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BUILD A CHANCE/STRATEGY ELECTRONICS GAME

Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE NOVEMBER 1976/$1.25

Build a "Westminster Chime" Digital Clock

Checking the Sun for Home Propagation Forecasts

How to Protect Power Supplies From Damage

The 35-mm Slide Syncer

AN AUDIO-VISUAL PROGRAMMER TO BUILD

TEST REPORTS:

Spectro-Acoustics Stereo Equalizer

Pickering Stereo Cartridge

Siltronix CB AM Mobile Transceiver

A CB/Ham Selective Calling Project

- CODED TONE ACTIVATES RECEIVER
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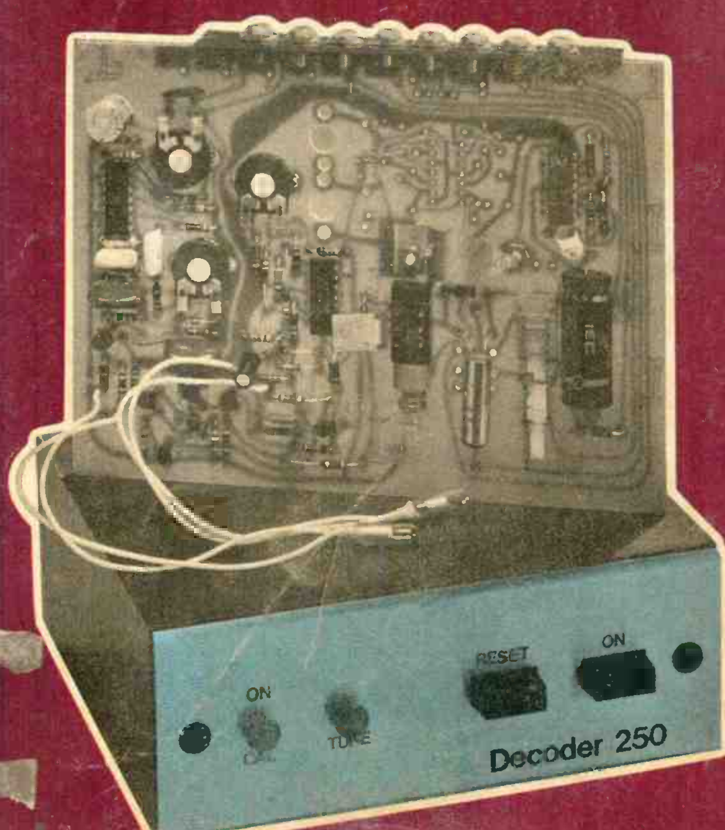

Experience is the best teacher. You might settle for any CB first time around. Understandably. A lot of people think they're all pretty much alike. But you'll soon discover that, like everything else, there are exceptions.

Ask the pros. America's long distance truckers. These guys talk CB day in and day out. And they demand the best. That's why truckers refer to the Cobra 29 as "The Diesel Mobile."

Listen to Cobra. You'll hear a big difference. Because the Cobra 29 gives you features which assure crystal clear reception. Like switchable noise limiting and blanking, to cut out practically all pulse and ignition interference. Add squelch control and RF gain and you've got exceptional—adjustable—receiver clarity. Even in the heaviest CB traffic. You also get Delta Tuning which makes up for the other guy, because even off-frequency transmitters are pulled in. Perfectly.

Talk to Cobra. And you know you're punching through. One glance at the 29's over-sized illuminated meter tells you just how much power you're punching out and pulling in. For voice modulation the DynaMike delivers at 100%. Same way with power: The 29 transmits at maximum power levels.

Sooner or later you'll get a Cobra. And you'll get engineering and craftsmanship second to none. Performance that will make your first CB seem obsolete. Reliability and durability that have set standards for the industry. Above all, you'll get power. The power to punch through loud and clear like nothing else. Because when it comes to CB radio, nothing punches through loud and clear like a Cobra.

Cobra

Punches through loud and clear.

Cobra Communications Products
DYNASCAN CORPORATION
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IF YOUR FIRST CB ISN'T A COBRA YOUR SECOND ONE WILL BE.

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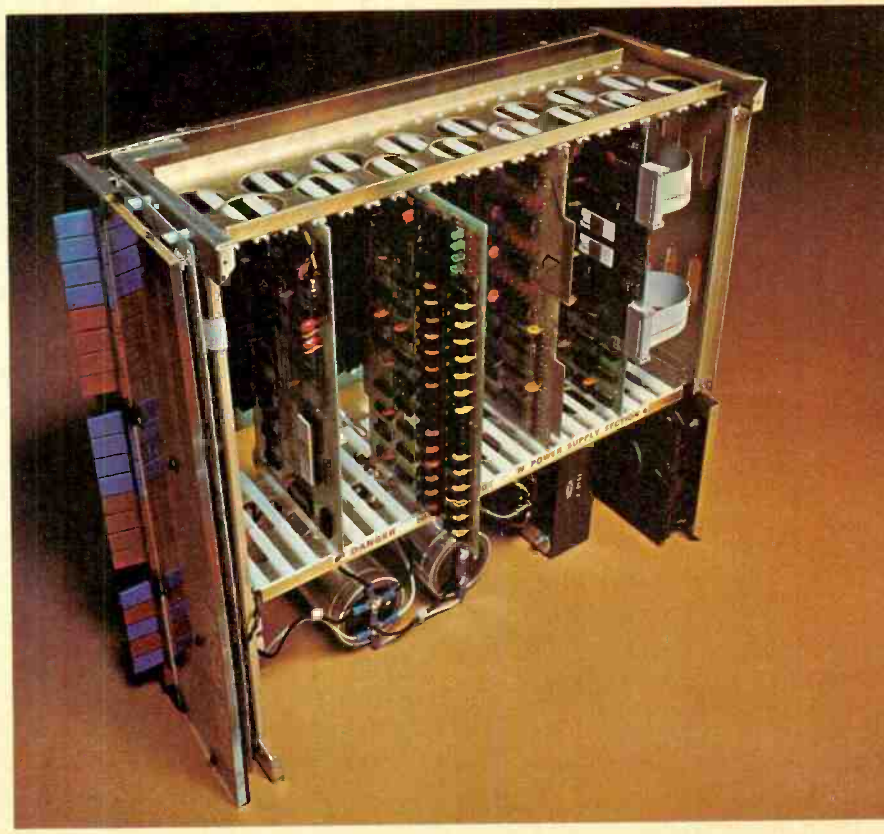
think IMSAI 8080.



Sure there are other commercial, high-quality computers that can perform like the 8080. But their prices are 5 times as high. There is a rugged, reliable, industrial computer, with high commercial-type performance. The IMSAI 8080. Fully assembled, it's $931. Unassembled, it's $599. And ours is available now.

In our case, you can tell a computer by its cabinet. The IMSAI 8080 is made for commercial users. And it looks it. Inside and out! The cabinet is attractive, heavy-gauge aluminum. The heavy-duty lucite front panel has an extra 8 program controlled LED's. It plugs directly into the Mother Board without a wire harness. And rugged commercial grade paddle switches that are backed up by reliable debouncing circuits. But higher aesthetics on the outside is only the beginning. The guts of the IMSAI 8080 is where its true beauty lies.

The 8080 is optionally expandable to a substantial system with 22 card slots in a single printed circuit board. And the durable card cage is made of commercial-grade anodized aluminum.

The IMSAI 8080 power supply produces a true 28 amp current, enough to power a full system.

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Find out more about the computer you thought didn't exist. Get a complete illustrated brochure describing the IMSAI 8080, options, peripherals, software, prices and specifications. Send one dollar to cover handling.

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CIRCLE NO. 33 ON FREE INFORMATION CARD

NOVEMBER 1976 VOLUME 10, NUMBER 5

Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

FEATURE ARTICLES

CONSTRUCTION ARTICLES

COLUMNS

PRODUCT TEST REPORTS

DEPARTMENTS

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Editorial

MAJORITY RULES—THE BITTER PILL

The attitudes of hams toward CB'ers have been changing. Many radio amateurs, for example, have also become CB'ers, recognizing the value of a two-way radio communication system that can be widely used on all highways throughout the country at most any hour. Conversely, there are CB'ers who, "tasting" two-way radio, have become radio amateurs in order to enjoy the benefits of long-distance communications, video transmissions, etc., as well as the technical camaraderie that exists in hamdom.

However, there exists a hard-core minority of hams who begrudge the easy manner in which citizens can get on the air. This attitude was underlined by letters I received from some hams in response to the favorable viewpoint expressed by our CB columnist toward "Class E" CB allocations. In an effort to defend retention of a small slice of the radio spectrum for hams—and I do not denigrate this view—virtually all the writers focused on one point: The use of the radio spectrum is a privilege that must be earned!

Well, these radio amateurs are spitting into the wind. According to this philosophy, taxicab drivers shouldn't be using two-way radios. Neither should boating enthusiasts. Obviously, personal communications via radio without requiring any technical know-how or passing of an examination is here to stay. So these hams shouldn't rest on this argument. There are certainly enough more cogent reasons that can be used in defense of retaining the present 220-MHz spectrum allocation.

It's doubtful, though, if these arguments will be sufficient to withstand the assaults of a majority group, judging by the way high-quality TV fare is excised owing to relatively low viewer numbers. In any event, this judgement is in the hands of the FCC, which must also consider many other factors.

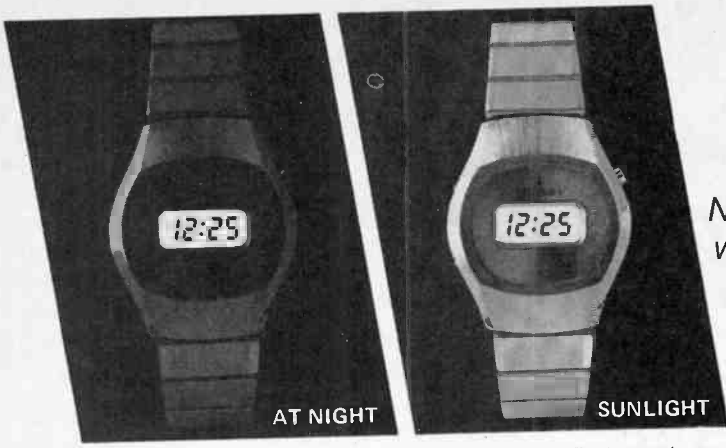
Hams are an elitist group by any definition. And like elitist groups everywhere, don't look kindly upon "out groups" that infringe on their territory. By maintaining high standards, however, their potential numbers—and "political" punch—are limited. Even today, most hams would prefer to maintain a Morse Code test, based on a 1975 ARRL study among its 100,000 members.

Moreover, proselytizing efforts over the years have been pathetically meager. This extends to top management of amateur radio equipment companies. As evidence, we get very little in the way of press releases on new equipment from these companies. Unlike CB manufacturers, they seem to be content to feed upon themselves by reaching people who are already hams. And that's why the great ham-gear names such as Hallicrafters and Hammarlund, among others, have gone the way of the famous great Auk.

There are some faint signs of regeneration for amateur radio in the matter of expanding their numbers. The American Radio Relay League was represented by an exhibit booth at last year's "Personal Communications" CB show, hoping to pick up some CB'ers. And the ARRL's new "Tune in the World with Ham Radio," with a workbook, cassette tape and call-area wall map for $7.00, is a nice package for beginners.

My 12-year-old, in fact, is using the above in his quest for a Novice license. I'd like him to become a ham because it *is* an accomplishment he can be proud of; and it can open the door to a life-long, fruitful hobby. In view of these opportunities for personal growth, I, for one, would look upon the weakening of amateur radio as a tremendous loss. We must make sure there is always room for the good things in life and not subjugate minority groups to the point of extinction.

Art Salsberg



Laser Beam Digital Watch

Never press another button, day or night, with America's first digital watch that glows in the dark.

Announcing Sensor's new Laser 220—the first really new innovation in digital watch technology.

Would you do this with your solid-state watch? Of course not. Most solid-state watches require care and pampering but not the Sensor. You can dunk it, drop it and abuse it without fear during its unprecedented five-year parts and labor warranty.

It's ingenious, it's simple and it makes every other digital watch obsolete. Scientists have perfected a digital watch with a self-contained automatic light source—a major scientific breakthrough.

SELF-CONTAINED LIGHT SOURCE

The Laser 220 uses laser beams and advanced display technology in its manufacture. A glass ampoule charged with tritium and phosphor is hermetically sealed by a laser beam. The ampoule is then placed behind the new Sensor CDR (crystal diffusion reflection) display.

The high-contrast CDR display shows the time constantly—in sunlight or normal room light. But, when the room lights dim, the self-contained tritium light source automatically compensates for the absence of light, glows brightly, and illuminates the display.

No matter when you wear your watch—day or night—just a glance will give you the correct time. There's no button to press, no special viewing angle required, and most important, you don't need two hands to read the time.

Replace the battery yourself by just opening the battery compartment with a penny. Free batteries are provided whenever you need them during the five-year warranty.

A WORRY-FREE WATCH

Solid-state watches pose their own problems. They're fragile, they must be pampered, and they require frequent service. Not the Laser 220. Here are just five common solid-state watch problems you can forget about with this advanced space-age timepiece:

1. **Forget about batteries** The Laser 220 is powered by a single EverReady battery that will actually last years without replacement—even if you keep the 220 in complete darkness. In fact, JS&A will supply you with the few batteries you need, free of charge, during the next five years. To change the battery, you simply unscrew the battery compartment at the back with a penny and replace the battery yourself.

2. **Forget about water** Take a shower or go swimming. The Laser 220 is so water-resistant that it withstands depths of up to 100 feet.

3. **Forget about shocks** A three-foot drop onto a solid hardwood floor or a sudden jar. Sensor's solid case construction, dual-strata crystal, and cushioned quartz timing circuit make it one of the most rugged solid-state quartz watches ever produced.

4. **Forget about service** The Laser 220 has an unprecedented five-year parts and labor warranty. Each watch goes through weeks of aging, testing and quality control before assembly and final inspection. Service should never be required. Even the laser-sealed light source should last more than 25 years with normal use. But if it should require service anytime during the five year warranty period, we will pick up your Sensor, at your door, and send you a loaner watch while yours is repaired—all at our expense.

5. **Forget about changing technology** The Sensor Laser 220 is so far ahead of every other watch in durability and technology that the watch you buy today, will still be years ahead of all others.

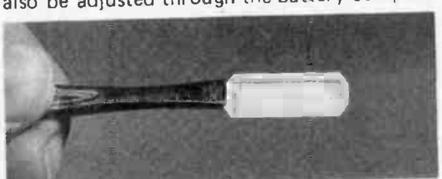
THE ULTIMATE ACHIEVEMENT

Other manufacturers have devised unique ways to produce a watch you can read at a glance. The new $300 LED Pulsar requires a snap of the wrist to turn on the display, but the Pulsar cannot be read in sunlight. The new $400 Longine's Gemini combines both an LED and liquid crystal display. (Press a button at night for the LED display, and view it easily in sunlight with the liquid crystal display.) But you must still press a button to read the time. All these applications of existing technology still fail to produce the ultimate digital watch: one you can read under all light conditions without using two hands. Until the introduction of the Sensor.

PLENTY OF ADVANCED FUNCTIONS

Sensor's five time functions give you everything you really need in a solid-state watch. Your watch displays the hours and minutes constantly, with no button to press. But depress the function button and the month and the date appear. Depress the button again and the seconds appear. To quickly set the time, insert a ball-point pen into the recessed time-control switch on the side. It's just that easy.

Sensor's accuracy is unparalleled. All solid-state digitals use a quartz crystal. So does the Sensor. But crystals change frequency from aging and shock. And to reset them, the watch case must be opened and an airtight seal broken which may affect the performance. In the Sensor, the crystal is first aged before it is installed, and secondly, it is actually cushioned in the case to absorb tremendous shock. The quartz crystal can also be adjusted through the battery compartment without opening the case. In short, your watch should be accurate to within 5 seconds per month and maintain that accuracy for years without adjustment and without ever opening the watch case.



The new exclusive laser-sealed tritium and phosphor light source is a thin solid-state tube that automatically illuminates the display when the lights dim.

STANDING BEHIND A PRODUCT

JS&A is America's largest single source of digital watches and other space-age products. We have selected the Sensor Laser 220 as the most advanced American-made, solid-state timepiece ever produced. And we put our company and its full resources behind that selection. JS&A will warranty the Sensor (even the batteries) for five full years. We'll even send you a loaner watch to use while your watch is being repaired should it ever require repair. And Sensor's advanced technology guarantees that your digital watch will be years ahead of any other watch at any price.

Wear the Laser 220 for one full month. If you are not convinced that it is the most rugged, precise, dependable and the finest quality solid-state digital watch in the world, return it for a prompt and courteous refund. We're just that proud of it.

To order your Sensor, credit card buyers may simply call our toll-free number below or mail us a check in the amount indicated below plus $2.50 for postage, insurance and handling. (Illinois residents add 5% sales tax.) We urge you, however, to act promptly and reserve your Laser 220 today.

Stainless steel w/leather strap $129.95
(Add $10 for matching metal band)

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Letters

WHERE CREDIT IS DUE

In "Buyer's Guide to Antenna Rotators" (August 1976), the interesting photograph that illustrates the corrosive effect on antenna rotators should have been credited to Channel Master.—*Daniel S. Roher, New York, NY*

ANOTHER TIM VIEW

I enjoyed reading Ralph Hodges' comments on the never-ending tubes-versus-transistors debate in the July "Stereo Scene." His sober observations were very refreshing. However, I must disagree with his comments regarding transient intermodulation distortion (TIM); an amplifier's ability to "keep up with the music signal" is adequately specified by its frequency response (for small signals) and its slew rate (for large signals). The technical papers written so far on TIM consist of little more than a rediscovery of slew-rate limiting and the consequences of this form of overloading. Many U.S. designers of high-quality amplifiers have routinely provided more than adequate slew rates in their products, which may explain why there is a lack of excitement over TIM here.

The argument that an amplifier is without feedback for a "moment" following the application of a signal is dubious. This "moment" is roughly equal to the excess phase delay (not to be confused with the open-loop time constant), which is generally 150 ns. An audio input signal limited to a 20,000-Hz bandwidth cannot rise fast enough in this time to overload an input stage. Finally, the amount of feedback used, when properly compensated, has little to do with susceptibility to TIM if adequate slew rate is maintained.—*Robert R. Cordell, Tinton Falls, NJ*

MIXING APPLES AND ORANGES

I built the "Improved Gas and Fume Detector" described in the August issue and am happy to state that it not only detects carbon monoxide and carbohydrates, but that it also detects the fats and proteins that my car produces. Seriously, though, I believe that the sentence on page 47 should read: "The major problem with . . . carbon monoxide and hydrocarbons." The last word should not be "carbohydrates" as in the article.—*Michael J. Di Julio, WB2BWJ, Maplewood, NJ*

The author meant to imply the equivalent of "apples and oranges" to indicate dissimilarity.

A ROUND OF CHEERS

Three cheers for "DX Programs and DX Clubs on Shortwave" in the August issue. I hope you will continue to cover the SWL/DX field in the future.—*Paul E. Kotke, St. Paul, MN*

FIREFIGHTER SPEAKS OUT

I enjoyed reading the informative article "Lightning and the Radio Amateur" ("Amateur Radio," August 1976) but the last sentence of the second paragraph was in poor taste and a disservice to firefighters. What many people do not realize is that there are times when walls and wiring must be cut open to check for the extension of fire. If we did not do this where indicated, chances are that a "hidden" fire would burn a home or shack down after we left.—*N. Nicastro, Jr., KMD1175, WDX2HHS, KNJ2AQ, Spotswood, NJ*

The author meant no disservice to the dedicated force of firefighters. All he was pointing out was that it's better to protect against the possibility of lightning-induced fire than to suffer the damage that can result without taking the proper precautions.

PICO NOT MICRO

There are two errors in "Learning Electronic Theory With Hand Calculators, Part Two." In the center of page 64, the second sentence in the paragraph that begins: "Finally, in a series RC circuit . . ." the X_C in the next sentence should be changed to Z. The second error was in converting the displayed quantity 2.780659563 − 11 to conventional capacitance notation; the correct answer should be 27.8 pF—not 0.0278μF.—*Ken Gentile, West Palm Beach, FL.*

TUNING IN PHYSICIANS RADIO

In the May 1976 "Letters" column, you turned aside an inquiry about the Physicians Radio Network, stating that it was confidential and available only to physicians. In New York, dedicated hypochondriacs can receive the net on the SCA subcarrier of WEVD-FM. But believe me, for non-pro's it wins the Emmy for the "World's Dullest Program."—*Edward M. Roberts, Glen Head, NY*

In my area at least, PRN is broadcast as a standard SCA subcarrier on WIOQ (102.1 MHz). An SCA subcarrier can hardly be called "confidential."—*L.S. Huntsinger, Audubon, NJ*

PROGRAMMABLE CALCULATORS

I was pleased with the article "Here Are

SAVE UP TO 50% ON PARTS.

Hobbyist or professional, there are probably a lot of circuits you build just for the fun of it. And a lot you'd *like* to build, but never get around to.

One reason is the cost of parts. Parts you buy for one project, but can't re-use... because you haven't time to take them carefully apart. Or because of heat and mechanical damage that occur when you do.

Now, there's an easier way that can save you big money on parts *and hours on every project*, as well: *Proto-Board® Solderless Breadboards*.

Now, assembling, testing and modifying circuits is as easy as pushing in—or pulling out—a lead. IC's, LED's, transistors, resistors, capacitors... virtually every kind of component... connect and interconnect instantly via long-life, nickel-silver contacts. No special patch cords or jumpers needed—just lengths of ordinary #22-30 AWG solid hookup wire.

