.05	0.95	0.85
28 Pin	1.40	1.25	1.10
36 Pin	1.59	1.45	1.30
40 Pin	1.75	1.55	1.40

SAMS BOOKS

TTL COOKBOOK
No.21035 . . . . $8.95
IC OP-AMP COOKBOOK
No.20969 . . . . $12.95
SECOND CLASS RADIOTELEPHONE LICENSE HANDBOOK, 5TH Ed.
No.21111 . . . . $7.50
TRANSISTOR SUBSTITUTION HANDBOOK, 15th Ed.
No.21169 . . . . $4.50
REFERENCE DATA FOR RADIO ENGINEERS, 6th Ed.
No.21218 . . . . $30.00
BASIC ELECTRICITY/ELECTRONICS SERIES, Vol.1:BASIC PRINCIPALS AND APPLICATIONS
No.20167 . . . . $5.50
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UNDERSTANDING IC OPERATIONAL AMPLIFIERS
No.20855 . . . . $3.95
HOW TO USE IC LOGIC ELEMENTS, 2nd Ed.
No.21081 . . . . $4.50
UNDERSTANDING CMOS INTERGRATED CIRCUITS
No.21129 . . . . $4 95

SOLID-STATE
Digital Auto Clock Build-It-Yourself Kit

FROM

COMPLETE KIT
— ONLY $40.00

Our Quality Is Best!

NEW 74C00 SERIES CMOS

74C00N	.38	74C74N	.90	74C157N	3.40	74C195N	1.80
74C02N	.40	74C76N	1.00	74C160N	2.10	74C221N	2.10
74C04N	.60	74C83N	2.75	74C161N	2.10	74C901N	1.00
74C08N	.40	74C85N	2.75	74C162N	2.10	74C902N	1.00
74C10N	.50	74C86N	1.00	74C163N	2.10	74C903N	1.00
74C14N	2.20	74C89N	14.00	74C164N	1.80	74C904N	1.00
74C20N	.50	74C90N	2.70	74C165N	1.80	74C906N	1.00
74C30N	.50	74C93N	2 70	74C173N	1.80	74C907N	1.00
74C32N	.50	74C95N	1.80	74C174N	1.70	74C914N	2.70
74C42N	2.10	74C107N	1.90	74C175N	1.70	80C95	1.00
74C48N	3.30	74C151N	3.80	74C192N	2.10	80C97	1.00
74C73N	1.20	74C154N	5.70	74C193N	2.10		

DISPLAYS — (COMMON ANODE) Data Sheet EP1000 $.25

LARGE 1"			XCITON .3"		
EP1000	RED	5.50	XAN72	RED	2.00
3 pcs	EP1000	15.00	XAN52	GREEN	2.00
5 pcs	EP1000	22.50	XAN82	YELLOW	2.00
LITRONIX .3"			LITRONIX .6"		
DL707	RED	2.35	DL747	RED	2.50