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PB-100	760	10	19.95	Kit—with larger capacity
PB-101	940	10	29.95	8 distribution buses, higher capacity
PB-102	1240	12	39.95	Large capacity, moderate price
PB-103	2250	24	59.95	Even larger capacity: only 2.7¢ per tie-point
PB-104	3060	32	79.95	Largest capacity: lowest price per tie-point
PB-203	2250	24	75.00	Built-in 1%-regulated 5V, 1A low-ripple power supply
PB-203A	2250	24	120.00	As above plus separate ½-amp +15V and −15V internally adjustable regulated outputs

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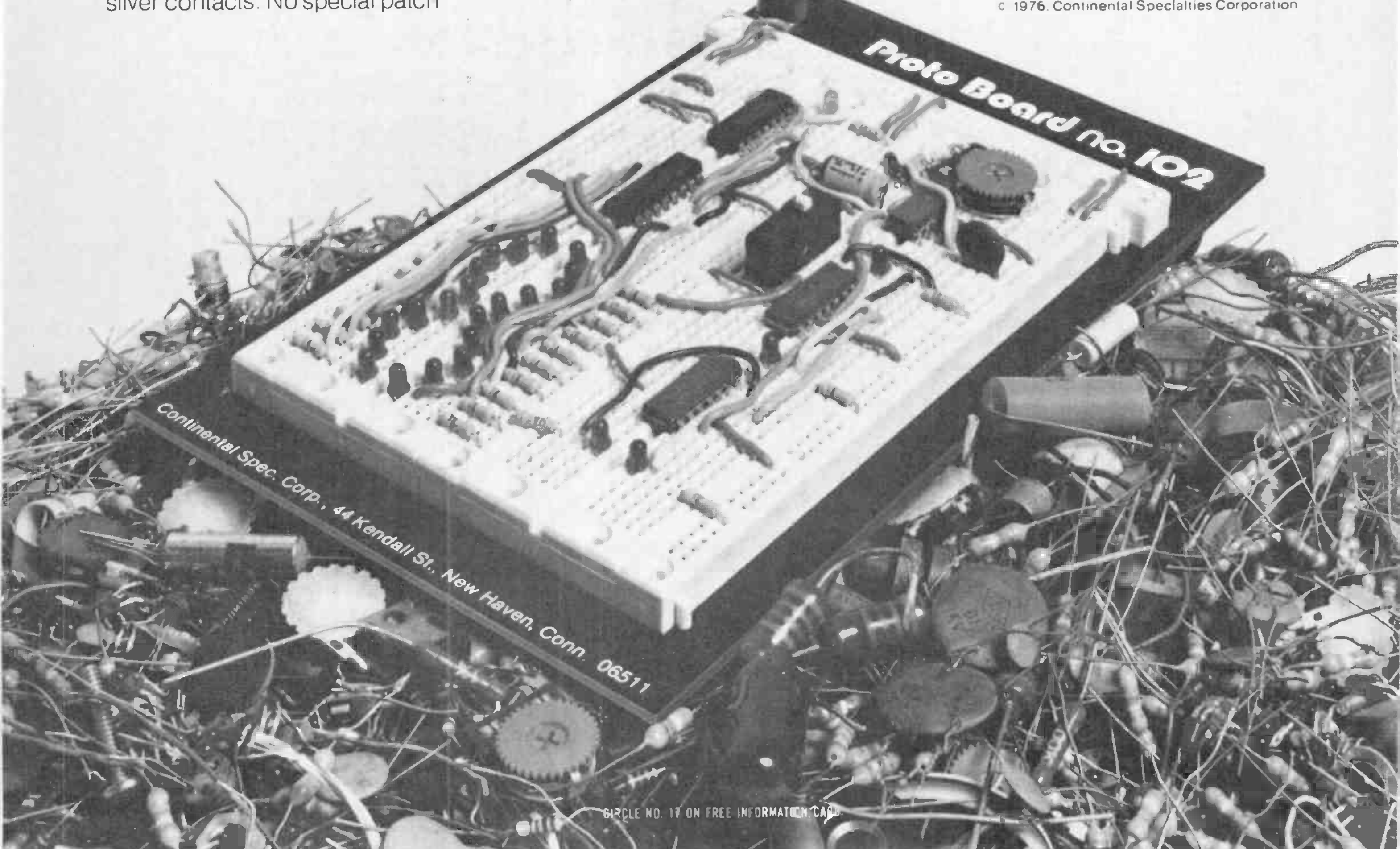

CIRCLE NO. 17 ON FREE INFORMATION CARD

the New Programmable Calculators" in the May 1976 issue of POPULAR ELECTRONICS. It is the first article that I have seen in any major consumer magazine dedicated to programmables.—*Philip Earnhardt, Burlington, NC*

FREE SCHEMATIC WOES

POPULAR ELECTRONICS has left it entirely up to project kit suppliers to provide free schematics and pc etching and drilling guides [when they're too large for magazine pages]. But the May 1976 Editorial states that it is not unreasonable for a supplier to drop the free patterns after a period of time. (The period mentioned was something over a year.) I agree with him. However, this means that your major construction articles have a built-in "destruct" feature.—*Andrew Oldroyd, Norman, OK*

Our new policy for future articles is to supply directly any artwork that is too large to appear in the magazine. We will keep such artwork on file for a number of years, thus obviating the problem of project obsolescence.

"MUSIC MODULE" PARTS SOURCES

The Top Octave Generator integrated circuit, *IC4*, called for in the "Music Modules" (June 1976) is a Mostek device that is also available from AMI. Suitable sources for crystals include Crystek, International Crystal, and CTS Knight. The optional Molex connectors are available from Tracy Design Corp. and Force Electronics; alternatively, any standard 0.153" edge connector can be substituted.—*Don Lancaster, Author*

GIANT STEP FOR UN-GENIUSES

At last! An article on 7400 series TTL IC's that explains the basic logic, with experimenter circuits. We, the un-geniuses of the IC world, took a giant step, thanks to the June 1976 "Experimenter's Corner." We would like to learn more and be shown more experiments with TTL devices.—*F. Arthur Byington, Birmingham, MI*

EUROPEAN TV QUALITY

The July 1976 Editorial titled "Who Killed TV Picture Quality?" struck me as being rather incomplete in that it made no mention of the SECAM (Sequential Couleur a Memoire) TV system used in some 20 countries nor of PAL (Phase Alternation Line) used in 22 other countries, including all of Australia. As of the end of 1974, there were 162-million NTSC, 74-million SECAM, and 70-million PAL TV receivers in use worldwide. Surely, the higher color stability of SECAM and PAL should have been mentioned.

Because of its superior color rendition and stability, SECAM 60 equipment was carried by Pioneer X for its color-TV pictures of Jupiter.—*J.M. Lagerwerff, Palo Alto, CA*

Having been involved with color TV in England, I endorse your Editorial comments about the very poor quality here in the U.S. Principally, the English system uses PAL transmission, which eliminates the "Purple Plague." Drift is cancelled by integration of adjacent lines by the eye. Thus, flesh tones are always correct and no need exists to distort the receiver's characteristics, which permits pure deep saturated tones to be displayed. In addition, the quality of electron optics seems to be much better. British engineers demand pin-sharp convergence, even at the corners of the screen.

I have the Independent Broadcast Authority Technical Reference Book that gives Codes of Practice for TV studio and broadcasting standards for Commercial (note that this is not BBC) television in the U.K. The standards call for very elaborate and complete specifications for every parameter of audio and video performance and include very detailed rules for assessing and reporting transmission quality. I doubt such standards exist in the U.S.

It has been my impression that a well-adjusted receiver in the U.K. gives a picture as good as a Technicolor movie. I think most Americans are completely unaware that their TV quality is lousy because nobody has exposed them to what can be done. —*R.J. Best, Miami, FL*

Our new Powerhouse receivers outpower the competition.

Lafayette's new Powerhouse receivers have the power, the features and the performance you want. And the competition only promises.

Just check our spec chart. We deliver. With no gimmicks or technical tricks.

Besides incredible specs our new Powerhouse receivers have some features you've never had on any receiver before. Stop in at any of the Lafayette stores or dealers coast to coast and hear what Dolby® FM noise reduction, mike mixing and detent controls can do to give you clean, distortion-free sound.

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Specifications	LR-9090	LR-5555	LR-3030	LR-2020	LR-1515
Power Min. RMS 20-20,000 Hz	90+90	55+55	30+30	20+20	15+15*
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Input Sensitivity: phono/Aux/Mike mV	2.5/150/6	2.5/150/6	3.5/150/	4.0/150/	4.0/150/
Tone	Bass/Mid/Treble	Bass/Mid/Treble	Bass/Mid/Treble	Bass/Treble	Bass/Treble
Speakers	A, B, C	A, B, C	A, B, 4/ch	A, B, 4/ch	A, B, 4/ch
FM Sensitivity (Stereo)	21.0 dBf (1.8 μV)**	21.0 dBf (1.8 μV)**	23.0 dBf (2.0 μV)**	23.0 dBf (2.0 μV)**	25.0 dBf (2.2 μV)**
Selectivity	80dB	80dB	70dB	70dB	60dB
Capture Ratio	1.25 dB	1.25 dB	1.5 dB	1.5 dB	2.0 dB
Price	$599.95	$399.95	$299.95	$249.95	$199.95

*@ 40-20,000 Hz **IHF ('58) Sensitivity (Mono)

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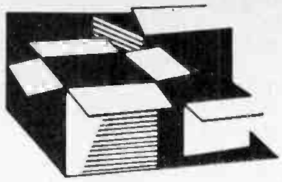


New Products

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.

ROYCE IN-DASH CB TRANSCEIVER

The Royce 1-614 is a combination in-dash CB transceiver and AM/stereo FM radio, featuring a PLL circuit that delivers 23-channel CB operation from two crystals, a dual-conversion CB receiver sec-

tion, AM/FM lighted slide-rule tuning dial, slide-type tone and balance controls, a local/distant switch for FM that is also an r-f gain switch on CB, and an LED that acts as a stereo indicator on FM and as a transmit light on CB. Other features include a 1⅜" × ⅜" S/r-f meter, pushbutton automatic noise eliminator, variable squelch control, and a universal trim plate that is said to match the decor of most cars. Size is 7"W × 6"D × 2"H (17.8× 15.2 × 5.1 cm). $269.95.

CIRCLE NO. 85 ON FREE INFORMATION CARD

AUDIO-TECHNICA HEADPHONES

The AT-705 electret condenser headphone from Audio-Technica features permanently polarized diaphragms that need no external source of power. The headphones plug into a small adapter that matches impedance circuits and contains a speaker/headphone switch. The AT-705 has a claimed frequency response of 20 to 20,000 Hz and has open-back ear cups. $89.95.

CIRCLE NO. 86 ON FREE INFORMATION CARD

MICROCOMPUTER POWER SUPPLY

Parasitic Engineering offers a constant-voltage power-supply kit for the Altair 8800 computer. Designed to "make the Altair almost immune to unreliable performance due to power line fluctuations," the power supply is said to deliver full output of 8 V at 12 A and ±16 V at 2 A "even when the line voltage is as low as 90 volts." It is also said to provide increased isolation from line noise and over-voltage protection, with an increase of less than 2% in output when the line voltage rises to 130 volts. Heart of the kit is a ferro-resonant constant-voltage transformer, which replaces all three of the standard Altair 8800 power transformers. $75.00. Address: Parasitic Engineering, P.O. Box 6413, Albany, CA 94706.

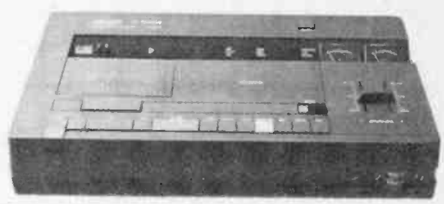
LAFAYETTE SUPER TWEETER

The Lafayette Model RP-1000 "Criterion Polymer" super tweeter can be used with existing two- and three-way speaker systems. The transducer utilizes a flat polymer diaphragm with an etched voice coil. When an audio signal is applied, the diaphragm is said to be driven equally at all points on its surface. No polarizing voltage or energizer is required. It is housed in a brushed aluminum case with a stand, and can be used as a freestanding unit or can be mounted in a speaker enclosure with the stand removed. Claimed frequency response is 4 kHz to 40 kHz, power handling capacity 30 watts, and impedance 8 ohms. Measures (exluding stand) 4½" × 4½" × 1⅜" (11.4 × 11.4 × 3.5 cm), and weighs 1.125 lb (0.51 kg). $59.95.

CIRCLE NO. 88 ON FREE INFORMATION CARD

LENCO CASSETTE DECK

Made in Switzerland and distributed here by Uher, Lenco's first stereo cassette deck is the C-2003, with direct drive, two capstans, three heads, and Dolby equalization. All mechanical functions are solenoid-operated, and logic controls permit changing from one function to another without pressing the stop button. An illuminated panel shows all functions as selected. Automatic tape selection is provided for chrome tapes, with manual selection for three additional types. A tape-motion sen-



sor automatically stops the tape if the cassette jams. Separate record and playback heads permit off-the-tape monitoring. Frequency response is 30 to 18,000 Hz ±3 dB without Dolby, S/N is better than 60 dB with Dolby, and wow & flutter is less than 0.10%. $695.50.

CIRCLE NO. 89 ON FREE INFORMATION CARD

HICKOK IN-LINE CB TESTER

Hickok's 388 in-line CB tester provides a 7-digit readout of SWR, percent modulation, and frequency. The SWR and percent modulation functions use the "dynamic ratio technique," which permits measurements without a calibrate/set adjustment regardless of power level. The 388 provides one-step connection of the coax connec-

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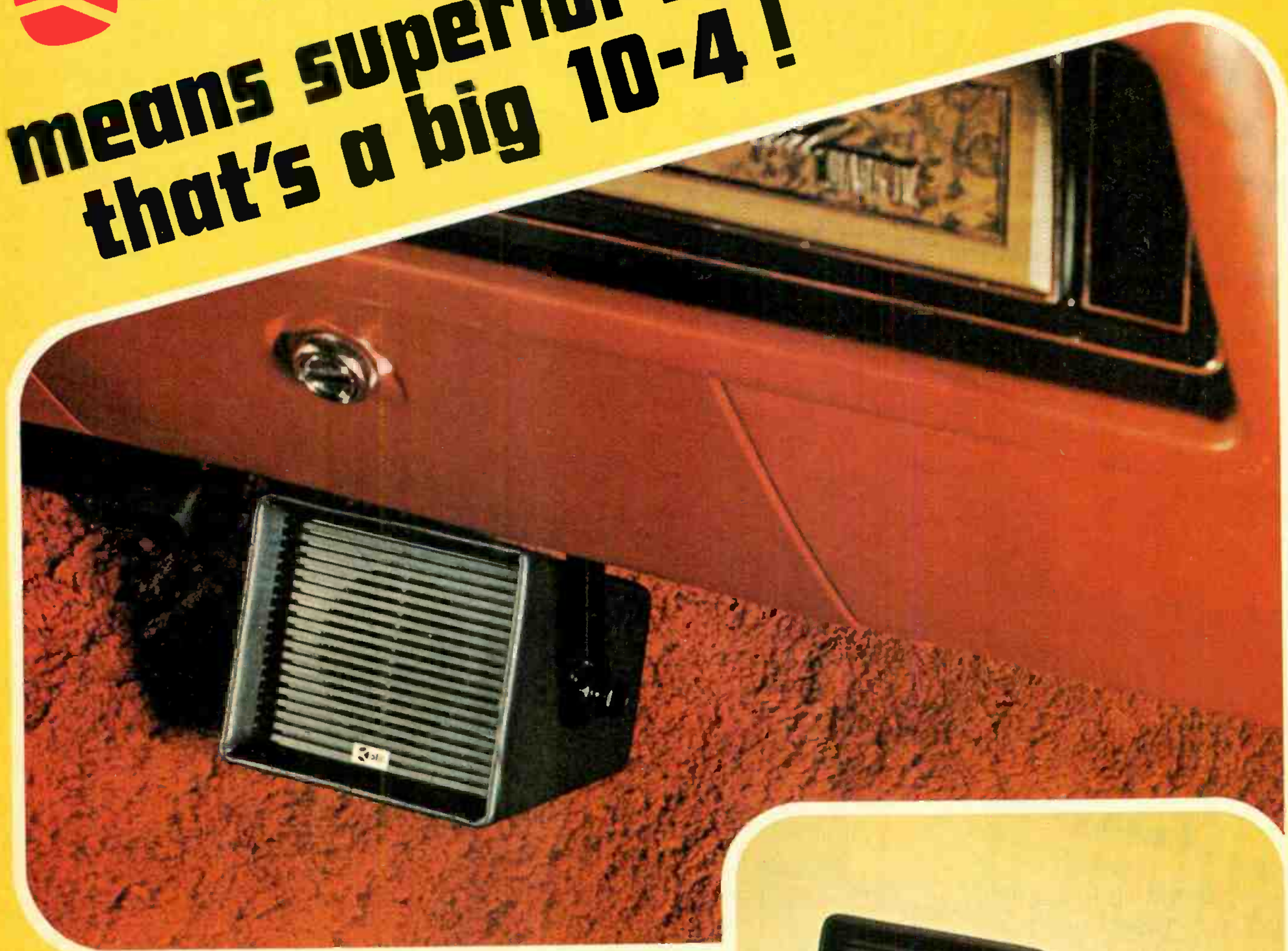

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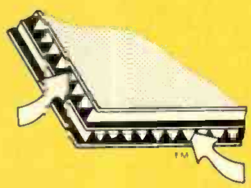

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tors between the transmitter and the antenna or dummy load. Frequency measurements are from 1 Hz to 80 MHz, with resolution to 10 Hz. Size is 8½"W × 6"D × 4"H (21.6 × 15.2 × 10 cm). The 388 with standard time base has a frequency accuracy of 10 ppm, at $349.00. The 388X, with a temperature-compensated crystal oscillator, frequency accuracy of 1 ppm and aging of less than 1 ppm per year, is $475.00.

CIRCLE NO. 91 ON FREE INFORMATION CARD

TANDBERG AM/STEREO FM RECEIVER

Tandberg's TR-2055 AM/stereo FM receiver, based on the top-of-the-line TR-2075, offers most of the same features,

including the same FM tuner. The TR-2055 is rated at 55 watts per channel into 8 ohms at 20 to 20,000 Hz with less than 0.15% THD. Features include tape contour jacks, electronic tuning with varactor diodes, two phono inputs, two tape-monitor inputs with tape copy, two tuning meters, and diode switching for all sources. $749.00.

CIRCLE NO. 92 ON FREE INFORMATION CARD

B&K SEMICONDUCTOR TESTER

The B&K 530 semiconductor tester features measurement of transistor cut-off frequency up to 1500 MHz in three ranges, with display on a separate meter. It permits in-circuit testing and lead identification of diodes, transistors, FET's (including power types) and SCR's. For out-of-circuit tests, transistor beta is measured in two ranges (20-200, 20-600) and Gm of FET's in two ranges (0.4-12, 4-400 milliohms); accuracy for both tests is within 10%. Other measurements include f_t, gate leakage and I_{DSS} of FET's, and BV_{CES}, I_{CES} and PIV of diodes. LED displays indicate whether the transistor is good and whether it is an npn, pnp, or n- or p-channel FET. An audible tone also indicates that the transistor is good. $250.00.

CIRCLE NO. 93 ON FREE INFORMATION CARD

VALOR CB PREAMP

The Valor VRSC-115 is called a "CB Receive Signal Preamp," designed to raise the strength of weak signals, or to attenuate loud ones, to a usable level. It is compatible with AM and SSB transceivers. The preamp comes with a bracket for under-dash mounting. The front panel includes a gain/attenuate control and indicator lights for power and transmit. Valor claims that weak signals can be boosted to +15 dB, and loud ones attenuated to −20 dB, on all 23 channels. $39.95. Address: Valor Enterprises, Inc., 185 West Hamilton St., Dept. 532A, West Milton, Ohio 45383.

PEARCE-SIMPSON MOBILE CB TRANSCEIVER

Pearce-Simpson's "Tiger Mark 2" mobile CB AM transceiver features "Hetrolock," which uses three crystals for 23-channel capability. Features include a delta-tune control called "Receiv-O-Slide," 12-volt operation with positive or negative ground, automatic noise limiter, noise blanker, squelch control, tone control, r-f gain control, S/r-f power meter, transmit indicator lamp, external speaker jack. $229.95.

CIRCLE NO. 95 ON FREE INFORMATION CARD

DYNACO POWER AMPLIFIER

Rated at 150 watts per channel into 8 ohms, with less than 0.25% THD, the Dynaco Stereo 300 power amplifier kit is designed

SWTPC 6800-SOFTWARE

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SAVE	READ	ON. . .GOSUB*	PATCH*	SGN	† LEFT$	† EXP
LOAD	RESTORE	IF. . .THEN*	RETURN	CHR	† MID$	† LOG
PATCH	LET*	INPUT	† DES	USER	† RIGHT$	† SQR
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** Direct mode statements*
† 8K Version only

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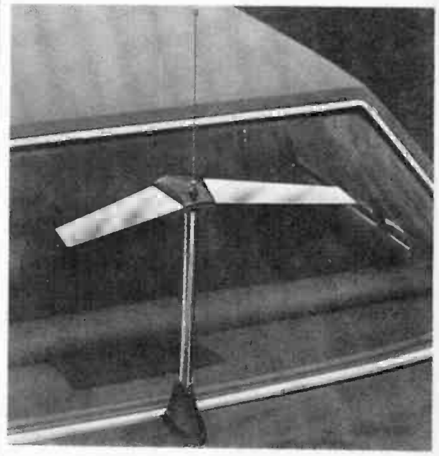
for easy rewiring into a 4-channel unit at 75 watts per channel. Except for output stages, all audio circuits are on two factory-wired, pre-tested circuit boards. The circuit is completely coupled (except the input) with full complementary-symmetry output and features thermally tracking bias. Amplifier and speaker are protected by volt-amp limiting, eight B+ fuses, four speaker fuses, and two thermal breakers, plus the ac line fuse. Behind the black panel, provision is made for either two or four optional rear-lighted output meters. It measures 18⅛"W × 14⅜"D × 7⅜"H (46 × 36.5 × 18.7 cm). $489, kit form; $699.00, assembled.

CIRCLE NO. 96 ON FREE INFORMATION CARD

CHANNEL MASTER CB ANTENNA

Channel Master's "Power Wing" mobile CB antenna "will not bend at any speed," according to the manufacturer, and is said



to provide higher average current and greater radiating efficiency than inductively loaded CB antennas. From base to wing, the antenna measures 16" high, plus an 8" telescoping stub for fine tuning. $39.95.

CIRCLE NO. 97 ON FREE INFORMATION CARD

MARANTZ STEREO PREAMPLIFIER

The Marantz 3800 combines a stereo preamplifier with a control console and a Dolby noise-reduction system. Distortion is rated at no more than 0.02% THD and 0.01% IMD; frequency response is "essentially flat" from 20 Hz to 20 kHz. The dynamic range is greater than 110 dB (high level). Tone controls include detented

straight-line bass, midrange and treble controls for both channels. Features two tape monitoring jacks and an EQ switch that permits equalizing tape-input signals with the tone controls while recording. $599.95.

CIRCLE NO. 98 ON FREE INFORMATION CARD

New Literature

CIRCUIT DESIGN CATALOG

E&L Instruments offers a new, 26-page catalog of electronic circuit design aids. The illustrated publication, describing over 180 products for experimentation with operational amplifiers, integrated circuit logic and microprocessors, includes solderless breadboarding sockets, tools, component kits and a selection of instruction manuals. Address: E&L Instruments, Inc., 61 First St., Derby, CN 06418.

CB ANTENNA CATALOG

A new 24-page catalog from Avanti illustrates its line of Citizens Band antennas. Described are seven base-station antennas, including the Moonraker; stacking kits; mobile antennas and accessories; marine antennas and accessories; monitors; switch boxes; and TV filters. All antennas are illustrated and complete specifications are provided. Also, a discussion of the variable conditions that affect antenna performance and a description of Avanti's co-inductive principle. Address: Avanti Research & Development, Inc., 340 Stewart Ave,, Addison, IL 60101.

BUZZ WORD BOOKLET

An expanded edition of "Sherry's Guide to Data Communication Buzz Words" is available from ICC. The updated, 24-page, pocket-sized booklet first published in 1972 is designed to aid the newcomer to the data communication field. Included are definitions and terms relating to terminals and the EDP field. Address: Public Relations Dept., International Communications Corp., 8600 NW 41st St., Miami, FL 33166.

ABOUT QUADRAPHONY

"Spatial High Fidelity Through SQ Quadraphonic Recording and Broadcasting," by CBS, is a 22-page, illustrated booklet, that answers questions most often asked by hi-fi listeners about quadraphonic broadcasting, recording and home listening. Included are sections on encoding, recording, decoding and logic systems used to produce ambient and surround sound; a technical summary of stereo-to-quad synthesis; a simple conversion of a home stereo to a quadraphonic system; and an explanation of the SQ quadraphonic system's compatibility with existing stereo and mono broadcasting and playing equipment. Send a stamped, self-addressed envelope (approx. 8½" × 4") to Information Services Dept., CBS Technology Center, 227 High Ridge Rd., Stamford, CN 06905.

ELECTRONICS SYMBOLS HANDBOOK

The Cleveland Institute of Electronics has available a new 22-page, pocket-sized reference titled "Electronics Symbols Handbook." Listed alphabetically and divided into 19 categories, are more than five hundred of the most frequently used symbols representing electronics components. Also featured is an electronics data guide, including conversion factors and constants, Ohm's Law formulas, resonant frequency, impedance, a decimal table and a color-code chart. Price, 50 cents. Address: Cleveland Institute of Electronics, Inc., Dept. J-103H, 1776 East 17th St., Cleveland, OH 44114.

CIRCUIT DESIGN RELIABILITY

"Circuit Reliability is not Semiconductor Reliability" is the title of "Tech Tips 3-4," offered by Westinghouse. Using equations and charts, the 3-page pamphlet illustrates that total circuit reliability is the product of the individual reliabilities of each component, and explains how to achieve this in circuit design. Address: Semiconductor Div., Westinghouse Electric Corp., Youngwood, PA 15697.

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But it wasn't enough to make them the best sounding headphones ever heard. We consulted world-famous designer Mario Bellini to help us make them the most comfortable headphones ever worn. Because we knew if they were uncomfortable, you wouldn't put up with them.

That's why a soft strap distributes the featherlight weight of the HP-1 and HP-2 evenly over your head. Special foam ear pads form a supple, compliant seal. Height and angle are completely adjustable to your head.

Yamaha musical technology is also highlighted in our superlative TC-800GL and TC-800D stereo cassette decks, offering cassette convenience with performance rivaling that of some of the finest open reel decks.

To satisfy the most sophisticated recordist, both the TC-800GL and TC-800D offer incredibly low 0.06% wow-and-flutter, Dolby* Noise Reduction, and Variable Pitch Control. (The TC-800GL can even be used for remote recording.) But, if you don't like to do a lot of fiddling around, both models offer automatic convenience features like Auto Timer Start, Auto Stop, Auto Memory Rewind, and Auto Switching for CrO_2 tape.

Also showing Mr. Bellini's touch, the functional wedge styling and stepped controls of these cassette decks give you easy control and visibility from any standing, sitting, or reclining position.

If you'd like a closer look at some other examples of form following function, send for our free catalog of stereo components. Or see your local Yamaha Audio Specialty Dealer. You'll get a lot more than just a demonstration.

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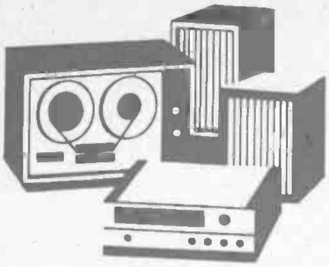


Stereo Scene

By Ralph Hodges

MODS AND MODIFIERS

BREATHES there a serious audiophile who has not at some time attempted to modify his equipment, either to personalize it or—if courageous or foolhardy enough—to improve it in some material way? Probably not many nowadays; given the complexity of design in modern audio gear. Interestingly, there are some people who make a business of equipment modification, offering customized versions of several popular components.

For a long time I've wanted to bring some of these business-minded customizers into these pages, to find out what they're doing and why, and to look critically at some of their products. This will be the first of (I hope) several columns that will explore the intricacies of this underground and interesting marketplace.

Doubling Dyna's. Dynaco is a company that is traditionally tolerant of unauthorized modifications—an unusually enlightened viewpoint. Consequently, the hills are alive with Dyna modifications. I first became aware of Jensens Stereo Shop and Frank Van Alstine because Dynaco tipped me off. "He listens," said the Dyna spokesman, in tones meant to convey a certain amount of respect. And so I got involved with the venture.

Van Alstine's flagship product is essentially an augmentation of the Dynaco Stereo 400 power amplifier, dubbed the Double 400. A significant amount of labor goes into the modification. First, it is completely ripped apart to get at the bottom tabs of the heat-sink assembly, which are drilled to accept double the number of output transistors. Then leads from the power supply are brought out to a side-mounted socket, into which is plugged an outboard capacitor box that quadruples the capacity of the supply. A front-panel switch is installed that enables you to bypass the amplifier's front end (including the gain controls and the patented "Dynaguard" protective circuitry). A number of changes are also made in the driver boards. And finally Dyna's optional heat-sink fan is added.

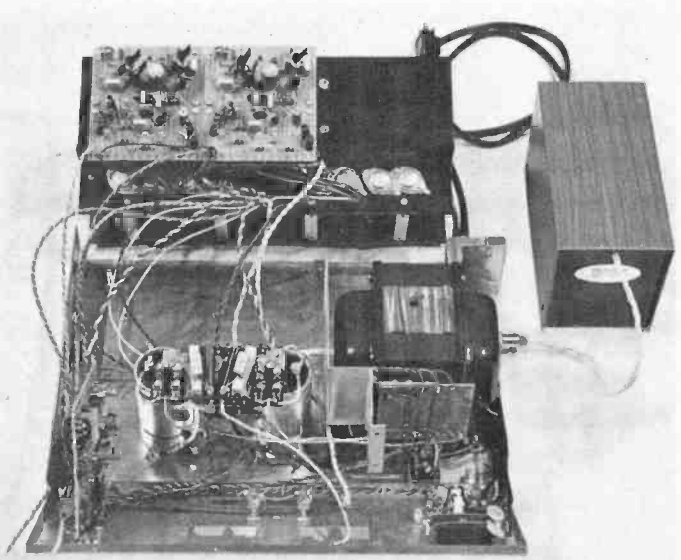
This is not, as you can see, a redesign of the amplifier in any real sense. What does it buy you, other than the satisfaction of owning what is probably the biggest Leyden jar in the history of consumer audio? I can say, without hesitation or fear of serious contradiction, that it buys you a better-sounding amplifier than the original, for most practical purposes. And by "most practical purposes" I mean the difficult and erratic load presented to an amplifier by many loudspeakers.

The reduced impedance of the power supply and enhanced volt/ampere-handling capability of the output stage really do seem to make a difference. This reminds me of various learned dissertations that have appeared in the press on the subject of difficult temporal shifts in the voltage/current demands placed on the amplifier during its relationship with a typical loudspeaker. But without getting into that, I would characterize the audible difference between the modified and stock amplifiers as: an appreciable difference in the bass (you must decide which is better, because I can't reliably do so); and a reduction in the subjective noise level of the stock amplifier.

Noise level? Yes, because other listeners and I hear a quietness behind and within the flow of music that the stock version seems not to possess. (There is, I assume, no significant noise-level difference between them under non-signal conditions, so this "noise" arises from the program.)

There is general agreement on this verdict among all I have talked to that have compared the two amplifiers, so I don't think we're discussing will-o'-the-wisps here. But it is also rightly pointed out that the Double 400 modification, while possibly doubling the pleasure of very critical listeners, also comes close to doubling in price.

So we have a thoroughly clear picture. Dynaco, while conceding the merits of the modification, would have entirely missed its market by incorporating it into its product. The modification is intended for a much more specialized consumership willing to pay the price. It has been established that the stock Stereo 400 is entirely fit competition for its peers in cost. It remains to be seen whether the same can be said about the modification. But I think it has a good chance.



The "Double 400" is an augmentation of Dynaco's Stereo 400 power amplifier.

Pre-empting the Preamp. Van Alstine's modification of the Dynaco PAT-5 preamplifier has been an ongoing process. I have been through several versions, and I understand there is a still-newer one that I haven't heard.

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Reg. Rate: 12 Issues for $9.98
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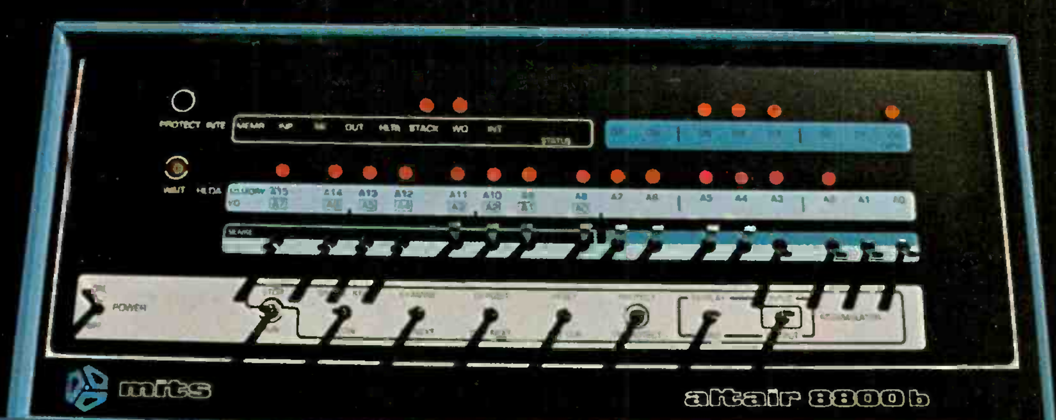

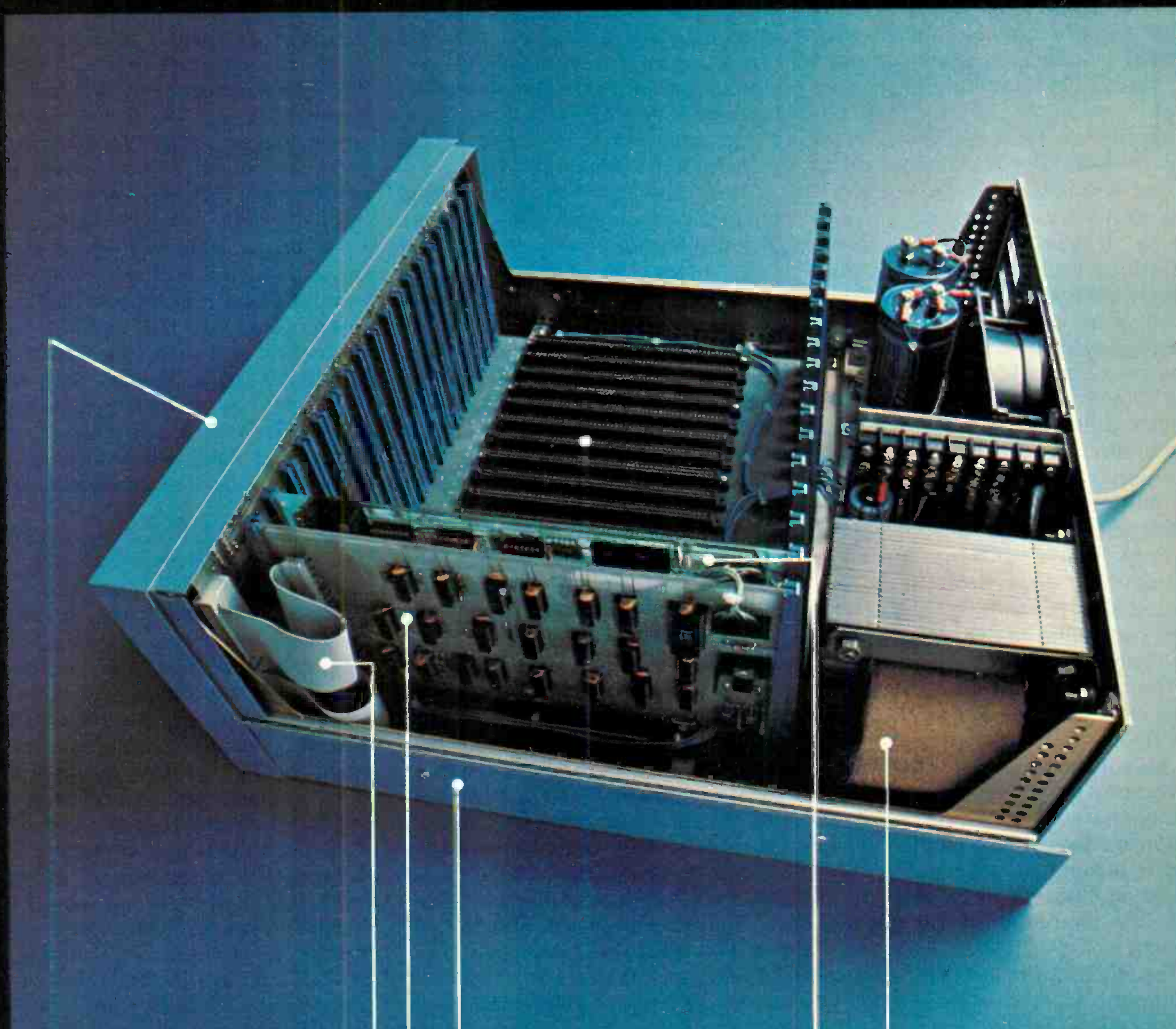

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CIRCLE NO. 49 ON FREE INFORMATION CARD

The modification has generally been a study on designing a preamplifier in reverse. Mr. Van Alstine *takes out* things, and then devises ways to make the preamp live with the loss. Most of the process has concentrated on the high-level section, constructed around one integrated circuit per channel. First there was a search for the "fastest" IC's available to use as possible substitutes. (I will not reveal the devices ultimately chosen because Mr. Van Alstine feels that his laborious efforts have earned him some right to exclusivity, and I agree.) Then, when the IC's were obtained, frequency-compensation components around the IC began disappearing. Output capacitors also went, together with other devices, reducing the entire output stage to only three components when the tone controls are out of the circuit. Changes were made in the B+ rails, and also in the supply itself. Then tantalum capacitors were brought in for selected spots and now I understand that metal-film resistors are being routinely substituted for carbons.

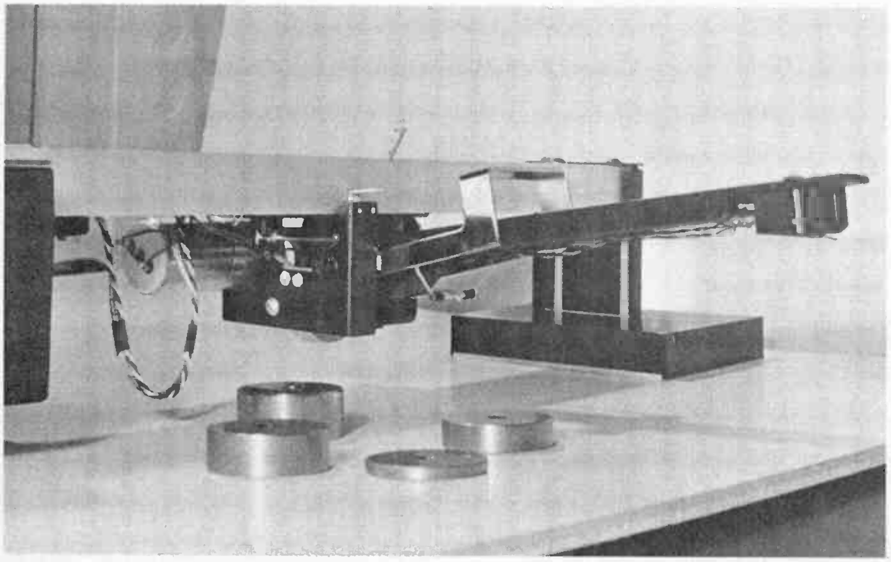
The modified PAT-5 has proved to be a more controversial product than the Double 400. There is not even universal agreement as to whether all the evolutions have been steps forward rather than steps backward. However, I took the sample provided to me and put it through an exceedingly demanding (though not-always-valid) test: the phase-flipped straight-wire comparison.

The straight-wire test involves comparing the sound of a preamplifier to the sound of a simple link of cable that bypasses it, switching from one to the other. The phase-flipped test combines the outputs of the preamp and straight wire, while inverting the phase of one of them. Ideally, the two signals should cancel completely, leaving nothing. Anything that's left is, presumably, an error made by the preamp in processing the signal.

The phase-flipped test is not a valid critique of a preamp, because completely tolerable phase shifts, among other things, can legitimately occur within preamps to prevent cancellation. So you can't indict a preamplifier for its failure to pass this test. But you can do nothing but praise a preamplifier that does pass it, and the PAT-5 modification came astonishingly close.

Most of the time, everything was inaudible, including hiss generated in the pre-cancellation stages. On extremely high-level passages (the program chosen was London's new recording of *Turandot,* whose first scene probably contains every berserk manifestation of musical waveform you're likely to encounter) there was an occasional soft "tst" of high-frequency noise. When I find out what this "tst" is, the modified PAT-5's high-level section should serve as a useful test bed for evaluating other products. In the meantime, the unit has to be considered above reproach in the areas of frequency response and phase linearity, and I wouldn't know how to criticize it on noise and distortion.

For those interested in any of the above, Frank Van Alstine's address is Jensens Stereo Shop, 2202 River Hills Drive, Burnsville, Minn. 55337.



The Shreve-Rabco tonearm, an adaptation of Rabco's SL-8E, is made of 22 pieces of balsa wood. Nine counterweights are provided.

Armless. Tonearms are a necessary nuisance, which is probably why many of them are designed to look so pretty. Their function is to serve as a rigid and imperturbable platform for the cartridge, and we haven't yet discovered any practical alternative to them. But few of them are rigid and all of them are perturbable, whether from acoustic feedback, seismic disturbance, or gross undulations of the record surface. The only reasonable solution is to design an arm that interacts with the cartridge to create a fairly high (above 10 Hz) resonance. However, then very close attention must be paid to pivot bearings, leveling, and the distribution of mass, because these factors will now dominate the behavior of the tonearm.

For various reasons, the straight-line-tracking tonearm principle, properly executed, offers great promise. However not a great many such arms have been properly executed, and the principle itself has some intrinsic liabilities. For one thing, skating force, which straight-line arms eliminate, acts as a stabilizing/damping mechanism on rotating arms, as does the skating compensation device that engages in a constant tug-of-war with it. So a radial-tracking arm, lacking this stabilizing set of forces, must be very good in itself in order to succeed.

The Shreve-Rabco tonearm, a modification of the discontinued Rabco SL-8E, is a stab in the direction of proper execution, and an accurate one. The arm itself is fashioned out of balsa wood, (a total of twenty-two pieces, reportedly), except for a magnesium block that houses the pivot sockets and a threaded nylon rod that supports the counterweight. The contact lever for the advance mechanism has been whittled down to a slim (adjustable) wire, and the arm-lift system has been completely altered. Nine threaded counterweights are provided. You pick the one that positions the counterweight as close as possible to the pivot assembly with your preferred cartridge.

All these steps are taken in the interest of low effective mass. For the bearings, perpetually lubricated sockets of the best quality are installed to receive the original Rabco needle-cones after they have been repolished. And the bearings, as well as the arm cartridge alignment, are ad-

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justed *by ear*. You can imagine what a laugh that idea gave me until David Shreve stopped in and demonstrated the process, which I in turn demonstrated to friends and colleagues the following night with a similar deflation of mirth. At least all these adjustments are readily accessible, so you can fiddle to your heart's content.

As to the performance of the arm, there is no question about its being superb. When properly leveled it could probably not be dislodged from the groove by an earthquake. It tracks at any force usable with any cartridge, and it is stable. The sample I have, playing a commercial pressing of a very difficult piano recording, can almost match a one-off copy of the master tape—a phenomenon entirely new to me. If you pick the proper cartridge the arm will actually filter out orange-peel (mold grain) noise, and it will make rumble a thing of the past.

But note also that the arm is in short supply, difficult to make and adjust, and difficult to ship. It is also horrendously expensive. If you happen to be in David Shreve's neighborhood (3402 N. Oakland Avenue, Milwaukee, Wis. 53211) and are prepared to write out a check in excess of $500, be my guest. But be sure to have your spouse cradle it gently in his/her lap on the drive to your home.

Modify? You might consider modified components if you are (like me) an all-out audiophile, as well as a tinkerer. Of course there are certain hazards. For example, plugging Van Alstine's output-capacitorless preamp into the wrong power amp could create unbelievable havoc. If you acquire one of Shreve's tonearms, be prepared to follow his written instructions (which are excellent) down to the last comma, despite your own ideas.

And there are other drawbacks. At the manufacturer's discretion, the warranty for your modification can become a worthless piece of paper, and you may create ill will in him that could be troublesome when the time for routine maintenance arises. In either case, you depend on the modifier for satisfaction and abide by his stated policy.

I've mentioned here only people who, on the basis of fairly long acquaintance, I've discovered to be completely trustworthy. Certainly there are other good modifiers out there. However, considering the hazards, I would say: caution.

Hobby Scene Q&A

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.

By John McVeigh

ACOUSTIC FEEDBACK

Q. ***How do the manufacturers and the users of commercial PA and sound equipment reduce or eliminate acoustic feedback, even at high sound pressure levels (such as at rock concerts)? Can I apply the same techniques at home?***

—Richard Lei, Rego Park, NY

A. In his *Stereo Scene* column in May 1976, Ralph Hodges discussed "The World of Sound Contracting." In that column he touched upon this particular subject and showed sample graphs for equalized and unequalized response of a large hall. By means of a narrow-band equalizer, the sound contractor can flatten out the frequency response and squash acoustic feedback. In the home, it is usually the turntable that is most affected by acoustic feedback. And in almost every case, the oscillations are at a low frequency. The best way to lick this problem is to physically isolate the turntable base, using a commercial shock mount with built-in damping or a home brew mount constructed from thick, spongy foam rubber.

FM INTERFERENCE

Q. ***I have a 5-band portable radio. When I switch to Public Service Band I (30-50 MHz) or PSB II/Air (108-174 MHz), I receive FM broadcasting stations. What causes this and how can I correct it?***

—Barry Sheffield, Chester, VA

A. Either the receiver has insufficient selectivity or the front end is being overloaded. You did not mention whether or not you are using the built-in whip or an external antenna. In either case, you could try putting a wave trap at the appropriate input. Use either a series LC circuit from the antenna input to ground or a parallel LC circuit between the antenna and the input to the r-f amplifier. Adjust either L or C to resonate the circuit and null out the undesired signal. But I'd suggest making the trap switchable (use a low-capacitance switch) so that you can still use the radio on the FM broadcast band!

COMPUTER RFI

Q. ***I recently got a Sphere Systems computer which is causing interference to nearby television receivers. (I am temporarily operating it outside of its cabinet.) Apparently, most of the interference is coming from the CPU board. Although I constructed a box from window screening and grounded it, the RFI problem remains. Any suggestions?***

—Charles Skeldon, New Brighton, MN

A. The majority of information signals that are generated by a digital system are square waves. Mathematically, a square wave can be described as a summation of sine waves harmonically related in frequency. The high-order harmonics can cause RFI and TVI. The best way to combat the problem is to button up the case tightly, making sure that there are clean metal-to-metal connections. If you *must* use the microprocessor outside its cabinet, try using very, very fine screening. Also, use a "brute force" filter on the ac line. Finally, you might try using ferrite beads on any lead more than a few inches long.