LEDs

.125" dia.
209 RED $.25
209 YELLOW .35
209 GREEN .35

.160" dia.
216 RED $.25
216 YELLOW .30
216 GREEN .30

LOW PROFILE .200" dia.
226 RED $.25
226 YELLOW .30
226 GREEN .30
226 ORANGE .30

.200" dia.
5053 RED $.35
5053 YELLOW .40
5053 GREEN .40
5053 ORANGE .40

.200" dia.
220 RED $.25
220 YELLOW .30
220 GREEN .30

.12" dia.
MV50 RED $.30

OPTO COUPLER
MCT 2 1.50

7400N TTL

7400	.18	7432	.32	7480	.80	74128	.60	74175	1.20
7401	.20	7433	.44	7482	1.50	74132	1.50	74176	1.20
7402	.18	7437	.36	7483	.82	74136	1.80	74177	1.20
7403	.20	7438	.35	7485	1.20	74141	1.70	74178	1.40
7404	.21	7439	.36	7486	.44	74145	1.20	74179	1.80
7405	.23	7440	.20	7489	2.20	74147	2.00	74180	1.20
7406	.30	7441	.90	7490	.56	74148	1.80	74181	3.10
7407	.36	7442	.66	7492	.60	74150	1.70	74182	1.00
7408	.28	7443	.78	7493	.62	74151	1.20	74184	2.80
7409	.28	7444	1.05	7494	.88	74152	1.20	74185	2.90
7410	.22	7445	1.05	7495	.90	74153	1.20	74188	5.00
7411	.26	7446	1.05	7496	.80	74154	1.20	74190	1.40
7412	.36	7447	.98	7497	5.00	74155	1.10	74191	1.30
7413	.54	7448	.98	74100	1.20	74156	1.20	74192	1.20
7414	.98	7450	.15	74105	.90	74157	1.20	74193	1.20
7416	.42	7451	.16	74107	.40	74158	1.40	74194	1.20
7417	.42	7453	.18	74109	.45	74160	1.30	74195	1.00
7420	.15	7454	.18	74110	.80	74161	1.40	74196	1.40
7421	.38	7459	.25	74111	1.00	74162	1.90	74197	1.40
7422	.60	7460	.19	74116	2.00	74163	1.50	74198	1.40
7423	.35	7470	.40	74118	2.00	74164	1.50	74199	1.40
7425	.40	7472	.40	74121	.60	74165	1.60	74200	7.00
7426	.30	7473	.42	74122	.48	74166	1.60	74221	1.40
7427	.36	7474	.42	74123	.95	74170	2.00	74279	1.20
7428	.50	7475	.70	74125	.55	74173	1.70	74298	1.80
7430	.26	7476	.44	74126	.60	74174	1.20		

74LS00

74LS00N	.36	74LS51N	.44	74LS132N	1.44	74LS193N	1.70
74LS01N	.44	74LS54N	.44	74LS136N	.74	74LS194AJ	2.20
74LS02N	.36	74LS55N	.44	74LS138N	1.60	74LS195AJ	2.20
74LS03N	.50	74LS73N	.58	74LS139N	1.95	74LS196N	2.76
74LS04N	.44	74LS74N	.58	74LS145N	1.64	74LS197N	2.84
74LS05N	.44	74LS75N	.79	74LS151N	1.55	74LS221N	1.76
74LS08N	.36	74LS76N	.62	74LS153N	1.30	74LS241N	3.00
74LS09N	.44	74LS78N	.92	74LS157N	1.30	74LS251N	2.06
74LS10N	.36	74LS83AN	1.44	74LS158N	1.68	74LS253N	2.40
74LS11N	.44	74LS85AN	2.10	74LS160N	3.00	74LS257N	1.89
74LS15N	.44	74LS86AN	.44	74LS161N	1.50	74LS258N	2.00
74LS20N	.44	74LS90AN	1.14	74LS162N	1.60	74LS260N	.44
74LS21N	.44	74LS92AN	.86	74LS163N	1.50	74LS266N	.72
74LS22N	.44	74LS93AN	.86	74LS164N	1.50	74LS283N	2.00
74LS27N	.44	74LS95AN	2.19	74LS170N	3.20	74LS290N	1.76
74LS30N	.36	74LS96AN	1.24	74LS174N	1.30	74LS293N	1.76
74LS32N	.44	74LS107N	.56	74LS175N	1.30	74LS299N	7.20
74LS33N	.56	74LS109N	.64	74LS181N	5.90	74LS375N	.82
74LS37N	.50	74LS112N	.64	74LS190N	2.85	74LS378N	1.60
74LS38N	.58	74LS113N	.64	74LS191N	2.70	74LS386N	.72
74LS40N	.44	74LS114N	.92	74LS192N	1.90	74LS670N	3.95
74LS42N	.92	74LS123N	1.10				

HIGH SPEED TTL

74H00N	.33	74H08N	.40	74H73N	.80	74H106N	.95
74H04N	.33	74H10N	.33	74H74N	.80		

SCHOTTKY TTL

74S00	.44	74S11	.65	74S64	.80	74S114	1.20
74S02	.60	74S20	.65	74S74	.90	74S133	.80
74S04	.55	74S30	.80	74S76	1.15	74S138	2.20
74S08	.80	74S32	.80	74S112	1.00	74S151	2.20
74S10	.55	74S40	.65	74S113	1.50	74S160	3.90
						74S257	2.40