MIXING WITH A GRID DIP

Q. ***Recently, I accidentally made a discovery that has led to many hours of listening enjoyment. While varying the frequency of my grid dip meter, which was placed near an FM radio tuned off-channel (about 90 MHz), I found that I could receive many different r-f transmissions. Some of those I've received are TV sound, aircraft, police, CB, 2-meter FM, telephone calls, and even WWV. I'm fascinated! But how does it do it?***

—Dennis Cole, Lincoln Park, MI

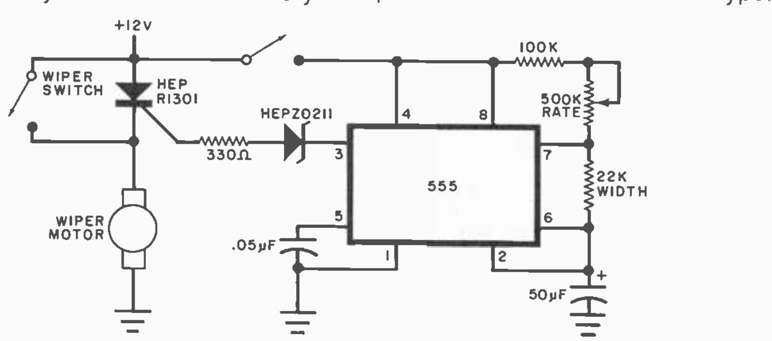
A. You have created a frequency converter stage. The grid-dip meter is the local oscillator, and some nonlinear element inside the receiver is acting as a mixer. The result is an additional heterodyne process. Exactly where the heterodyning is taking place is hard to determine, because one variation on Murphy's Law states that a linear circuit will often behave nonlinearly. Furthermore, just imagine how many *pn* junctions there are inside the radio's case, each of which can act as a diode mixer. Interestingly, you are receiving AM as well as FM transmissions. I imagine that is the result of slope detection. A variation of your technique has been used by many shortwave listeners who copy CW and SSB signals on shortwave portables lacking bfo's. By tuning a signal generator or the local oscillator of another receiver to the proper frequency, they could reinsert a "carrier" for proper detection. Happy Listening!

WINDSHIELD WIPER DELAY

Q. ***Do you have a circuit for a variable delay control for windshield wipers?***

—Doug Swart, Plainview, NY

A. The circuit shown is a result of colaboration between myself and reader Jack Rutherford of Burlington, North Carolina. It will provide a sweep rate of from one every 5 seconds to one every 37 seconds. An SCR is used for triggering the windshield wiper motor rather than a relay to avoid mechanical bounce problems. The SCR, a HEP R1301, will handle 20 amperes of maximun forward current, sufficient for even a hefty wiper motor. The SCR should be heat-sinked. All resistors are half-watt carbon, and the 50µF capacitor should be a tantalum type.



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CIRCLE NO 63 ON FREE INFORMATION CARD

BY PE EDITORIAL STAFF *

PROPAGATION FORECASTS FOR RADIO COMMUNICATORS

How to examine the sun safely and use other sources to determine sunspot activity.

IN ADDITION to being the ultimate energy source for all earthly life, the sun plays a dominant role in the long-range propagation of radio waves. Solar radiation causes atoms in the upper atmosphere to ionize, resulting in the formation of the ionosphere, off which radio waves bounce to return to the earth and provide long-distance communications. The density and height of the ionosphere determine the wavelength and the angle of the reflected wave.

There is also a correlation between the presence of sunspots on the solar disc and the degree of ionization of the upper atmosphere. With all we know about solar activity, however, we cannot yet predict with a high degree of accuracy ionospheric "weather" and its influence on radio.

Records of sunspot activity have been reliably kept since only about 1750; but this still enables us to develop a plot which shows the so-called sunspot cycle. The up-and-down nature of sunspot count is evident in the plot shown in Fig. 1; but note that irregularities can be detected. Observe, too, that sunspot peaks have been as low as 60 and as high as 200. Moreover, the valleys in the graph have not always reached the zero mark, although some have remained near zero for a year or more. Thus, the 11-year "sunspot cycle" is also an approximation since there have been longer and shorter cycles.

For more than a year now, knowledgeable people have been wondering when Cycle 20 (in the recorded history of cycles) is going to bottom out. Have we already passed the sunspot minimum? When will Cycle 21 begin to show strength? Is it already revealing itself? Will it ever? These are the questions being asked; and the answers given differ widely.

Equipment. Active hams, CB'ers, and SWL's have a keen interest in keeping up with the sun's activity. Most radio communication enthusiasts, however, don't realize that they can do so without setting up elaborate solar observatories in their

* Source of Information: Edward P. Tilton, W1HDQ

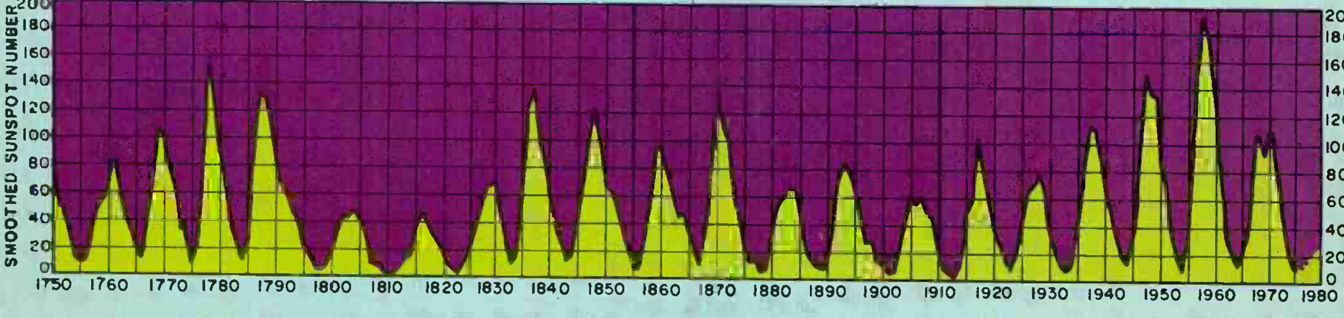
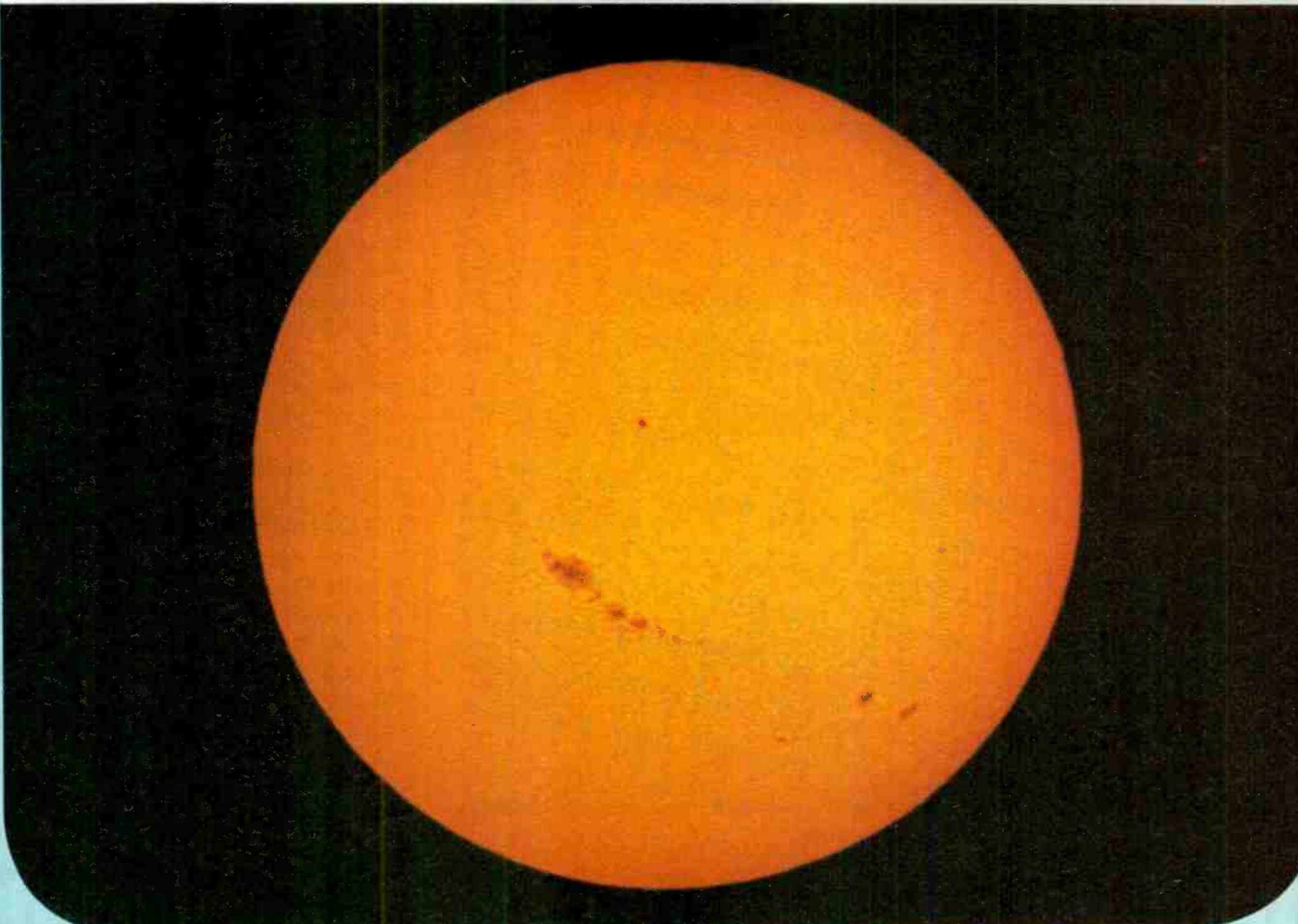


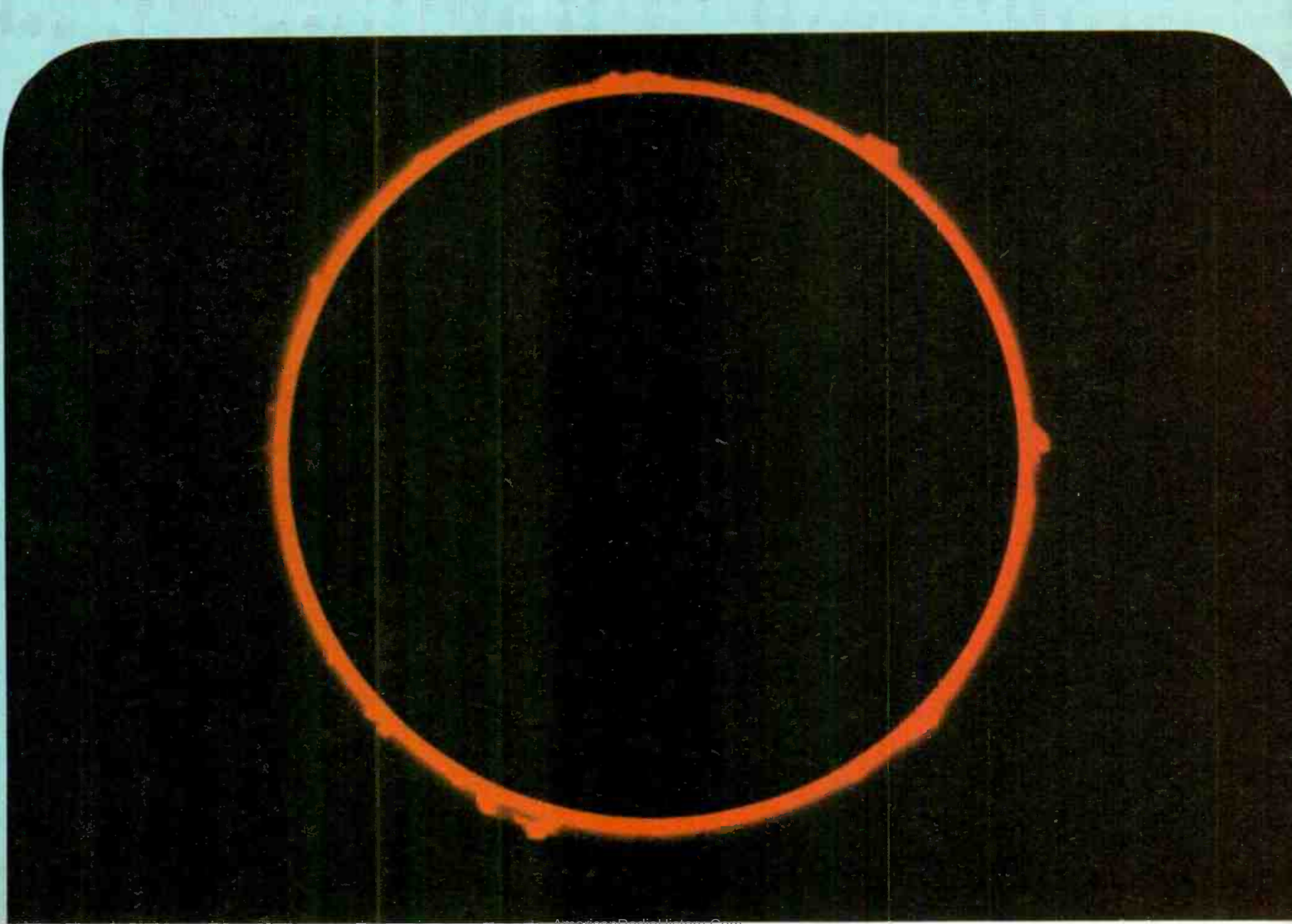
Fig. 1. Smoothed sunspot number plotted from 1750 to present. Cyclic variation is apparent.



Color photos courtesy Tiara Observatory—Tersch Enterprises.

Photo (above) of entire sun disc, Jan. 30, 1968, when sunspot activity was very high. Spots have dark centers (umbra) and surrounding grey areas (penumbra). Darkening around edge is from looking through more and more of sun's atmosphere.

View (below) of sun taken with chronograph. The bright surface (photosphere) is blocked to see atmosphere next to surface. Red chromosphere is seen in the light of hydrogen-Alpha wavelength. Projections from chromosphere are prominences.



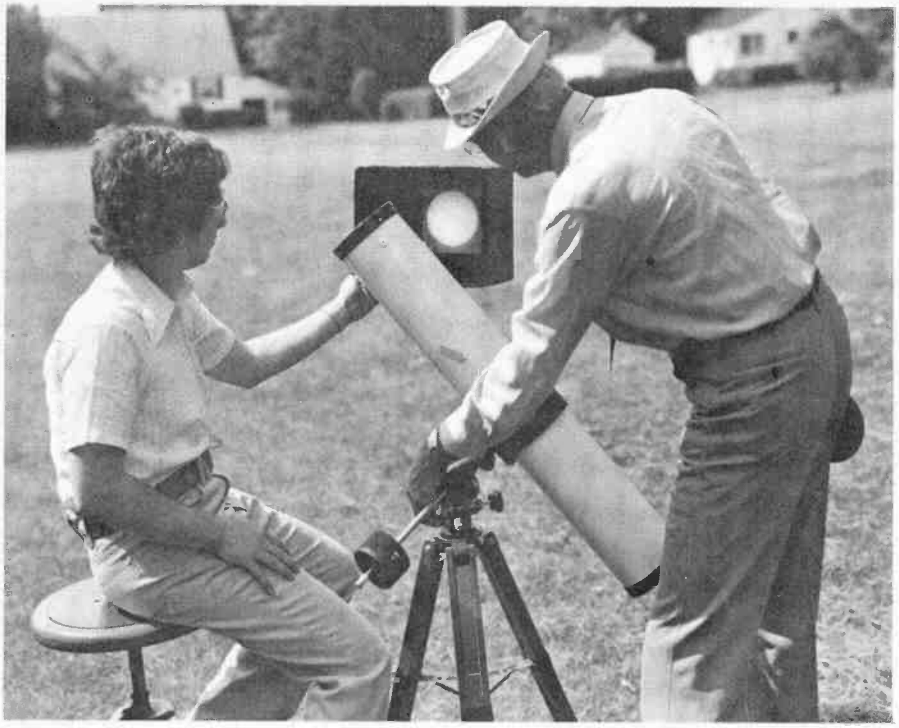


Fig. 2. Using a 5" reflector telescope and black box to view projected image of the sun.

back yards. One can keep track of what's happening on the sun even at the bottom of Smog Valley with any old "spyglass." People have used an antique mariner's glass, a surplus military target telescope, bird watchers' telescopes, a $29 zoom-lens telescope, and the 5" (127-mm) reflector shown in Fig. 2. Whatever you use, though, be sure you don't look directly at the sun with the scope (or your naked eye) except with a filter that is safe for sun use. The various scopes mentioned above should be used for projection viewing only.

In Fig. 3, a Celestron 5 telescope is shown being used for direct viewing of the sun *with the manufacturer's full-aperture solar filter in place*. This filter passes only 0.01% of the light striking it to the viewer's eye, the minimum amount of filtering considered safe. You can make you own solar filter by mounting a Wratten neutral-density filter (density No. 4, available from Eastman Kodak dealers) in a lens-cap arrangement of your own fabrication. Be absolutely certain that any such filter is tightly mounted so that it doesn't accidentally slip out of place when you're looking into the scope's eyepiece. Incidentally, the Wratten No. 4 filter is also useful with large telephoto lenses that can be attached to single-lens reflex cameras for solar photography.

With an inexpensive low-power telescope, a camera tripod equipped with a pan-tilt head, and a few viewing accessories, you'll always be ready to check the sun, even on long road trips. To use the equipment, set the scope on the tripod and tilt it up in the general direction of the sun. Hold a white card in line with the eyepiece and adjust the orientation of the scope until the shadow it casts on the card is circular. Slow movement of the scope will then bring out a bright spot in the center of the shadow. This is the solar image. Adjusting the scope for a sharp-edged solar disc will bring the sunspots—if there are any—into near focus.

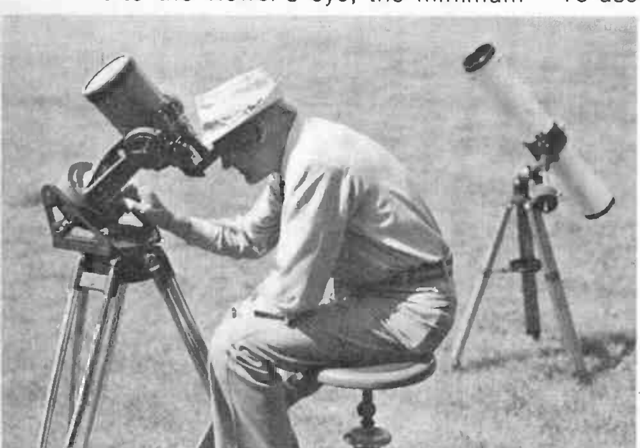


Fig. 3. Viewing the sun directly through Celestron 5 telescope equipped with full-apertue solar filter. Hat brim shields eyes from sun and makes fine details on sun easier to resolve. (Photos on this page courtesy American Radio Relay League, Inc.)

Better detail and contrast can be obtained by enlarging the shadow area. Put a card baffle measuring at least 12" (30.5 cm) square over the body of the scope to shade the projection surface from the sun's direct light. For even more clarity, project the image into a "black box" (as shown in Fig. 2). An ordinary cardboard box painted flat black will do. The viewing surface can then be good-quality white paper or any smooth surface inside the box painted flat white. Better still, put a cover on the projection box and cut a hole just large enough to permit you to look into the box and see the projected image at the bottom.

You will discover that the more ambient light you exclude from the projection area, the better will be the detail of the image and the larger the image you'll be able to use effectively. Bear in mind, however, that any gains you make must be paid for, which means that larger images will demand more precise aiming and tracking adjustments.

When you're using a telescope of more than 20×, an equatorial mount and rack-and-pinion drive become very helpful. The better scopes are usually equipped with these features, and some have mounted projection devices and electric clock drives. The latter two are also available as options for those telescopes that don't include them as standard features. A moderately priced 2" or 3" refractor that's fully equipped with features and accessories makes an excellent setup for projection viewing.

Interpretation of what you see is an involved process that requires a skill developed through practice and experience. Correlating what you see with observed propagation effects can develop into an absorbing side hobby. You might find it useful to make two sketches of each observation; one to show the locations and general appearances of any spots and the other an enlarged view of major spots or groups of spots.

A LOOK AT SOLAR RADIATION

Sunspots are visible evidence of solar activity, wellsprings of the kinds of radiation that affect radio communication for better or worse. The types of radiation with which we are principally concerned are ultraviolet light and atomic particle emission. As with all electromagnetic waves, UV travels at roughly 300,000 km (186,000 miles) per second. Thus, if we see a sudden change in the appearance of a sunspot group or detect an increase in solar radiation by electronic means, we can expect propagation changes almost immediately.

Ionization of the earth's outer atmosphere (production of the ionospheric layers that make long-distance communication possible) is a sudden effect, much like turning on a fluorescent lamp. The F layer, located some 140 to 200 miles out in space, is "turned on" by solar UV radiation and acts as the principle radio "mirror," reflecting waves back toward the earth. This ionized layer appears to build up gradually each morning and to dissipate each evening.

A sudden burst of UV radiation, such as that which accompanies the appearance of a solar flare, can change the state of the ionosphere almost immediately. (It arrives here about eight minutes after it has left the sun.) The effect of the UV flash is a rise in the maximum usable frequency (muf) which is the highest frequency that will support communication over a given signal path. Also, the received noise level will probably increase, especially if the antenna is directional and is aimed at the rising or setting sun.

Such a burst of UV radiation is accompanied by charged-particle emission. This "solar wind" moves more slowly, however, spraying out into space with what has been called the "garden-hose effect." (For a practical demonstration of this effect, turn on the water pressure suddenly in a hose lying loose on a lawn.) The solar wind follows devious paths, which means that the effects of the particle burst may not be observed on earth for as long as one to four days after it left the surface of the sun. When the particles enter the earth's magnetic field, you'll know about it quickly, particularly if you live in the Northeastern US or Canada. Shimmering aurorae may appear and signals in the lower portion of the hf spectrum will take on a wavery sound. This is sometimes followed by partial or complete loss of communication. Frequencies above about 25 MHz (higher in periods of generally higher solar activity) can open up for short skip, and signals may also show the typical auroral "fuzz," or distortion, resulting from multipath scattering in the aurural regions. The distortion tends to increase with increasing frequency.

In times of generally lower solar activity, such as the present, the effects of particle radiation are mostly mild. Aurorae are relatively rare and the disturbances associated with solar-flare activity are much less severe and frequent than they will be in a few years from now.

A widely overlooked fact about solar cycles is that, regardless of the current phase, there are large variations in the level of activity from time to time. It's rare to have more than 10 consecutive days of solar stability. Even near the normal "bottom" of the cycle, solar activity and visible sunspots can increase steadily for several days, reaching peaks more characteristic of middle or even peak years. These anomalies often sneak up on professional forecasters so that even the newest amateur observer will not have to wait long to find "official" forecasts as far off the beam as local weather forecasts are at times. High-activity peaks have appeared in 1974, 1975, and 1976, supposedly the lowest three years of a dying Cycle 20.

Sources of Information. There are several information sources for propagation conditions. For example, annual and monthly forecasts are offered by many shortwave club newsletters and amateur radio magazines.

The National Bureau of Standards radio stations WWV and WWVH are another valuable source of information. These stations transmit continuously on 2.5, 5, 10, 15, 20, and 25 MHz, primarily for the purpose of providing accurate time and frequency standards.

Propagation bulletins are given at 14 minutes past the hour on WWV and are updated four times daily, usually at 0114, 0714, 1514, and 1914 Coordinated Universal Time. UTC is the same as GMT, which is equivalent to EST plus five hours. The following information is given: propagation quality forecast; condition of the geomagnetic field; coded forecast for the North Atlantic path; the K index; and the 2800-MHz solar flux.

Propagation quality is given in one of nine degrees, ranging from "useless" to "excellent." *Geomagnetic activity* is given as "quiet," "unsettled," or "disturbed." The *coded forecast* is a simple quantized statement of propagation quality. The *K index* is, in effect, a numerical statement of geomagnetic activity. It reflects an actual reading taken just before bulletin time and is a direct indication of likely propagation quality on high-latitude paths and on frequencies where geo-magnetic field effects are critical (mostly below 15 MHz at times of low solar activity). The *solar flux index* is a measure of solar radiation. It correlates well with the muf (maximum usable frequency) for F-layer propagation and reasonably well with long-term sunspot number information. It is much more useful in planning radio communication than the sunspot number, because it is essentially current information. Both the K index and the solar flux are given with the expected direction of change, making them very valuable for short-term forecasting and planning when to use different frequencies.