CMOS

4000AE	.20	4023AE	.24	4051AE	1.70	4093AE	1.65
4001AE	.24	4024AE	.95	4052AE	1.40	4095BE	1.95
4002AE	.24	4025AE	.24	4053AE	1.70	4098AE	2.50
4006AE	1.30	4026AE	2.50	4055AE	1.95	4099AE	2.50
4007AE	.24	4027AE	.55	4056AE	1.99	4502AE	1.50
4008AE	1.40	4028AE	1.00	4060AE	2.10	4507BE	.60
4009AE	.50	4029AE	1.20	4063AE	2.50	4508BE	2.20
4010AE	.50	4030AE	.48	4066AE	.90	4510AE	1.40
4011AE	.24	4033AE	2.00	4068AE	.44	4511BE	1.30
4012AE	.24	4035AE	1.30	4069AE	.44	4512BE	1.30
4013AE	.40	4040AE	1.20	4070BE	.60	4514AE	5.00
4014AE	1.20	4041AE	1.25	4071AE	.45	4515AE	5.00
4015AE	1.30	4042AE	1.20	4072AE	.34	4516AE	1.75
4016AE	.80	4043AE	.95	4073AE	.40	4518AE	1.50
4017AE	1.05	4044AE	1.10	4075AE	.40	4520AE	1.28
4018AE	1.24	4046AE	3.10	4076AE	1.24	4528AE	2.20
4019AE	.54	4047AE	2.50	4077AE	.40	4585AE	2.05
4020AE	1.45	4048AE	1.43	4078AE	.40	4901AE	.32
4021AE	1.30	4049AE	.58	4081BE	.40	4911AE	.32
4022AE	1.05	4050AE	.58	4082AE	.39		

NEW OK WIRE-WRAP TOOL & WIRE

WSU 30	Wire wrap tool		$5 95
R 30B 0050	50ft. roll, blue wire	30AWG.	$1.98
R 30Y 0050	50ft. roll, yellow wire	30AWG	$1.98
R 30W 0050	50ft. roll, white wire	30AWG.	$1.98
R 30R 0050	50ft. roll, red wire	30AWG.	$1.98

CONTINENTAL SPECIALTIES

PROTO BOARDS & EXPERIMENTERS

Build & test circuits as fast as you think!

PB-6	$15.95	PB103	$59.95
PB100	19.95	PB104	79.95
PB101	29.95	EX300	9.95
PB102	39.95	EX600	10.95

PROTO BOARDS

With built-in regulated short-proof power supplies

PB203 5V, 1 amp regulated power supply $ 75.00
PB203A 5V, 1 amp and ±15V, ½ amp regulated power supply 120.00

LOGIC MONITOR 1

Simultaneously displays static and dynamic logic states of DTL, TTL, HTL or CMOS DIP ICs. Pocket size. $74.95

LOGIC MONITOR 2

Displays static and dynamic states of digital ICs such as C-MOS, HTL, TTL, DTL & RTL Selectable threshold control. $124.95

LOGIC PROBE LP-1

Compact, circuit-powered multifunction logic probe. Multi family compatability. DTL/TTL/HTL/CMOS. Traces logic levels and pulses through digital circuitry $44.95.

SOCKETS & BUS STRIPS

Plug in, wire, test, modify or expand without patch cords or solder. Snap together to form breadboard needed.

PN/Description	Term'ls	Price
QT59S Socket	118	$12 50
QT59B Bus	20	2.50
QT47S Socket	94	10.00
QT47B Bus	16	2.25
QT35S Socket	70	8.50
QT35B Bus	12	2.00
QT18S Socket	36	4.75
QT12S Socket	24	3.75
QT8S Socket	16	3.25
QT7S Socket	14	3.00

PROTO-CLIP

For power-on/hands off signal tracing. Bring IC leads up from PC board surface for fast trouble shooting.

PC14	14-pin	$4.50
PC16	16-pin	4.75
PC24	24-pin	8.50
PC40	40-pin	13.75

TOP VIEW BOTTOM VIEW

CARBON FILM RESISTORS (5%)

Only in Multiples of 100 pcs per value (ohms)
¼W . . . $1.69 per 100
½W . . . $1.79 per 100

10	100	1.0K	10K	100K	1.0M
11	110	1.1K	11K	110K	1.1M
12	120	1.2K	12K	120K	1.2M
13	130	1.3K	13K	130K	1.3M
15	150	1.5K	15K	150K	1.5M
16	160	1.6K	16K	160K	1.6M
18	180	1.8K	18K	180K	1 8M
20	200	2.0K	20K	200K	2 0M
22	220	2.2K	22K	220K	2.2M
24	240	2.4K	24K	240K	2.4M
27	270	2.7K	27K	270K	2.7M
30	300	3.0K	30K	300K	3.0M
33	330	3.3K	33K	330K	3.3M
36	360	3.6K	36K	360K	3.6M
39	390	3.9K	39K	390K	3.9M
43	430	4.3K	43K	430K	4.3M
47	470	4.7K	47K	470K	4 7M
51	510	5.1K	51K	510K	5 1M
56	560	5.6K	56K	560K	5 6M
62	620	6.2K	62K	620K	6.2M
68	680	6.8K	68K	680K	6 8M
75	750	7.5K	75K	750K	7.5M
82	820	8.2K	82K	820K	8.2M
91	910	9.1K	91K	910K	9.1M