A typical bulletin sounds like this: "The radio propagation quality forecast for 1900 UTC is *fair* to *good*. The geomagnetic field is *quiet*. The coded forecast is *November five*. The K index for 1800 UTC is *two*, expected to remain the same. The 2800-MHz solar flux index is *72*, expected to rise slowly." What does all this mean?

Since a steady K index of two or less means generally low geomagnetic activity, it can be assumed that there is no abnormal amount of charged-particle emission from the sun entering the earth's magnetic field at the moment. And a low, but rising, solar flux indicates a somewhat higher F-layer muf will develop. If the bulletin is correct as to these trends, the propagation forecast will be right — conditions will be above average and the muf will rise. The "November" part of the coded forecast stands for *N*, or "normal," and "five" means fair to good conditions.

A fast-rising K index means increased absorption of radio signal energy in the ionosphere and reduced signal levels or perhaps loss of communication entirely. The effects are generally more pronounced in the higher latitudes; hence the forecast for the North Atlantic path — a busy circuit traversing high latitudes from most of the United States. The operator will do well to get his message across as soon as possible since conditions are changing rapidly.

If the K index rises above three, there will be a marked deterioration in communication. At five or six, total loss of contact will probably result. An index of seven means that a really severe disturbance is under way, affecting all but transequatorial paths, even those at the low end of the hf range. However, it's good news for vhf enthusiasts because auroral openings are almost certain in the northern US.

Rising solar flux means increased UV (ultraviolet) radiation. The reading broadcast over WWV is derived from information taken on 2800 MHz in Ottawa, Ontario, Canada, at 1700 UTC (noon Ottawa standard time). The 1914 WWV bulletin reflects the 1700 Ottawa observation. Although the language appears to imply that the reading is updated with each bulletin change, this is rarely the case. So, if you can't copy four bulletins each day, concentrate on the one at 1914. It's the best of the lot for fresh solar flux information.

As with the K index, the trend in solar flux is important. So is the rate of change. A slow, steady rise in solar flux — say one point per day — with perhaps no rise at all on some days within a generally upward period means gradually improving conditions on all frequencies, particularly if the K index remains low and fairly constant. The muf will increase perceptibly with each rise in the solar flux. A week of this can mean a great deal to amateur radio operation on the 15-meter band during the fall and winter of 1976-1977 and SWL's monitoring the 16- and 13-meter shortwave bands. A really marked rise can even bring the region above 27 MHz, including the Class D Citizens Band and 10-meter amateur radio band back to life briefly as F-layer DX territory.

Beware of a fast-rising solar flux. If it rockets up at a rate of three or more points per day, there will be short-lived gain, even a spectacular improvement in muf, but communications disaster isn't far away. When the solar flux peaks out, the K index will surely rise and then up goes the ionospheric absorption of hf signals. High-latitude circuits will fade out first, and the 160- and 180-meter amateur and 120-, 90-, and 75-meter shortwave bands will quickly go to pot. This can be followed by deterioration and blackout of the 60-, 49-, 41-, 40-, and 31-meter bands. Even 25 and 20 meters can go under. But be sure to watch the transequatorial circuits at such times. They may become extraordinarily active somewhere along the line, at least for a brief period of time.

Summing Up. Every change in the solar flux can be related to what can be seen on the sun by direct viewing or by projection. If your eyesight and viewing equipment are good and you get frequent looks at the sun under good viewing conditions, you'll be able to keep up with the propagation guessing game about as well as the pro's do. With some experience and understanding of the factors involved in charting WWV information and matching it with sketches of the visible variations of activity on the face of the sun, you'll discover a hobby-within-a-hobby that can be pursued at many levels of sophistication.

This is the time to start tracking the sun, when solar activity is generally low. Spots and groups of spots are presently well spread out. The significance of what is seen is far more easily grasped now than it will be in a few years, when the sun will likely be freckled with spots. ◈

Editor's Note: As this article was going to press, there appeared evidence that the entire WWV propagation bulletin service might be terminated. Should this happen, ARRL has plans to air such bulletins over W1AW.

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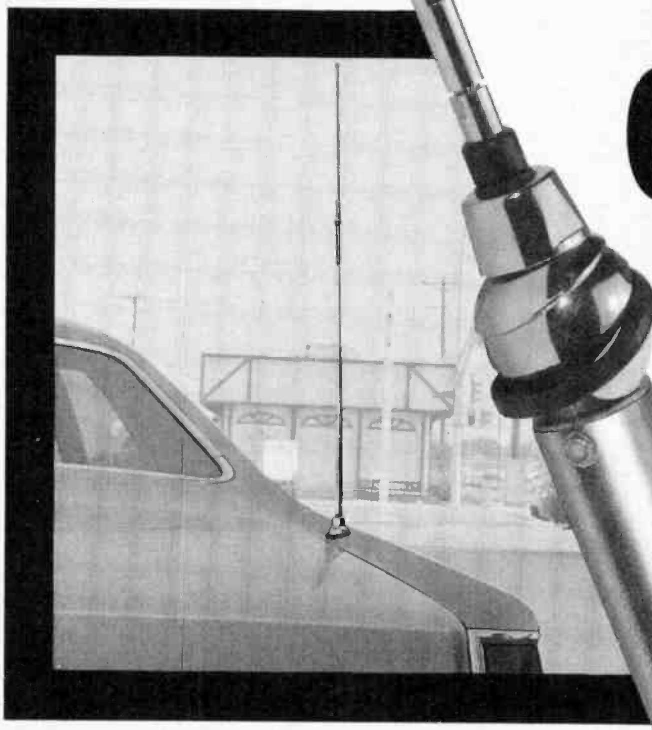

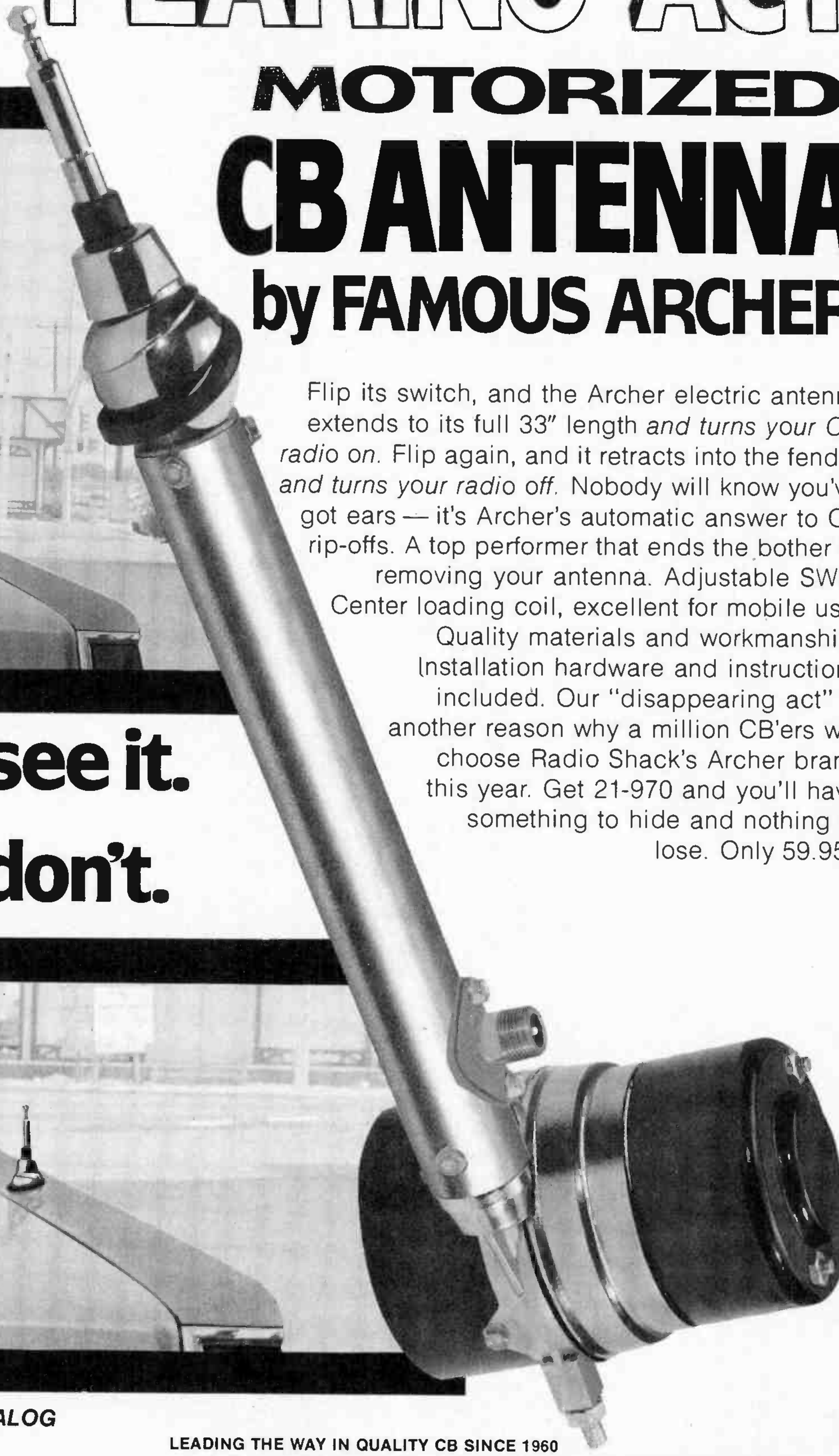

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A CB/Ham Selective Calling Project*

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*U.S. and foreign patents applied for.

BY MARTIN MEYER

THE ever-increasing activity on the radio communication channels has created an urgent need for a device that will alert you to only those calls specifically directed at you. Ideally, the device would keep your receiver silent, turning on the audio only when a specially coded signal is received. This is exactly what the "Call Selector" described here is designed to do.

The Call Selector eliminates the need for you to monitor the constant "chatter" on the channel to which you are tuned while waiting for a call. The basic one-way Call Selector system consists of an encoder and a decoder (More elaborate arrangements are described later.) The calling party transmits a coded signal on a previously agreed upon channel. You (at the receiving end) leave your transceiver turned on at all times, but you do not hear anything until the special signal is decoded. Then you simply establish contact with no fuss or bother.

The encoded signal consists of a tone whose exact frequency and duration is keyed to the decoder at the receiving end. This tone can be transmitted over any AM, single sideband (SSB), or FM transmitter, making the system usable by CB'ers, hams, and commercial radio operators. There are about 100 combinations of time and frequency that can be selected, ensuring a minimum of false calls even in busy traffic areas. The system is also immune to extraneous noises and voices to further safeguard against false triggering.

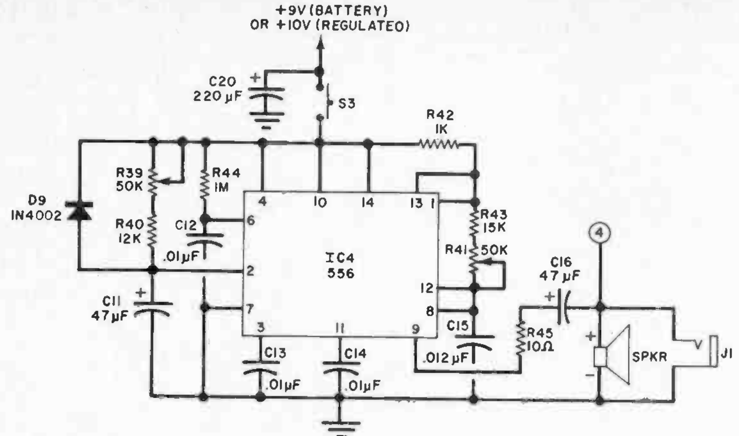


Fig. 1. The encoder uses a timer to generate a tone.

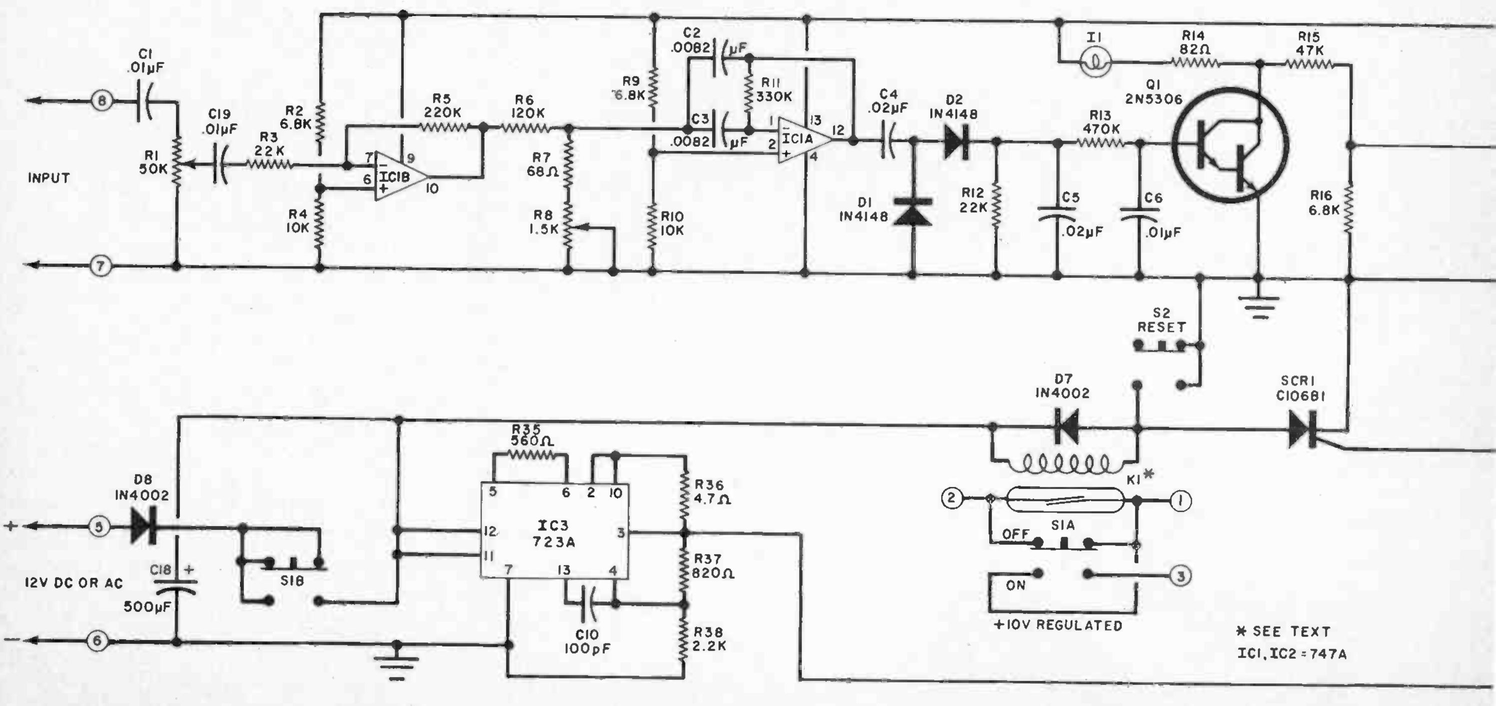
Any number of transceivers can be equipped with the system and tuned to the same frequency/time signal to communicate with each other. For example, you can equip a number of mobile transceivers with only an encoder to allow a base-station operator to listen to only those calls in which he is interested.

About the Circuit. The encoder, shown schematically in Fig. 1, consists of dual 556 timer *IC4*, a small dynamic loudspeaker, and supporting components. Half of *IC4* is used as a monostable, or "one-shot," multivibrator, which allows the other timer to free run for a given period of time when activated by closing *S3*. The output of the second timer is an audio tone with a frequency between 1000 and 4000 Hz. The actual operating frequency is determined by the setting of *R41*. The width of the monostable multivibrator's output pulse (and thus duration of the audio tone) is controlled by *R39* over a range of 1 to 4 seconds. The output of the free-running timer is coupled by *R45* and *C16* to the speaker.

The encoding tone is acoustically coupled to the microphone of the transmitter with which the Call Selector is being used. This is accomplished by pressing the microphone's housing down on *S3* and holding the mike's push-to-talk switch closed for the full duration of the tone. Because the encoder draws no current until *S3* is closed, a 9-volt transistor battery is suitable for the power source. However, if a two-way encode/decode system is desired, the encoder can be mounted on the same circuit board as the decoder and power can be drawn from a common +12 volt dc or ac supply. (If an on-board encoder is used, *C20* should be omitted.) The encoder's output will be the same with either power supply and will be stable over a wide temperature range.

The decoder is shown schematically in Fig. 2. The encoded signal from the receiver is coupled into the circuit through *C1* and sensitivity control *R1*. The signal is passed through *C19* and *R3* into the inverting (−) input of *IC1B*. This operational-amplifier stage has a voltage gain of 10 and operates from a single-ended dc power supply, as do all succeeding op-amp stages. Resistors *R2* and *R4* set the noninverting input of *IC1B* at approximately half the supply voltage.

The output of *IC1B* goes to the inverting input of *IC1A*, which is a very selective bandpass filter whose cutoff frequency can be varied between 1000 and 4000 Hz by *R8*. When the receiver's audio output contains a component at the center frequency of the filter, a signal appears at the output of *IC1A*. This signal is coupled by *C4* to *D1* and *D2*, which can detect (rectify) it, and the rectified waveform is smoothed by *R12*, *R13*, *C5*, and *C6* into a dc voltage. When this dc voltage is applied to *Q1*, the Darlington transistor conducts and cuts off *Q2*, at which point, *C9* starts charging through *R17* and the base-emitter



junction of *Q4*. The voltage across *C9* drives *Q3*, the output of which is applied to the noninverting (+) input of *IC2B* and the inverting input of *IC2A* through *R22* and *R26*, respectively.

Normally, the base of *Q6* is positive, and the transistor conducts. However, due to the comparator action of *IC2A* and *IC2B*, the voltage at the base of *Q6* will drop to zero after *C9* begins to charge and then go positive as charging continues. The exact point at which the momentary drop in voltage occurs is determined by the setting of *R20*. Also, *Q5* is always conducting except during the "window" period generated by the charging of *C9*.

Transistors *Q4* and *Q5* are normally conducting as a result of current delivered to their bases through *R29* and *R31*. Both transistors are driven into cutoff only when two conditions are simultaneously satisfied. Transistor *Q5* must be cut off by the drop in the voltage at the output of window generator *IC2*. Transistor *Q4* will be momentarily cut off when the trailing edge of the tone signal discharges *C9*. If these events occur simultaneously, the outputs at the collectors of *Q4* and *Q5* go high and trigger on *SCR1*, which, in turn, energizes reed relay *K1*, closing its contacts. The SCR conducts and the relay remains energized until RESET switch *S2* is closed.

The contacts of *K1* close only when a tone of the proper frequency and time duration is applied to the input of the decoder. Any voice or low-frequency signal that passes through the active filter will constantly discharge *C9*. This makes the system insensitive to heterodynes, voice components, and noise. For stability, the decoder circuit, except for *K1* and *SCR1*, is powered by voltage regulator *IC3*. If an encoder is mounted on a decoder's circuit board, it will also receive its power from the regulated output of *IC3*.

Construction. The encoder and decoder can be assembled on perforated board, using sockets for the IC's, or on a single or separate printed circuit boards. The actual-size etching and drilling and components placement guides for the system are shown in Fig. 3. If you plan to build the encoder and decoder on the same board, use the larger board and install the encoder components in the shaded area of the components placement guide. (Do not forget to omit *C20* in this case.) Alternatively, if you wish to have the encoder and decoder in separate boxes, use both boards, but eliminate the components in the shaded area.

Wire the board or boards as shown, starting with installation of the fixed resistors and nonpolarized capacitors. Then install the electrolytic capacitors, diodes, transistors, and IC's, paying careful attention to polarization, basing, and orientation. Finally, mount the potentiometers, reed relay, and switches. In the author's prototype, *S3* was formed from No. 4 machine hardware and a 1⅜" × ½" (3.5 × 1.3 cm) piece of springy brass shim stock. The brass shim was formed to take advantage of its natural resilience to keep it from touching the machine screw contact. A short length of wood dowel or plastic rod can be used as the pushbutton for the switch. If you prefer, you can use a standard normally open pushbutton switch, connecting it to the pc board via short lengths of hookup wire

Mount *J1, I1, I2, SPKR,* and the dowel or plastic rod for *S3* (or *S3* itself) on the top of the box in which you house the encoder/decoder. If you are housing the encoder and decoder in separate boxes, install the 9-volt transistor battery for the encoder off the board where it will not interfere with the board, speaker, or *S3*. In either case, mount the activating button of *S3* close to the speaker.

The numbers of the contacts on terminal strip *TS1* on the encoder/decoder components placement guide refer to the same numbered points in Fig. 1 and Fig. 2. This terminal strip provides a convenient means of connecting the system to its power supply, an external speaker, and any other warning device you might want to use, such as a Sonalert, LED, etc., when a properly coded signal is received. The decoder board will also accommodate a Sigma No. 77RE2 dpdt relay in the event the spst reed relay will not provide a sufficient number of contacts.