ALUMINUM ELECTROLYTIC CAPACITORS

(RADIAL LEAD)

MFD	10V	16V	25V	35V	50V
1	.12	.13	.14	.15	.16
5	.13	.14	.17	.20	.24
10	.14	.15	.18	.22	.26
22	.15	.16	.21	.23	28
33	.16	.17	.22	.24	30
47	.17	.18	.24	.25	.32
100	.18	.20	.26	.30	.35
220	.23	.25	.35	.40	50
330	.30	.33	.40	.45	55
470	.35	.40	.45	.60	80
1000	— —	— —	.65	.80	1 20
2200	— —	— —	1.30	1.60	2 50

RESISTOR ASSORTMENTS

Each assortment contains 5 pcs each of 10 different values. Values included are shown in (Ohms)
¼W,5% (50 pcs total). . .$1.75 / ½W,5% (50 pcs total). . .$1.85

Asst.1: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56 ohm
Asst.2: 68, 82, 100, 120, 150, 180, 220, 270, 330, 390 ohm
Asst.3: 470, 560, 680, 820 ohm, 1K, 1.2K, 1.5K, 1.8K, 2.2K, 2.7K
Asst.4: 3.3K, 3.9K, 4.7K, 5.6K, 6.8K, 8.2K, 10K, 12K, 15K, 18K
Asst.5: 22K, 27K, 33K, 39K, 47K, 56K, 68K, 82K, 100K, 120K
Asst.6: 150K, 180K, 220K, 270K, 330K, 390K, 470K, 560K, 680K, 820K
Asst.7: 1M, 1.2M, 1.5M, 1.8M, 2.2M, 2.7M, 3.3M, 3.9M, 4.7M, 5.6M, (½W Assortment No.7 doesn't include 5.6M)
Asst.8R: (All seven assortments above) ¼W 5% 350 pcs total: $10.95 ½W 5% 350 pcs total: $11.55

FEBRUARY SPECIALS

SANKEN HYBRID POWER AMPLIFIER

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SI-1020G $13 95
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.22	35	.33	10.0	16	.42
.33	35	.33	10.0	25	.45
.47	35	.33	10.0	35	.90
.68	35	.33	15.0	20	.45
1.0	35	.33	15.0	35	1.32
1.5	35	.40	22.0	16	.45
2.2	20	.33	33.0	20	1.32
2.2	35	.40	47.0	20	1.53
3.3	35	.42	68.0	16	1.62
4.7	35	.45			

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MF	V	$	MF	V	$
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.0012	1000	.14	.047	250	.15
.0015	1000	.14	.056	250	.15
.0018	1000	.14	.068	250	.15
.0022	1000	.14	.082	250	.17
.0027	1000	.14	.1	100	.17
.0033	1000	.14	.12	100	.18
.0039	630	.14	.15	100	.20
.0047	630	.14	.18	100	.21
.0056	630	.14	.22	100	.23
.0068	630	.14	.27	100	.26
.0082	630	.14	.33	100	.30
.01	630	.14	.39	100	.33
.012	630	.14	.47	100	.36
.015	400	.15	.56	100	.44
.018	400	.15	.68	100	.47
.022	400	.15	.82	100	.54
.027	400	.15	1.0	100	.60
.033	250	.15			