Aligning the System. To get the Call Selector system to operate properly, the decoder must be made to respond

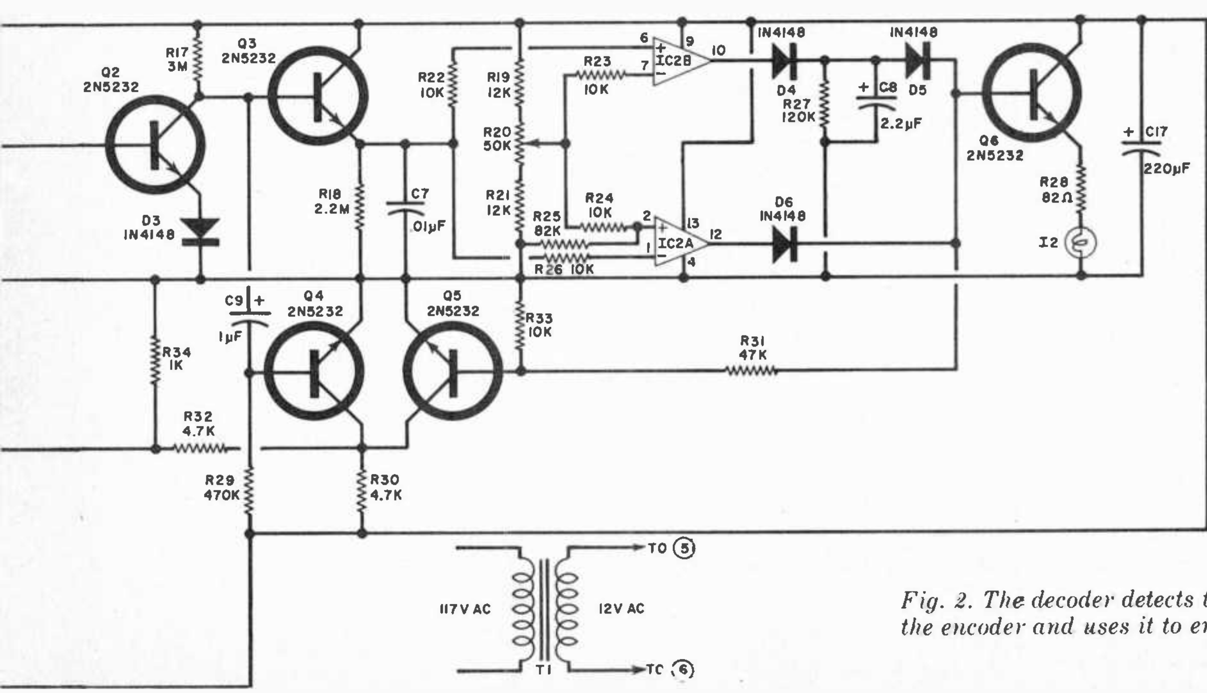
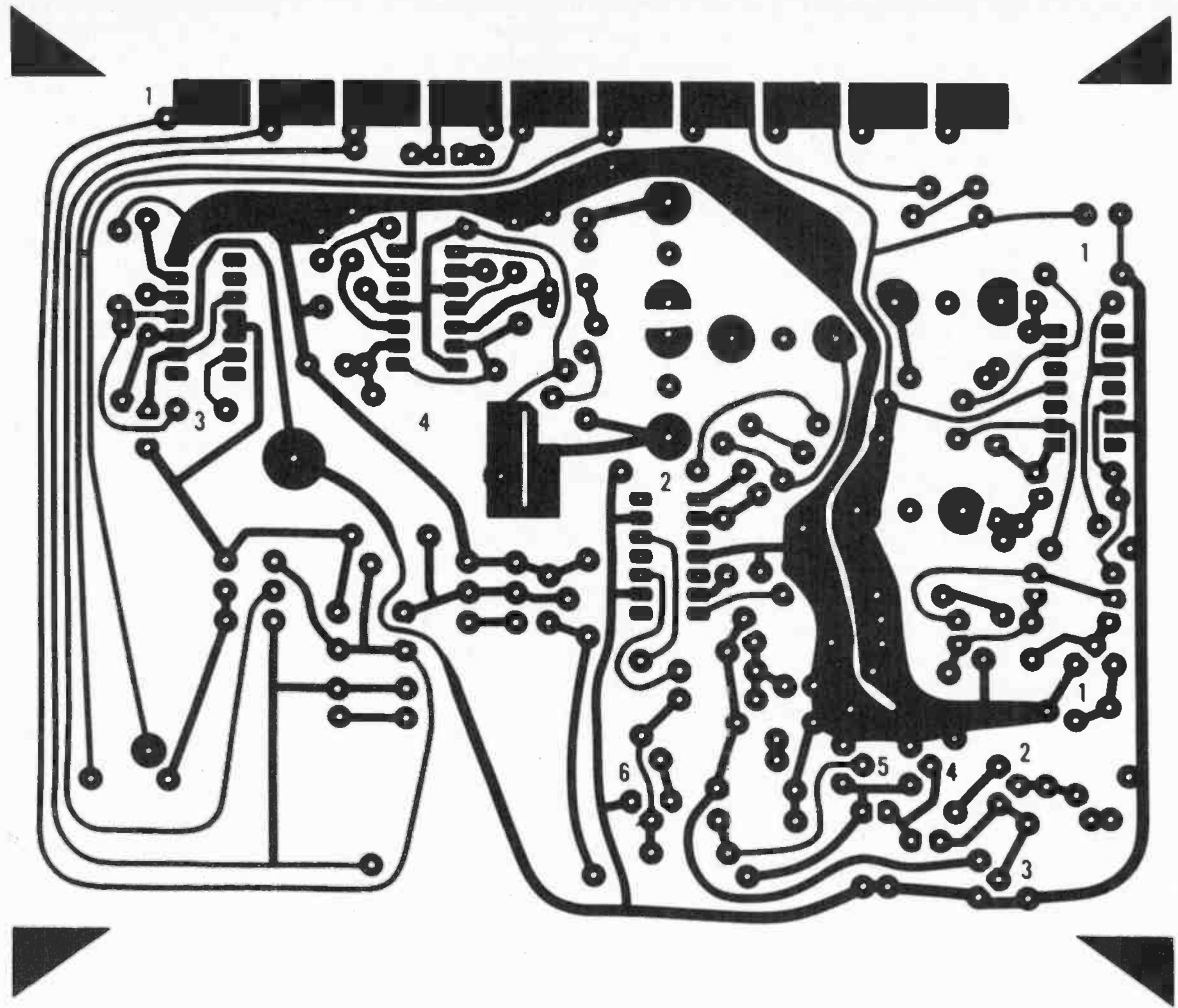


Fig. 2. The decoder detects the audio tone from the encoder and uses it to energize a reed relay.



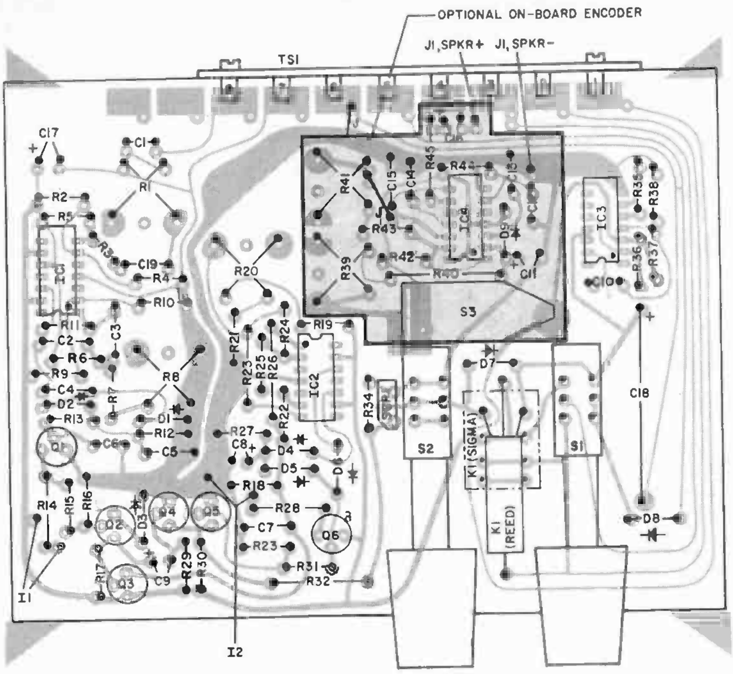
to the selected frequency/duration characteristics of the encoder's output signal. To align a system consisting of separate encoder and decoder, you will need a shielded cable terminated at one end in a plug that mates with jack *J1* in the project. Connect the "hot" lead of the cable terminal 8 and the shield to terminal 7 of *TS1*. For a system in which the encoder and decoder are on the same board, simply connect a jumper between terminals 4 and 8. This allows the system to be calibrated by direct interconnection, rather than by transmitting test tones on the air.

Connect power to the system. Set *R1* in the decoder and *R39* in the encoder to maximum clockwise and *R8*, *R20*, and *R41* for center of rotation. Depress *S3* and hold it down for the full duration of the test tone while adjusting *R41* until *I1* glows. This sets the encoder for the maximum 4-second tone duration. It may be necessary to repeat this procedure several times before *R41* is properly set.

DECODER PARTS LIST

C1,C6,C7,C19—0.01-µF disc capacitor
C2,C3—0.0082-µF, 10% Mylar capacitor
C4,C5—0.02-µF disc capacitor
C8—2.2-µF, 25-volt electrolytic capacitor
C9—1-µF, 25-volt, 5% tantalum capacitor
C10—100-pF disc capacitor
C17—220-µF, 25-volt electrolytic capacitor
C18—500-µF, 25-volt electrolytic capacitor
D1 through D6—1N4148 diode
D7,D8—1N4002 rectifier diode
I1, I2—6-volt, 100-mA lamp and assembly (Radio Shack No. 272-1535 or similar)
IC1, IC2—747A dual operational amplifier IC
IC3—723A voltage regulator IC
K1—12-volt spst reed relay (or Sigma No. 77RE2 dpdt relay—see text)
Q1—2N5306 npn Darlington transistor
Q2 through Q6—2N5232 npn silicon transistor
R1,R20—50,000-ohm trimmer potentiometer
R8—1500-ohm trimmer potentiometer
Following resistors are ¼ watt, 5% tolerance:
R2,R9,R16—6800 ohms
R3,R12—22,000 ohms
R4,R10,R22,R23,R24,R26,R33—10,000 ohms
R5—220,000 ohms
R6,R27—120,000 ohms
R7—68 ohms
R11—330,000 ohms
R13,R29—470,000 ohms
R14,R28—82 ohms
R15,R31—47,000 ohms
R17—3 megohms
R18—2.2 megohms
R19,R21—12,000 ohms
R25—82,000 ohms
R30,R32—4700 ohms
R34—1000 ohms
R35—560 ohms
R36—4.7 ohms
R37—820 ohms
R38—2200 ohms
S1—Dpdt pushbutton switch
S2—Spdt pushbutton switch
SCR1—C106B1 silicon controlled rectifier
T1—12-volt, 500-mA transformer
TS1—8-contact screw-type terminal strip
Misc.—Perforated or printed circuit board; suitable chassis box; hookup wire; machine hardware; solder; etc.

Note: The following items are available from Netronics Research & Development, Rte. 6, Bethel, CT 06801. Complete kit of parts with instructions for one-way system which includes separate encoder and decoder, wood case for decoder, and plastic case with visor clip for encoder (Kit N5000), $44.95 + $1.50 postage; Separate encoder kit with plastic case, visor clip and instructions (Kit N6000), $14.95 + $1 postage and handling; Combination encoder/decoder for two way system which includes all parts, instructions, a wood case and built-in heavy-duty speaker (Kit N7000), $49.95 each + $1.50 postage and handling. Also available separately: decoder pc board, $5.25; encoder pc board, $3.95; reed relay, $2.60, 12-volt transformer, $2.75; S3 encoder switch and plunger, $1.30. Add $1 postage and handling for separate parts orders.



Once *I1* comes on while *S3* is depressed, *I2* should blink about half way through the tone burst. Adjust *R39* so that *I1* turns off just after *I2* blinks. Once this adjustment has been made, depress RESET switch *S2*.

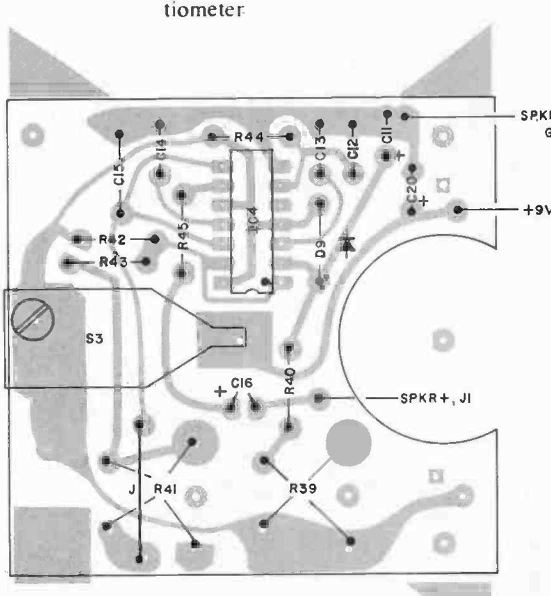
Connect an ohmmeter between terminals 2 and 3 on *TS1*. The meter should indicate an open circuit. With power switch *S1* off, the ohmmeter should indicate short circuit (zero ohms) with *S1* on. Depress *S3* for the full duration of the tone burst; *I1* should turn off immediately after *I2* blinks and the meter should indicate a short circuit. Depress *S2*; the relay's contacts will open and the meter should indicate an open circuit. If you do not obtain the proper results, repeat the alignment procedure until you do.

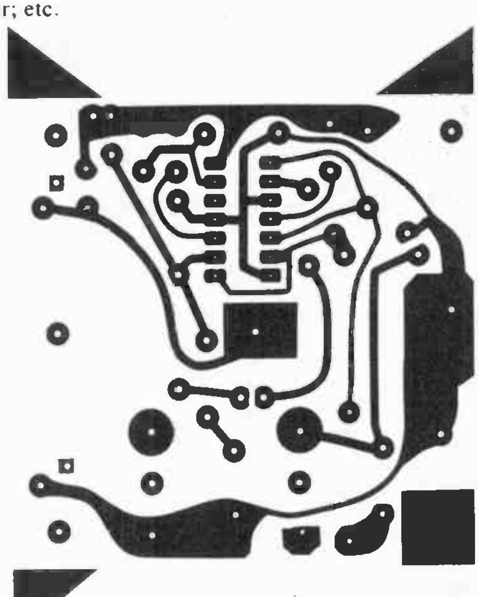
In Use. You can recalibrate the Call Selector system for any frequency between 1000 and 4000 Hz and for any tone duration between 1 and 4 seconds. Sensitivity control *R1* can be set for any desired signal level threshold. In practice, you use the microphone to

Fig. 3. If you want encoder and decoder together, use board on opposite page and install all components as above. For separate units, leave off components in shaded area above and build separate encoder board shown below.

ENCODER PARTS LIST

C11—47-µF tantalum electrolytic capacitor
C12,C13,C14—0.01-µF disc capacitor
C15—0.012-µF, 10% Mylar capacitor
C16—47-µF, 25-volt electrolytic capacitor
C20—220-µF, 25-volt electrolytic capacitor (see text)
D9—1N4002 rectifier diode
IC4—556 dual timer IC
J1—Miniature phone jack
R39,R41—50,000-ohm trimmer potentiometer
Following resistors are ¼ watt, 5% tolerance:
R40—12,000 ohms
R42—1000 ohms
R43—15,000 ohms
R44—1 megohm
R45—10 ohms
S3—Spst switch (see text)
SPKR—8-ohm, 2¼"-diameter dynamic speaker
Misc.—Perforated or pc board; suitable chassis box (if assembled separately); machine hardware; hookup wire; solder; etc.





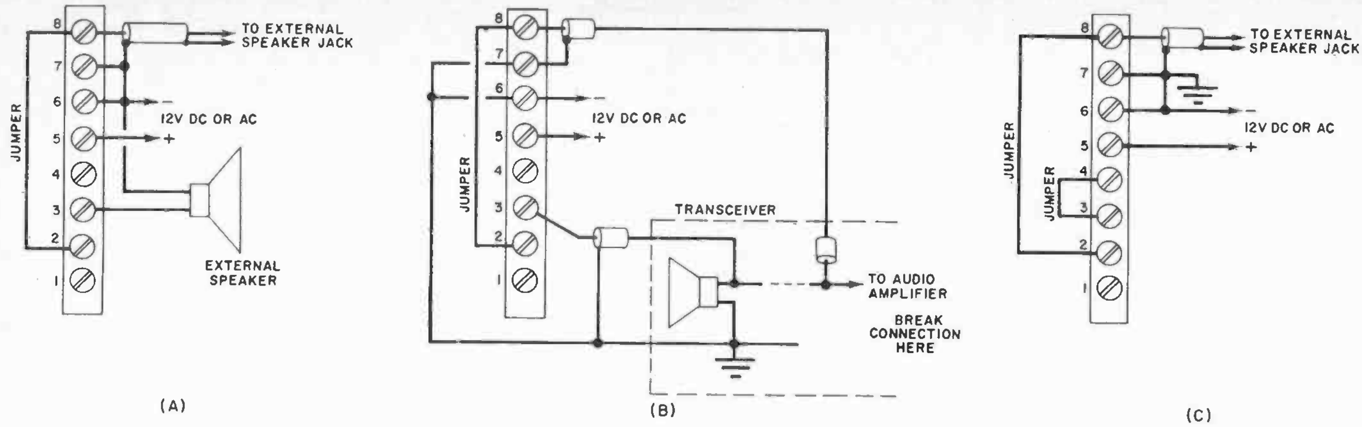


Fig. 4. Ways to use the system: with external speaker (A); with transceiver's speaker (B); and with the combination encoder/decoder's internal speaker (C).

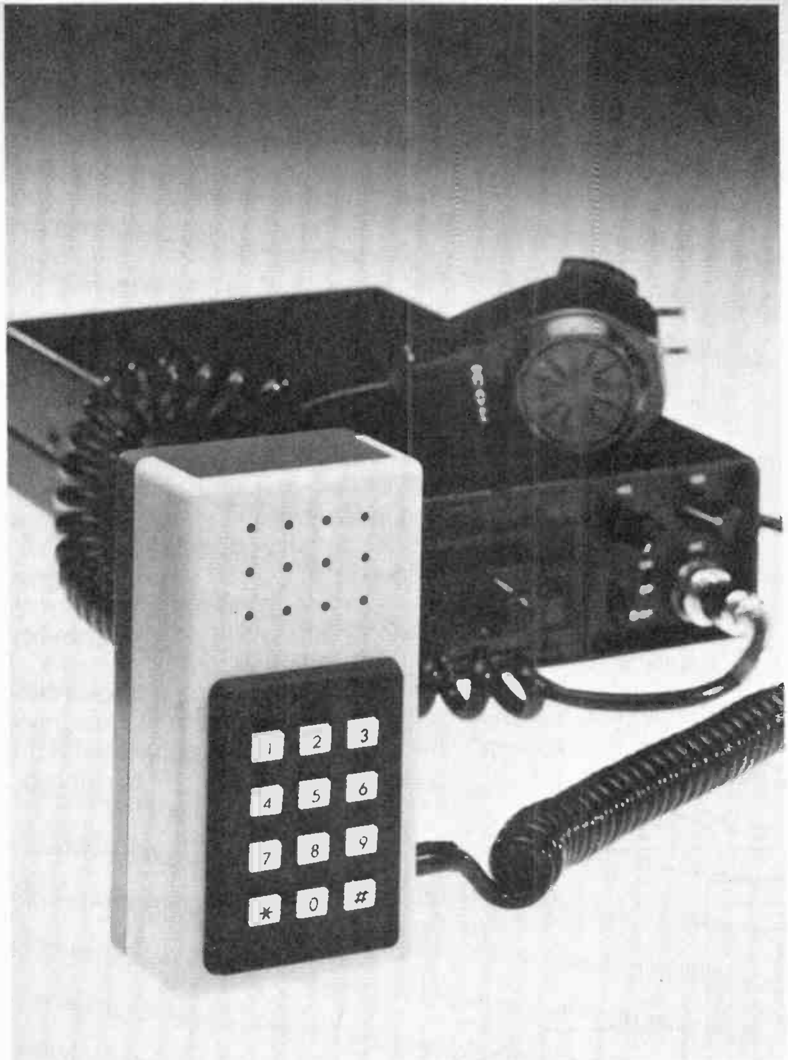
depress S3, holding the mike's pickup element directly over the Call Selector's speaker for the entire duration of the tone burst. This keeps the activating signal modulating the carrier at a constant level because the mike will be stationary with respect to the speaker.

There are several different ways to connect the system to your transceiver, three of which are illustrated in Fig. 4. If you plan to use the decoder with an external speaker and do not want to touch the "insides" of the transceiver, follow the wiring scheme detailed in Fig. 4A. Use a length of shielded cable to transfer the audio signal from the receiver's external-speaker jack to the decoder's terminal strip. Terminate the cable with a plug that mates with the transceiver's jack.

You can wire the system to the transceiver's internal speaker as shown in Fig. 4B. This connection requires a slight rewiring of the transceiver's circuit. Break the connection between the audio output stage and the speaker. Rewire the circuit as shown, using shielded cable. When the relay contacts close, the audio path to the internal speaker will be completed.

The diagram shown in Fig. 4C is for systems in which the encoder and decoder are assembled on the same board. This wiring scheme allows you to use the decoder/encoder's built-in speaker as an encoder transducer and as the transceiver's external speaker.

For all three interconnections detailed in Fig. 4, the decoder can be bypassed by placing S1 in the OFF position. The receiver's audio signal will then be applied directly to the internal or external speaker. ◈



TIE INTO HAM REPEATERS WITH THIS LOW-COST AUTOPATCH

Crystal-controlled Touch-Tone® pad for initiating telephone calls from vehicles.

BY JOE JARRETT

AN INCREASINGLY important part of amateur radio operation these days is the vhf/uhf repeater (automatic relay station) and its common accessory, the autopatch. A repeater is usually located on top of a high building, a tower, or a mountain and in many cases it is able to increase the usual 3-to-10-mile range of low-power equipment to more than 100 miles.

An autopatch is an automatic telephone patch that enables repeater users to initiate and dial telephone numbers from a vehicle or hand-held transceiver without assistance from a phone operator or other amateur stations. An autopatch is legal as long as it is not used to avoid toll charges and approved interface equipment connects the repeater to the phone line.

Most repeaters operate under remote control (not legal for CB radio use) and many of them have autopatch provisions. There must be a way of remotely turning these systems on and off in case of equipment malfunction or illegal use. Also, the users of autopatch must have a way of connecting or disconnecting the telephone line to the repeater phone patch and dialing the desired number. One of the easiest ways to accomplish these jobs is by using the Touch Tone® approach.

The Touch Tone system uses eight different audio tones at frequencies carefully selected not to be harmonically related. The keyboard is arranged in rows (horizontal) and columns (vertical) so that, when a particular key is depressed, two tones are generated—one for the row and the other for the column. These tones are then transmitted to the remote decoding equipment that "recognizes" the tones being transmitted as one of ten digits or six special codes (*, #, A, B, C, D). The four letters are extra keys and are not the same as those on conventional number keys. They are used in military systems and some computers.

Recently, the Mostek Corp. announced two dual-tone, multi-frequency (DTMF) generators, MK5085 and MK5086, that can be used to build a low-cost (under $25) Touch-Tone encoder. The only difference between the two IC's is in the method of keyboard entry. In the MK5086 (used in this project), the row and column keys are switched to the positive supply when a key is operated. The MK5085 uses a calculator-type scanning technique that allows the use of single-pole switches on the keyboard.

Circuit Operation. The complete circuit is shown in Fig. 1. The reference frequency is determined by a conventional 3.579 MHz color-TV crystal, with *R5* used as the bias resistor. Operating one of the pushbuttons on the keyboard starts the oscillator. (See box for details of IC operation.)

The TONE output of *IC1* (pin 16) is coupled to modulation level potentiometer R3, whose rotor is connected through *R4* and *C3* to the transmitter microphone input. The circuit consisting of *IC2*, an audio power amplifier, is used to drive an internal loudspeaker for monitoring the tones, while *R2* determines the speaker volume.

Operational amplifier *IC3* is used as a 0-4-second timer for the transmit hold-on delay. The MUTE output (pin 10) of *IC1* is held to ground when no key is depressed. Thus capacitor *C4* is discharged through *R6* to cause the non-inverting (+) input of *IC3* to be at ground. The inverting input (−) is at a voltage level determined by the setting of hold-on time potentiometer *R7*

Since the voltage at pin 5 is lower than the voltage at pin 4, the output of *IC3* (pin 10) is at ground so both *Q1* and *Q2* are turned off. These two transistors are connected in a Darlington configuration and are used to key the push-to-talk (PTT) line of the transmitter when they are turned on.

When a key is depressed, the MUTE output of *IC1* is pulled up to the positive supply. Diode *D1* becomes forward biased and *C4* is charged (within several milliseconds) to the positive supply less the diode drop of *D1*. The (+) input of *IC3* is now at a higher voltage than the (−) input so the output of *IC3* switches to the positive supply. Resistors *R8* and *R9* reduce the drive to the transistors. When *Q1* turns on, so does *Q2* and the PTT line is pulled down to the ground level. This causes the transmitter to key and transmit the tone signal.