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APS5 6	5	6	50 40
APS12 4	12	4	
APS15 3	15	3	
APS24-2.2	24	2 2	
APS28-2	28	2	
APS5-10	5	10	71.20
APS12 7	12	7	
APS15-6	15	6	
APS24 5	24	5	
APS28-4	28	4	
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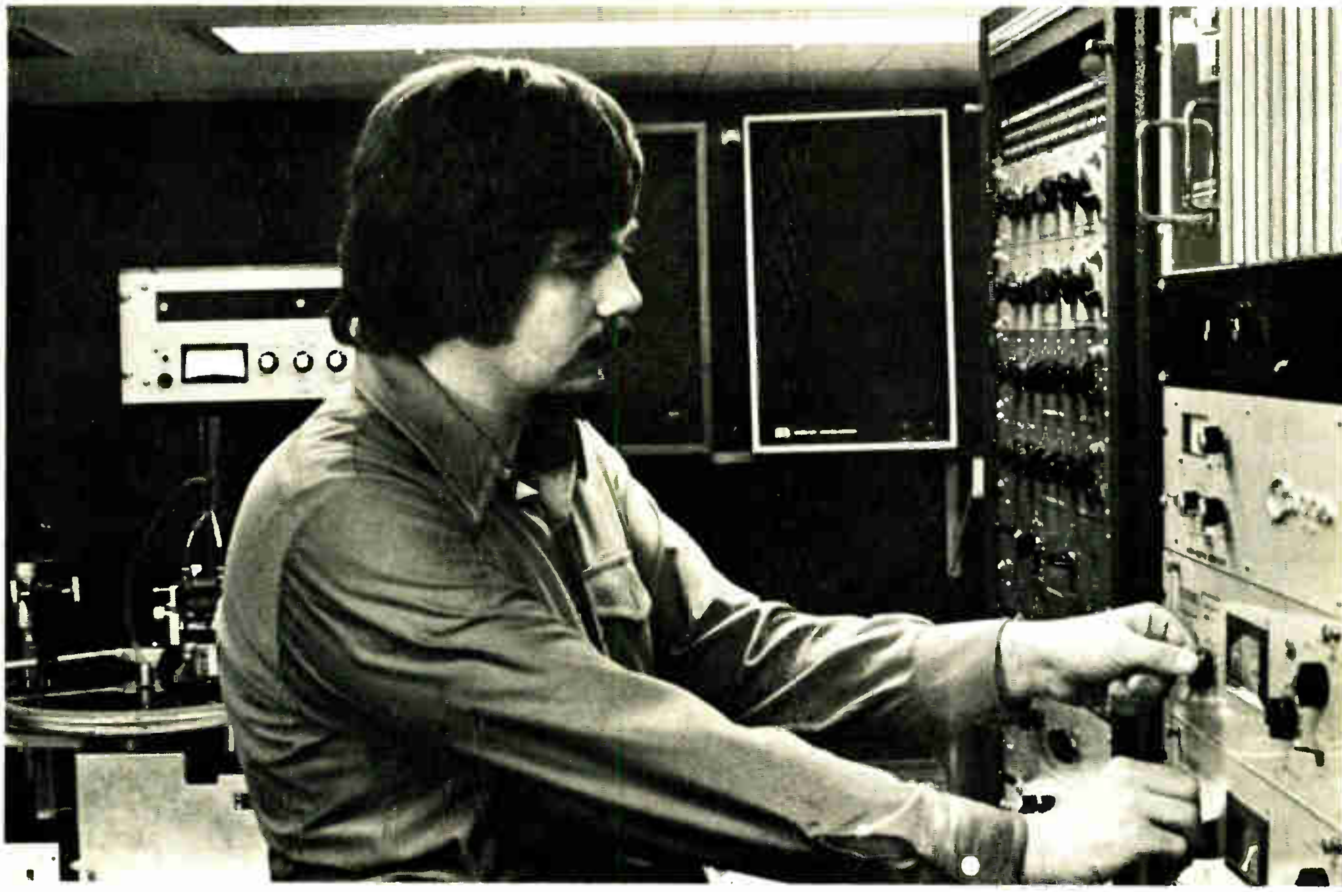
According to TRUTONE RECORDS..."The Stanton calibrated 681 series is our total point of reference in our Disc Mastering Operation"



"Carl Rowatti, Chief Engineer, adjusting the Program limiters prior to cutting a master lacquer".

Trutone can be described as a family enterprise . . . but what a family! Father Lou Rowatti is the President; Son Carl is Vice President and Chief Engineer; and daughter-in-law Adrianne handles the business end of the operation. They have great pride in their family, in their family's enterprise and in their products. That's why they insist on using the best — always.

Trutone Records in Northvale, New Jersey always uses the Calibrated Stanton Triple-E for A-B comparisons between tape and disc. They also use the Triple-E to check the frequency response of the cutter head (they'll record a 1,000 Hz tone and a 10 kHz tone twice a day to check the condition of the cutting stylus and the high end frequency response of the cutter head).

They make test cuts and play them back, using the Triple-E for reference, as high as 15 kHz all the way down to 30 Hz. Carl Rowatti says "We use the Stanton Calibrated 681 series as our total point of reference in our disc mastering operation. Everything in the studio is judged — and we think perfectly judged for quality—with this great cartridge".

Professionals can't afford to take chances with quality. That's why they depend on Stanton in their operations.

Each Stanton 681 Triple-E is guaranteed to meet its specifications within exacting limits, and each one boasts the most meaningful warranty possible. An individually calibrated test result is packed with each unit.