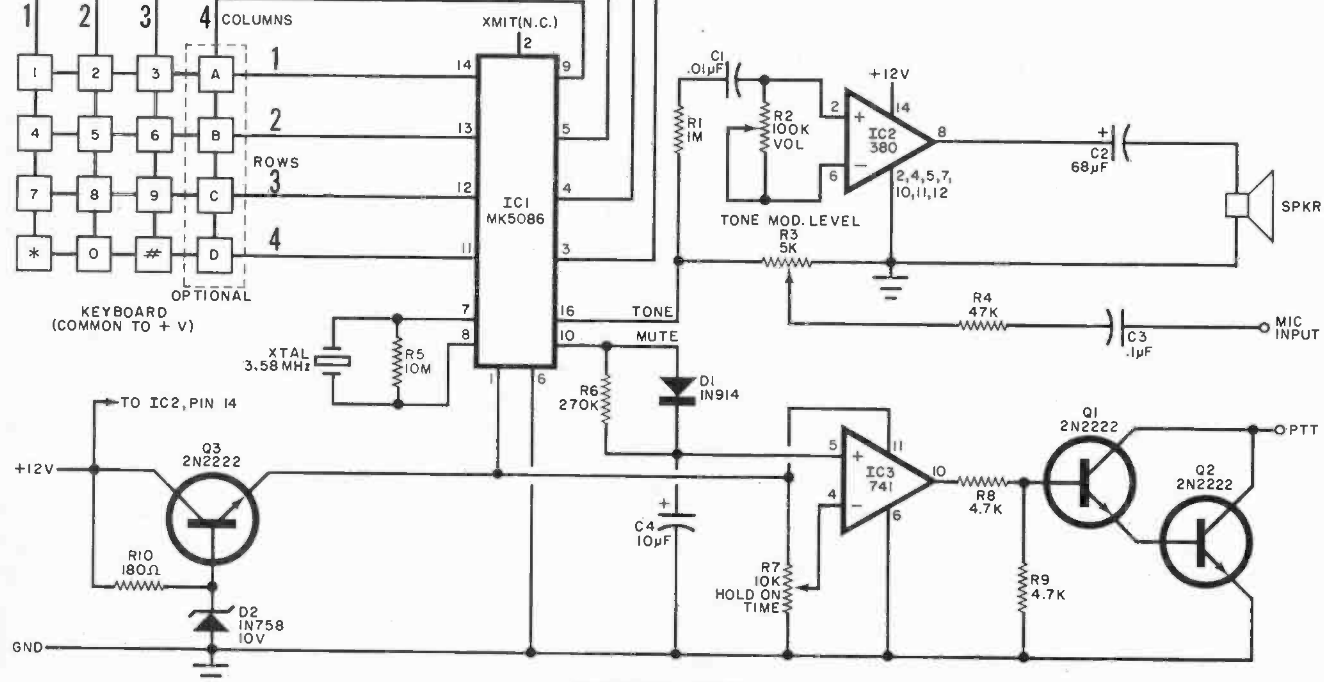
When the key is released, the MUTE output drops, *D1* becomes reverse biased, and *C4* begins to discharge through *R6*. As this happens, the voltage on the (+) input of *IC3* decreases until it is no longer greater than the voltage on the (−) input. At this time, the output of *IC3* switches to the ground level, thus turning off the two transistors and stopping the transmitter. Capacitor *C4* will not discharge far enough for this to happen however as long as the keys are operated reasonably fast. Complete discharge will occur after the last key entry and depends on the setting of *R7*.

View of the inside of the author's prototype.

The value of resistor *R4* is the coarse adjustment of the tone level. Depending on the transmitter used, the value of *R4* can range from 1000 to 100,000 ohms.

Some older types of equipment may require high current for keying, or may key the positive supply instead of ground. In this case, a low-current relay can be used in the PTT line (connected to the 12-volt supply), with the relay contacts keying the transmitter.

Fig. 1. Outputs of IC1 drive audio amplifier and operate transmitter PTT circuit.



PARTS LIST

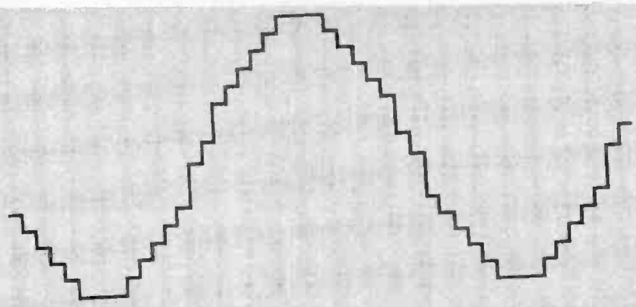
C1—0.01µF, 50-V disc capacitor
C2—68-µF, 25-V electrolytic capacitor
C3—0.1-µF, 50-V disc capacitor
C4—10-µF, 25-V electrolytic capacitor
D1—1N914 diode
D2—1N758, 10-V zener diode
IC1—MK5086, DTMF generator (Mostek)
IC2—LM380 audio power amplifier (National)
IC3—741 op amp
KEYBOARD—Digitran Corp. KL54 (12 keys); KL0049 (16 keys)
Q1, Q2, Q3—2N2222 transistor (or similar)
R1—1-megohm resistor
R2—100,000-ohm pc potentiometer (see text)
R3—5000-ohm pc potentiometer
R4—47,000-ohm resistor (see text)
R5—10-megohm resistor
R6—270,000-ohm resistor
R7—10,000-ohm pc potentiometer
R8, R9—4700-ohm resistor
R10—180-ohm resistor
SPKR—8-ohm, small diameter loudspeaker
XTAL—3.57 9545 MHz color-TV crystal
MISC.—Suitable chassis 4¾" × 2½" × 1½" (Vero Co. #90-20-087), 4-lead flexible cable, mounting hardware, etc.

Note: The following is avaiable from S. D. Sales, Box 28810, Dallas, TX 75228: kit of all parts except chassis, speaker, and interconnecting cable at $22.50 plus $0.75 for postage.

IC OPERATION

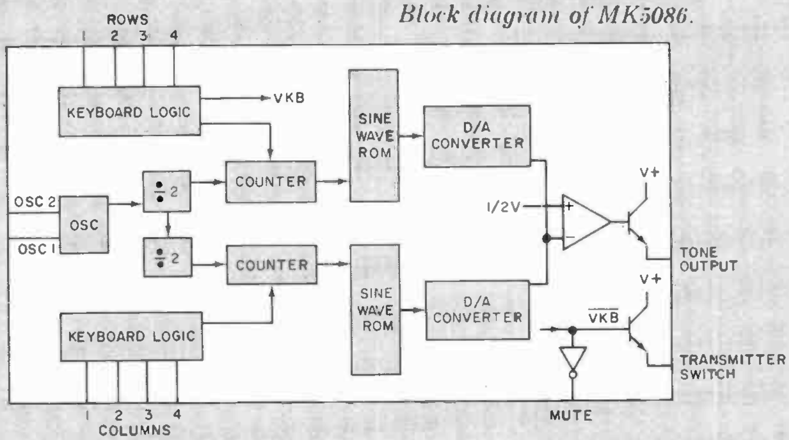
As shown in the block diagram of the MK5086, the row and column select keys are switched to the positive supply in the standard 2-of-8 format. (One key operates both the selected row and column.

The output of the crystal oscillator is divided by two counters—one for the rows and the other for the columns—and the amount of frequency division is determined by the keyboard entry switching.



Output of D/A converter.

Block diagram of MK5086.



Each sine-wave synthesizer is formed by a 5-bit, 32-state counter, decode ROM, and R-2R ladder network D/A converter. The output of each D/A converter is the 26-step sine wave shown in the waveform diagram. Six steps are missing out of the possible 32 to give the best-fit, least-distortion sine wave.

The two waveforms (row and column) are mixed in an op amp (on chip) to produce a true dual-tone signal. This is fed to a bipolar transistor (on chip) that supplies enough current to drive a 1000-ohm load to a typical 450 mV for the row tones and 640 mV for the column tones. (Telephone specifications require that the column tones be 2½ dB greater in amplitude than the row tones.)

Besides the TONE output, the MK5086 has outputs called XMIT (pin 2) and MUTE (pin 10). The XMIT output is an npn bipolar transistor that is turned on and pulls to the positive supply when no keys are operated. It is an open circuit when any key is depressed. The MUTE output is a standard CMOS circuit that is at the negative supply (when used) and switches to the positive supply when a key is depressed.

Construction. The entire circuit can be assembled on a small pc board. An etching and drilling guide and component placement are shown in Fig. 2. Observe the polarities of diodes and polarized capacitors. Sockets for the IC's are optional. Note that *IC1* is a CMOS device and must be handled with the usual precautions. The IC comes in a shorting carrier and should be kept in the carrier until time for installation. Handle it only by the edges of the plastic package. In soldering the CMOS IC, use a clip lead between the soldering iron tip and the positive foil pattern on the board. Note also that volume control *R2* is mounted on the control board. If remote control is needed, use an outboard potentiometer and run the connecting leads to the *R2* pads on the board.

After all components are installed, connect the leads for the keyboard and accessory cable. The latter should have four leads (PTT, microphone, ground, +12 V) and should be as long as necessary for the installation. The physical size of the keyboard will determine the finished size of the project and the case used to hold it. The 9-pin connector shown in the photograph was used to connect the project to an IC-230 transceiver.

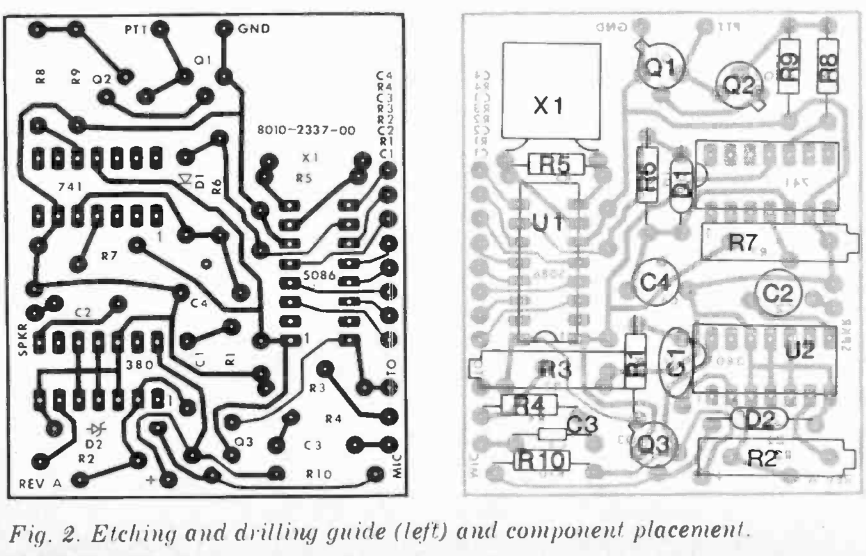


Fig. 2. Etching and drilling guide (left) and component placement.

Operation. After assembly, power up the system and determine the correct value for the combination of *R3* and *R4* to produce the required modulation level.

The dialer enables hands-off operation without annoying carrier drop between each dialed digit. The amount of hold-on time can be set by adjusting *R7*. The speaker volume is adjusted by *R2*.

The dialer should produce no r-f interference. A 5-watt rig has been keyed with its antenna resting on the dialer box with no discernable effect.

Because each section of the country has different rules regarding how to use repeaters, you must check your local repeater group for details before using the dialer.

PIONEER HAS DEVELOPED A RECEIVER EVEN THE COMPETITION WILL ADMIT IS THE BEST.

One look at the new Pioneer SX-1250, and even the most partisan engineers at Marantz, Kenwood, Sansui or any other receiver company will have to face the facts.

There isn't another stereo receiver in the world today that comes close to it. And there isn't likely to be one for some time to come.

In effect, these makers of high-performance receivers have already conceded the superiority of the SX-1250. Just by publishing the specifications of their own top models.

As the chart shows, when our best is compared with their best there's no comparison.

To begin with, the SX-1250 is at least 28% more powerful than any other receiver ever made. Its power output is rated at 160 watts per channel minimum RMS at 8 ohms from 20 to 20,000 Hz, with no more than 0.1% total harmonic distortion.

And, for critical listening, no amount of power is too much. You need all you can buy.

To maintain this huge power output, the SX-1250 has a power supply section unlike any other receiver's, with a large toroidal-core transformer and four giant 22,000-microfarad electrolytic capacitors.

But power isn't the only area in which the SX-1250 excels. The preamplifier circuit has an unheard-of phono overload level of half a volt (500 mV). This means that no magnetic cartridge in the world can drive the preamp to the point where it sounds strained or hard. And the equalization for the RIAA recording curve is accurate within ±0.2 dB. A figure unsurpassed by the costliest separate preamplifiers.

Turn the tuning knob of the SX-1250, and you'll know at once that the AM/FM tuner section is also special. The tuning mechanism feels astonishingly smooth, precise and solid.

FM reception is loud and clear even on weak FM stations because the tuner combines extremely high sensitivity with highly effective rejection of spurious signals.

Of course, the Pioneer SX-1250 carries a price tag commensurate with its position at the top. But if you seek perfection you won't mind paying the price.

If, on the other hand, you'd mind, look into the new Pioneer SX-1050 or SX-950. They're rated at 120 and 85 watts, respectively, per channel (under the same conditions as the SX-1250) and their design is very similar. In the case of the SX-1050, virtually identical.

That means you don't just come to Pioneer for the world's best.

You also come to us for the next best.

For informational purposes only, the SX-1250 is priced under $900. The actual resale price will be set by the individual Pioneer dealer at his option.

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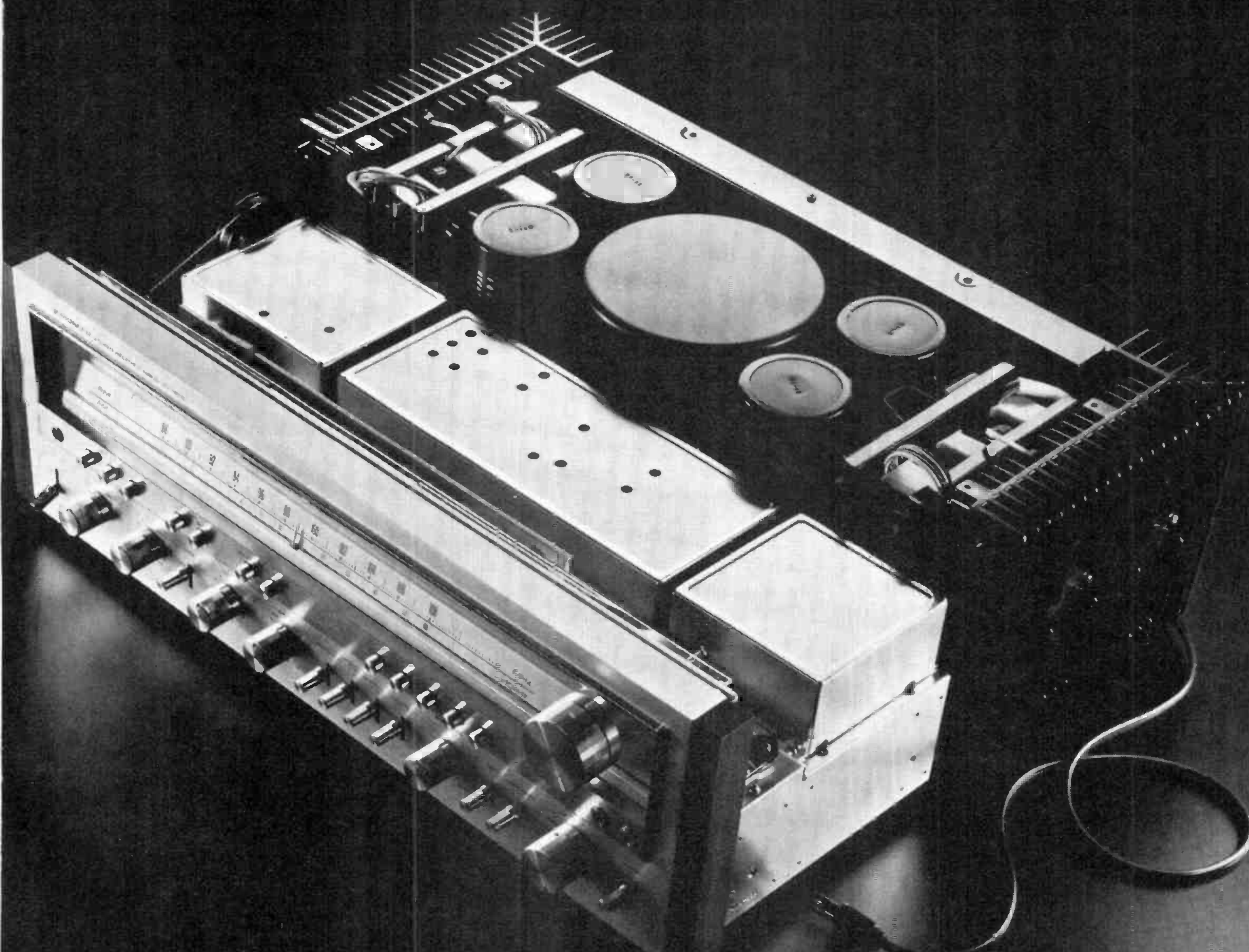
CIRCLE NO. 73 ON FREE INFORMATION CARD

	PIONEER SX-1250	MARANTZ 2325	KENWOOD KR-9400	SANSUI 9090
POWER, MIN. RMS, 20 TO 20,000 HZ	160W+160W	125W+125W	120W+120W	110W+110W
TOTAL HARMONIC DISTORTION	0.1%	0.15%	0.1%	0.2%
PHONO OVER-LOAD LEVEL	500 mV	100 mV	210 mV	200 mV
INPUT: PHONO/AUX/MIC	2/1/2	1/1/no	2/1/mixing	1/1/mixing
TAPE MON/DUPL	2/yes	2/yes	2/yes	2/yes
TONE	Twin Tone: Bass-Bass-Treble-Treble	Bass-Mid-Treble	Bass-Mid-Treble	Bass-Mid-Treble
TONE DEFEAT	Yes	Yes	Yes	Yes
SPEAKERS	A,B,C	A,B	A,B,C	A,B,C
FM SENSITIVITY (IHF '58)	1.5μV	1.8μV	1.7μV	1.7μV
SELECTIVITY	80 dB	80 dB	80 dB	85 dB
CAPTURE RATIO	1.0 dB	1.25 dB	1.3 dB	1.5 dB



PROTECTING YOUR POWER SUPPLY

Components in modern power supplies cost too much to leave them unprotected from shorts, overloads, etc.

BY ROBERT C. ARP, JR.

THE COST of modern sophisticated power supplies is high enough to warrant as much consideration for their protection as that given to their rectification and regulation circuits. While fuses and circuit breakers have been the traditional means of protecting power supplies, they are often not fast enough to prevent solid-state devices in newer supplies from destructing due to overloads and the like. The devices most able to protect semiconductors are other semiconductors.

Here are ways to protect a power supply from the three primary causes of failure: shorted output; shorted filter capacitors; and excessive current through the load. There are two general methods of protection. The first is the control of the transformer's primary circuit. The second is the removal of base drive from a transistor in series with a load.

In either case, we will assume that the protection circuit is part of a more complex power supply. High-current power supplies are used in some examples simply to indicate that the methods of protection are not limited to low-current applications. Obviously, devices with lower current and power ratings can be used where possible.

Primary Circuit. The block diagram in Fig. 1 shows a basic method of power supply protection. Characteristic of this arrangement is the triac in series with the primary of the transformer. During normal operation, the trigger control allows the trigger circuit to apply a brief gate signal to the triac for every alternation of the ac line voltage. After the triac is turned on by the gate signal, it remains on for the complete half cycle until the zero-crossing point is reached at the end of the alternation.

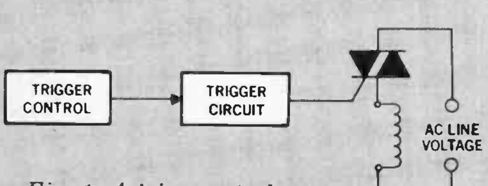


Fig. 1. A triac controls voltage across primary.

If the trigger control inhibits the trigger circuit while the triac is conducting, the triac cuts off when the line voltage approaches zero. It remains off until another gate signal is applied. Hence, the ac input to the transformer can be removed within a half cycle of the line voltage by designing the transformer's secondary circuit to inhibit the trigger circuit when a filter-capacitor short or supply output overload occurs.

The circuit shown in Fig. 2 is one type of control technique used in the primary circuit of a power supply. Under normal conditions, the gate of triac *Q1* receives a brief gate signal from the *IC2* zero-voltage switch at the beginning of each line alternation while the line voltage is near zero. Resistor *R1*, in series with the MT2 terminal of *Q1* and gate terminal of *Q2*, permits a continuous flow of alternating current through the gate of *Q2*. The primary of *T1*, in series with *Q2*, receives the full ac line voltage under these conditions.

Zero-voltage switch *IC2* can be used to provide pulses that are synchronized with the time of zero voltage in the ac cycle to the gate of a triac. Triac firing can be inhibited by the application of a positive (TTL-compatible) voltage to pin 1 of *IC2*.

The triple 3-input NAND gate used for *IC1* converts short-circuit logic-0 conditions to a logic-1 condition for inhibition of *IC2*. (A 5-volt dc supply was used for the IC's power and, consequently, for the inhibit signal.)

The inhibit signal appears at pin 1 of *IC2* when points A or B (at *Q3*) are shorted to point O (common). With *IC2* inhibited, *Q1* cannot provide ac to flow through the gate of *Q2*. When the line voltage falls to zero at the end of the alternation, during which the short occurs, *Q2* will cut off and remain off. After the short condition is removed, *Q1* turns on with the next gate signal from *IC2* and the system returns to normal operation.

If no filter capacitors were used (as in a simple battery-charging circuit), the self-resetting action would take place within one alternation of ac line voltage. Unfortunately, the inclusion of filter capacitors in the secondary circuit causes a resetting time lag on the order of one second for each 1000 μF used. If the resetting time is of no concern, no other consideration need be given this point. If you desire quick resetting time, you can do one of two things: First, include a dpst reset switch to momentarily break the connections between points A and B and *IC2*. Secondly, you can omit the connection between point A and *IC1* and include an isolation diode in the secondary circuit (Fig. 3); *IC2* will not, however, be inhibited by a shorted filter capacitor.

The circuit in Fig. 2 will not reset if a short occurs across the output terminals while a load is connected. In such a case, the load must be removed, or a reset switch must be used as explained above.

Although *Q2* will remove power from *T1's* primary immediately when the output terminals of the supply are shorted, a spark will occur. The amplitude of the spark can be considerably reduced by incorporating the transistor stage shown in Fig. 3.