Whether your usage involves recording, broadcasting, disco or home entertainment your choice should be the choice of the professionals...the Stanton 681 TRIPLE-E.

Write today for further information to: Stanton Magnetics, Terminal Drive, Plainview, New York 11803

STANTON

Lou Rowatti inspects a master lacquer, Adrianne checks the lathe.

Carl Rowatti adjusts the pitch computer on the mastering lathe.

Carl installs the Stanton Calibrated 681 Triple-E on the playback table.

Lou Rowatti (The Prez) adjusting the high frequency limiter in his cutting room.

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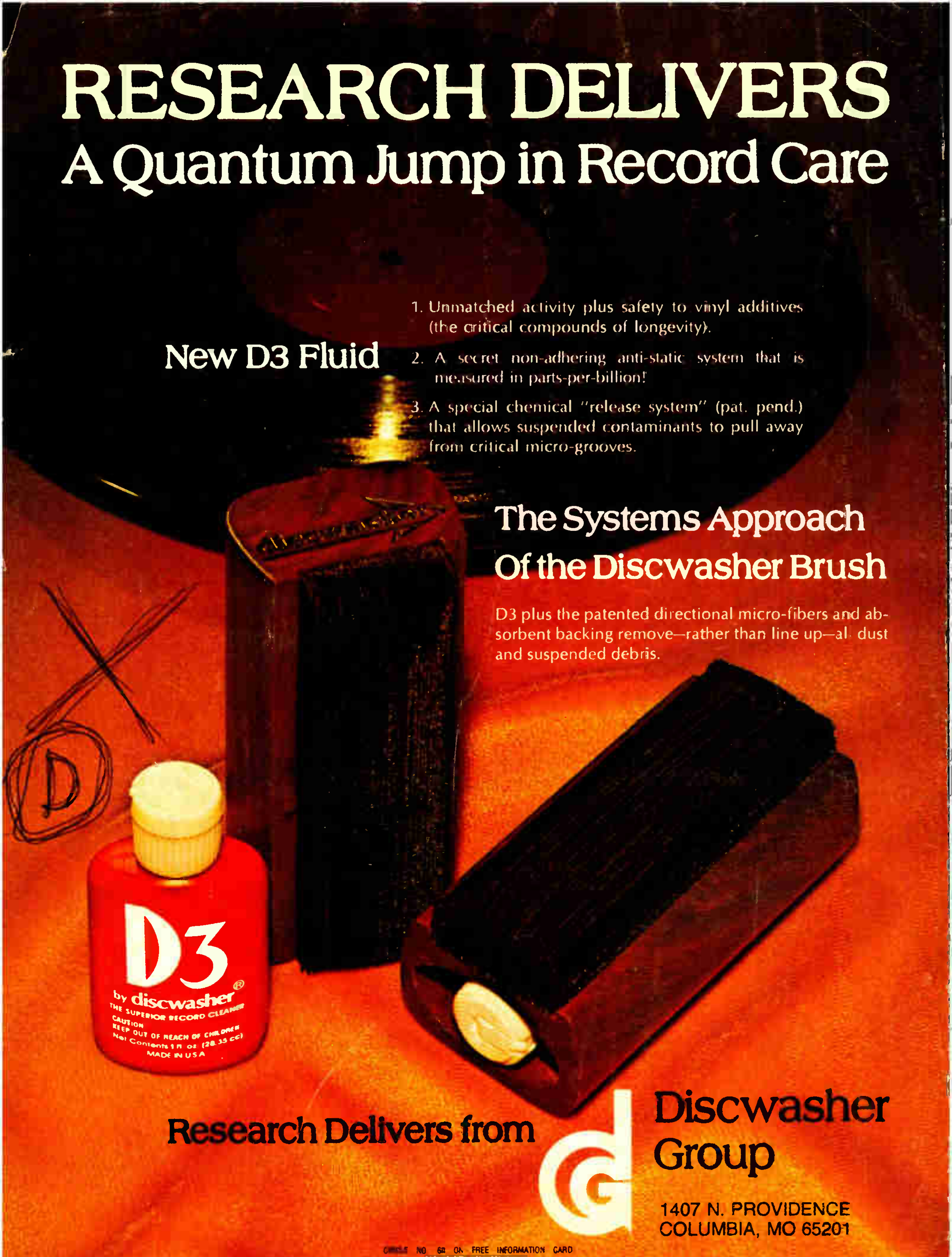

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