Removing Base Drive. If a transistor is placed in series with the output terminals of a power supply, an ar-

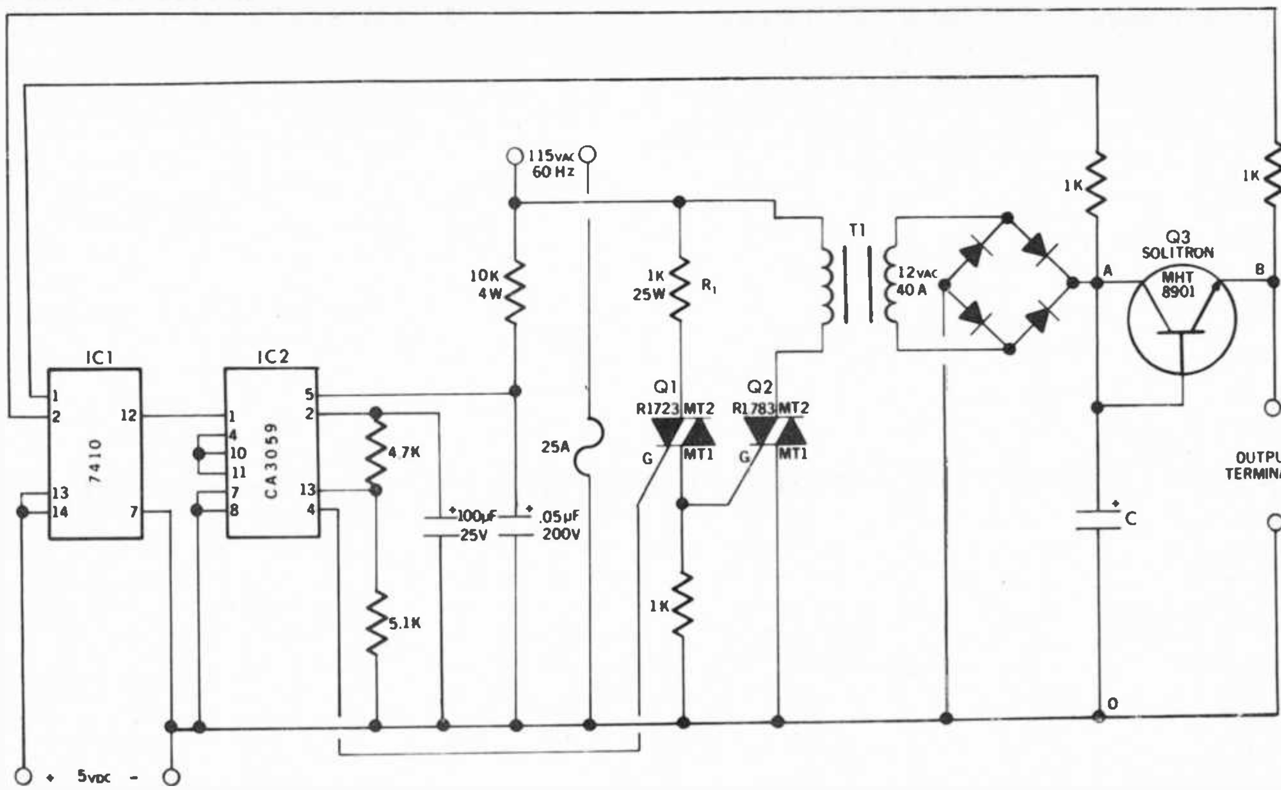


Fig. 2. One type of control technique used in the primary circuit.

rangement commonly used in series voltage regulators, the secondary circuit can be turned off by any action that removes base drive from this transistor. This can be done by shunting the base to ground with an SCR, optical coupler, or another transistor.

A method of removing base drive with an SCR when a desired maximum flow of current is exceeded is shown in Fig. 4. By varying R_g and R_s, the transistor can be cut off at any desired level of current flowing through the output of the supply.

Under normal operating conditions, the transistor is biased on by R_b. The current flowing through the output develops a voltage drop across R_s. Because a very low amplitude gate voltage is needed to trigger on the SCR, the resistance and power rating of R_s can be relatively small for high-current applications. The voltage drop across R_s is used to provide a gate signal for the SCR that is proportional to the level of the current flowing through the load. If the resistance of R_s is high enough, the level of load current at which the SCR shunts the transistor's base drive to ground can be varied by R_g. When the voltage drop across R_s is sufficient to trigger on the SCR, the transistor cuts off within microseconds. (A reset switch must be provided as shown to return the circuit to normal operation.)

Because of R_b, the transistor must operate in the active region. If the resistance of R_b is too low, the SCR will be required to handle a large current. Conversely, if the resistance of R_b is too high, the transistor will be forced to dissipate considerable power. Usually, a value for R_b must be chosen to keep the transistor's power dissipation and the current through the SCR at reasonable levels. The necessary current rating of the SCR can be determined (after R_b is chosen to provide the desired transistor power dissipation) by dividing the input voltage by the value of R_b.

Assume you're working with the following components and conditions: V_{in} = 34 volts dc, C = 18,300 μF (40 V), R_b = 30 ohms (50 W), R_g = 1780 ohms, R_s = 2.2 ohms (220 W), SCR = 2N682, and Q = HEP S7000. Here, the SCR will trigger on when the current reaches 10 A. You can also measure the following parameters: V_{CE} = 11.5 V dc, V_{BE} = 1.5 V dc, I_B = 350 mA, and I_{SCR} = 1.1 A. And the power dissipation of the transistor can be found by using the formula $P_D \approx V_{CE}I_C$, which would yield 115 watts.

Light-emitting diodes can be switched on and off in nanoseconds, and optical couplers with transistor detectors can switch at speeds of 2 to 5 μs. It is logical, therefore, to consider a protection system based on these high-speed devices. A typical optical coupler protection circuit is shown in Fig. 5.

It is not necessary for the series transistor in Fig. 5 to dissipate large amounts of power because this transistor (*Q1*) can be operated in or near the saturation region. Heavy base drive is applied to *Q1* through *Q2* according to the formula $I_{B(Q1)min} = I_{C(Q1)} / h_{FE(Q1)}$, where $I_{B(Q1)min}$ is the minimum base current that assures saturation of *Q1*, $I_{C(Q1)}$ is the maximum expected collector current, and $h_{FE(Q1)}$ is the minimum expected h_{FE}. Transistor *Q2* is used to supply base drive for *Q1* so that only *Q2*'s relatively small base current need be shunted to ground to turn off *Q1*.

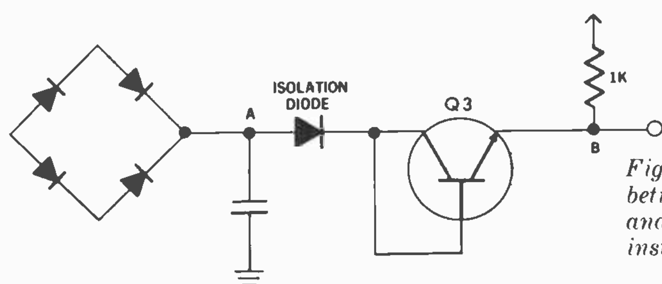


Fig. 3. Isolation diode between filter capacitor and transistor permits instantaneous reset.

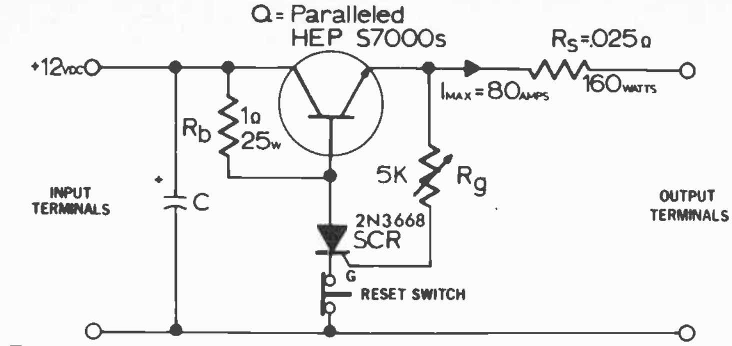


Fig. 4. A gate signal for the SCR is developed by the current through R_S.

There are many variations of the circuit shown in Fig. 5, but we will limit our discussion to this specific circuit configuration. It should be noted that R_S can have a value much lower than 1 ohm, which results in a lower wattage rating for this resistor. The optical coupler should consist of an infrared LED and a silicon transistor detector.

After assembling the circuit as shown, disconnect the anode lead of the LED from point A. Power up the supply, and monitor $I_{C(Q1)}$ and $V_{CE(Q1)}$ while decreasing R_B until *Q1* goes into saturation. Then adjust R_B until *Q1* is operating in the active region, just short of saturation. (This speeds up the cutoff action of *Q1* and keeps the photodetector current low.) When adjusting R_B, monitor $I_{B(Q2)}$ to make sure you don't exceed the current rating of the photodetector.

Connect the LED's anode back to point A and short the output of the supply. Adjust the R_{LED} control for an $I_{C(Q1)}$ short-circuit current of 15 mA. (Actually, the short-circuit current can be set to about 1 mA, but the adjustment of R_{LED} becomes critical for currents below 15 mA.)

With the adjustments performed as described and a 5-ohm value for R_L, $I_{C(Q1)}$ would be 640 mA. Reducing R_L to 3.33 ohms would drop $I_{C(Q1)}$ to 27 mA and $V_{CE(Q1)}$ to 4.4 V. This yields a 0.195-W $P_{D(Q1)}$. This current-limiting circuit produces an I_C versus R_L curve with a very steep slope, which results in very little overshoot of the desired maximum current.

With R_B and R_{LED} properly adjusted, *Q1* will operate in or near the saturation region with a heavy base drive supplied by *Q2*. If the current through R_S exceeds the maximum for which the circuit is adjusted, determined by the resistance of R_S, R_B, and R_{LED}, the LED will emit enough light to reduce the resistance of the photodetector. The result is that *Q2*'s base drive will be shunted to ground and the transistor will be cut off.

Because this circuit is very temperature sensitive, a reset switch must be provided as shown. When power is first applied to the system, no current flows through *Q2* until the reset switch is operated to momentarily disconnect R_P from ground. After a few minutes warm-up, the system is self-resetting.

A Current Limiter. The self-resetting circuit shown in Fig. 6 lacks some of the advantages of the previous circuits. Transistor *Q1* is again in series with the load, while *Q2* supplies sufficient base current to keep it operating in the saturation region for a significant range of loads.

In the following discussion, we will assume that a wide range of loads will be applied to the output of an unregulated power supply rated at 40 amperes. (If the load is to be fixed, circuit components can easily be chosen so that *Q3* provides a sharp turn-off of *Q1* if $I_{C(Q1)}$ increases beyond a chosen maximum. However, if the load is variable, R_C must be selected so that *Q1* passes the desired range of currents, with R_B and R_E chosen to provide rapid turn-off for the loads that will cause excessive current to pass through *Q1*.)

The graphs shown in Fig. 7 are plots of $I_{C(Q1)}$ versus R_L for the circuit shown in Fig. 6. From plot A, it can be seen that as R_L is decreased (increased load), the current through *Q1* increases to a maximum of 14.5 A when R_L is 0.3 ohm. Decreasing R_L further yields a reduction in $I_{C(Q1)}$ instead of an increase. This $I_{C(Q1)}$ decrease with increasing load continues until R_L is 0.25 ohm, at which point the circuit becomes unstable. When a load of 0.25 ohm is connected to the supply's output, $I_{C(Q1)}$ momentarily goes to 12 A, after which *Q1* turns off and $I_{C(Q1)}$ reduces to zero. For load resistances less than 0.25 ohms, *Q1* is in the cutoff region and $I_{C(Q1)}$ is zero.

Plot B, an expanded view of $I_{C(Q1)}$ for small values of R_L, shows how the *Q1* collector current varies when load resistance approaches zero. When R_L is 0.3 ohm, $I_{C(Q1)}$ is at the maximum 14.5-A value. For loads between 0.3 and 0.25 ohm, $I_{C(Q1)}$ decreases almost linearly. Load resistances of less than 0.25 ohm are a virtual short circuit at the output terminals of the supply and cause *Q3* to keep *Q2* at cutoff.

The operation of the circuit is quite

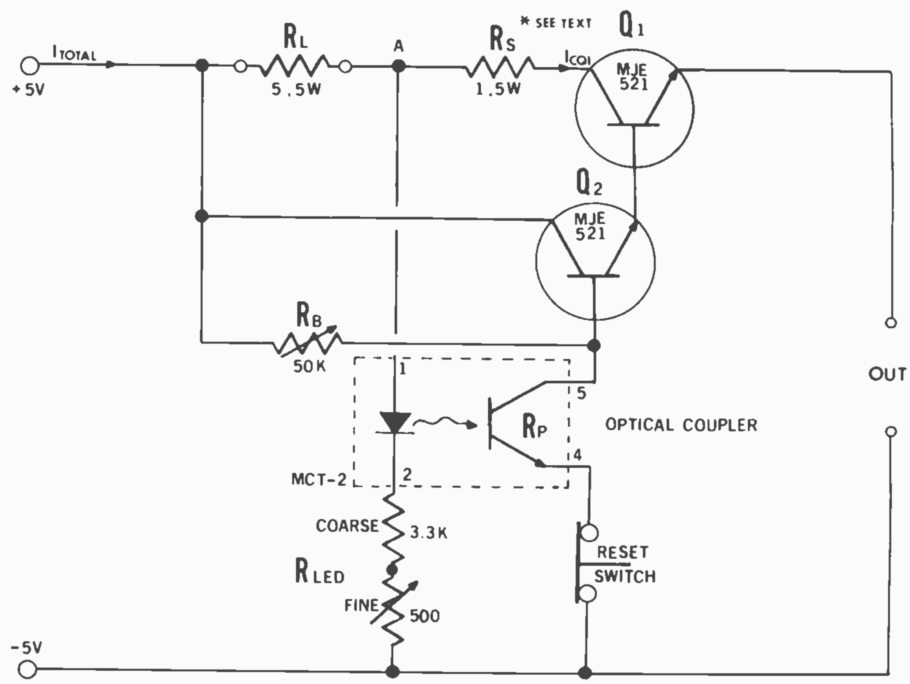


Fig. 5. Opto-coupler controls Q2 on basis of current in Q1.

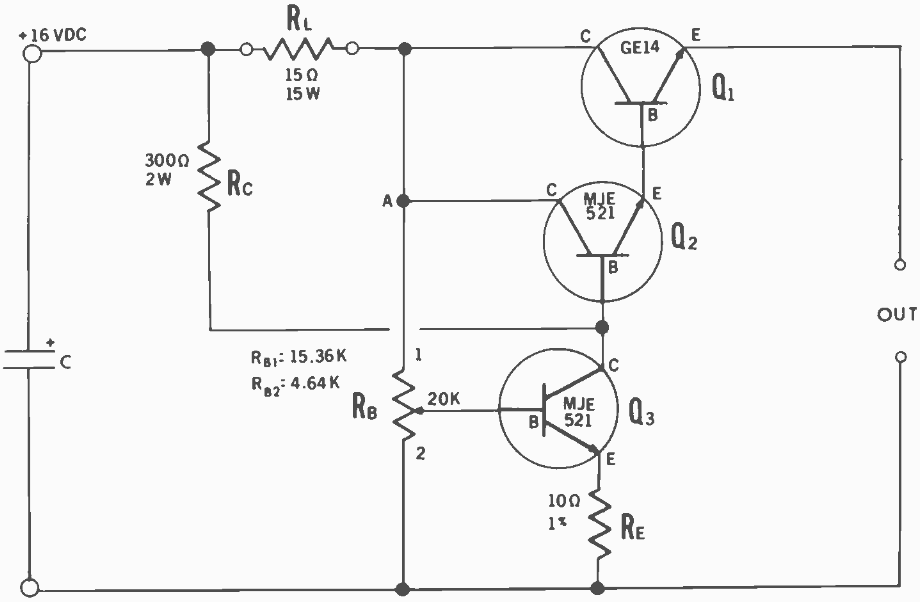


Fig. 6. A self-resetting current limiter with short-circuit protection.

TABLE I—CIRCUIT PARAMETERS FOR DIFFERENT LOAD RESISTORS

	(A) R_L = 15 ohms			(B) R_L = 0		
Parameter	**Q1**	**Q2**	**Q3**	**Q1**	**Q2**	**Q3**
V_{CE}	0.61 V	0 V	1.49 V	16 V	15.8 V	0.25 V
V_{CB}	−0.143 V	−0.74 V	1.3 V	15.8 V	15 V	−0.35 V
V_{BE}	0.75 V	0.74 V	0.17 V	0.42 V	0.385 V	0.65 V
I_C	1.09 A	38 mA	0	23 mA	14 µA	48 mA
I_B	9 mA	46 mA	0	15 µA	9 µA	0.7 mA
I_{RB1}	32 µA	—	—	1 mA	—	—
I_{RB2}	32 µA	—	—	0.3 mA	—	—
V_{in}	16 V	—	—	16 V	—	—
V_L	15.9 V	—	—	0 V	—	—
P_D	0.7 W	0 W	0 W	0.37 W	2×10^{-4} W	0.012 W

straightforward. However, the adjustment of R_B and value of R_E that allow self-resetting are critical. Before R_B and R_E can be adjusted to the proper values, R_C must be chosen to allow the desired maximum $I_{C(Q1)}$. To select R_C, disconnect point 1 of R_B from junction A. The minimum value of $I_{B(Q1)}$ to keep *Q1* in saturation can be estimated from the formula $I_{Bmin} \approx I_C/h_{FE}$. For a maximum of 15 A for $I_{C(Q1)}$ using a GE14 transistor (h_{FE} = 45) for *Q1*, I_{Bmin} would be 0.333 A. The minimum value of $I_{B(Q2)}$ is found by using the $I_{B(Q1)min}$ value for $I_{C(Q2)}$. Hence, using an MJE521 transistor whose h_{FE} is 40 for *Q2*, we obtain $I_{B(Q2)min}$ = 0.33/40 = 8 mA. Then, determining the value for R_C we have $R_C = V_{in}/I_{B(Q2)}$ = 15/0.008 = 1875 ohms.

You can select a potentiometer for R_B by using the formulas given in "A Simple Method For Biasing Transistors" (June 1975). Let the base voltage of *Q3* be approximately 0.7 V, $I_{C(Q3)} = I_{B(Q2)}$ = 8 mA, and $I_{bias} \approx 0.1 \times I_{C(Q3)}$ = 0.8 mA. Assume that R_B consists of two resistors, *R1* for the portion of the pot above the wiper and *R2* for the lower portion. Now, $R2 = V_{base}/I_{bias}$ = 0.7/0.0008 = 875 ohms. Then for *R1*, consider the output of the power supply to be shorted and determine *R1* from the formula $R1 = (V_{in} - V_{base})/I_{bias}$ = (15 − 0.7)/0.0008 = 17,875 ohms. Adding the results obtained, we end up with a total resistance of 18,750 ohms. A

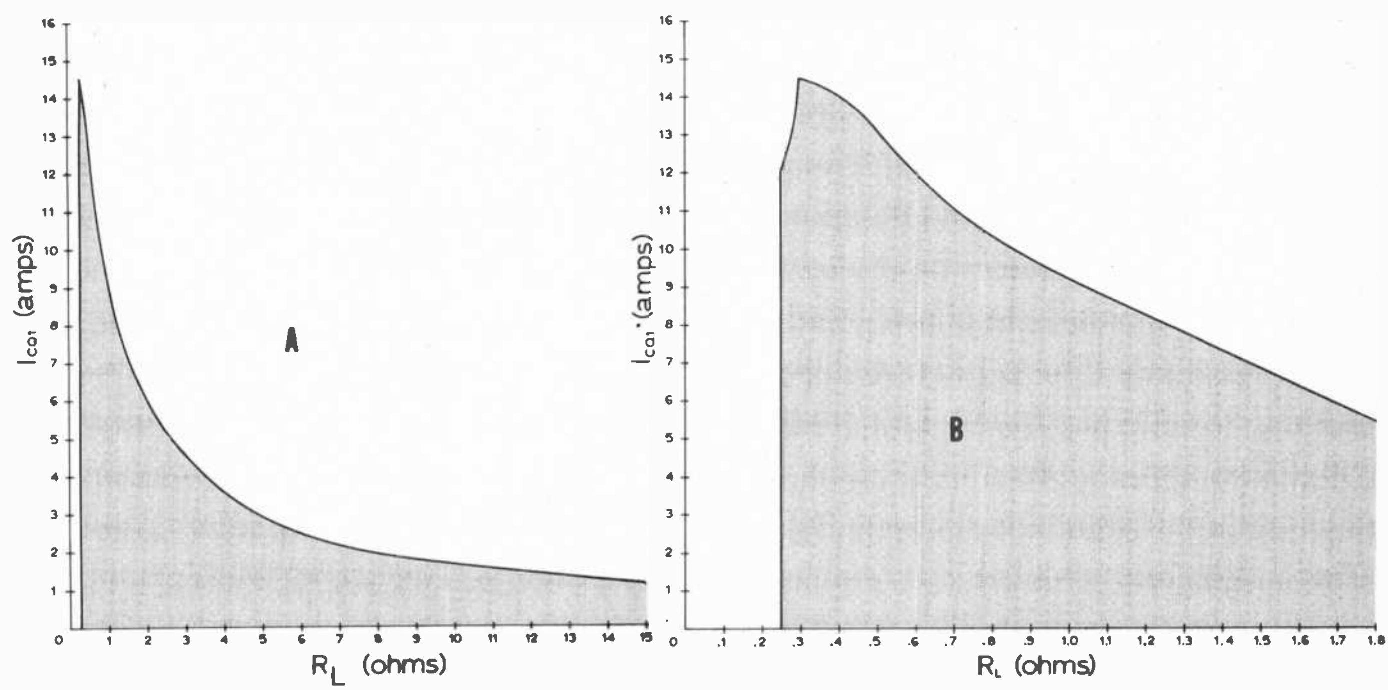


Fig. 7. In (A) load varies from 15 to 0 ohms; (B) load approaches zero.

standard 20,000-ohm potentiometer can, therefore, be used for R_B.

The adjustment of R_B is accomplished by connecting point 1 of the pot to junction A and installing a resistance decade box set to zero ohms as R_E. With a 15-ohm load connected to the output of the supply, $I_{C(Q1)}$ should measure 1 A. (The collector current for *Q1* should be monitored during all adjustments. Also, the power supply should be shut off when installing and removing ammeters.) Start with a 0-to1-A ammeter and adjust R_B until $I_{B(Q3)}$ is nearly zero. Continue in this manner, using a more sensitive ammeter, until $I_{B(Q3)}$ is exactly zero.

Remove the ammeter from the supply and connect the base of *Q3* as shown in Fig. 6. The decade box in the emitter leg of *Q3* should still be set to zero. Short the supply's output terminals; $I_{C(Q1)}$ should drop to zero. If the current through the collector of *Q1* doesn't drop to zero, $I_{B(Q3)}$ or R_E has not been set to zero. Remove the short from across the supply's output, leaving only the 15-ohm load. The collector current of *Q1* should remain at zero; if it doesn't and the circuit self-resets, no R_E is needed. (This is not likely to occur.) With no self-reset, increase R_E in 1-ohm steps until $I_{C(Q1)}$ goes back to 1 A. Short the output of the supply again; $I_{C(Q1)}$ should go to zero and the circuit should restart when the short is removed.

The higher the resistance of R_E, the greater will be the off current of *Q1*. With repeated trimming of R_B and R_E, the collector current of *Q1* when the supply's output is shorted can be brought down to 5.4 mA. The circuit can be made much less dependent on the setting of R_B, and R_E can be zero, if a reset switch is used to return the circuit to normal operation after an overload. In this case, R_B would be adjusted as before, and a reset switch would be operated to momentarily break the R_B connection to junction A. The pot could then be trimmed to yield a minimum collector current in *Q1*.

The capacitor shown across the input of the circuit in Fig. 6 is not part of the protection system. It is simply representative of the filter capacitor in the power supply. Under normal conditions, *Q2* supplies the base current to *Q1*. Both *Q1* and *Q2* operate in the saturation region to assure that full power is delivered to the load. The A section of Table I shows the measured and calculated parameters for *Q1, Q2, and Q3* for the 15-ohm load, R_L.

If R_L is reduced to zero (shorted output terminals), *Q3* will conduct and *Q1* and *Q2* will be driven into cutoff. The B section of Table I shows the parameters for the transistors when $R_L = 0$.

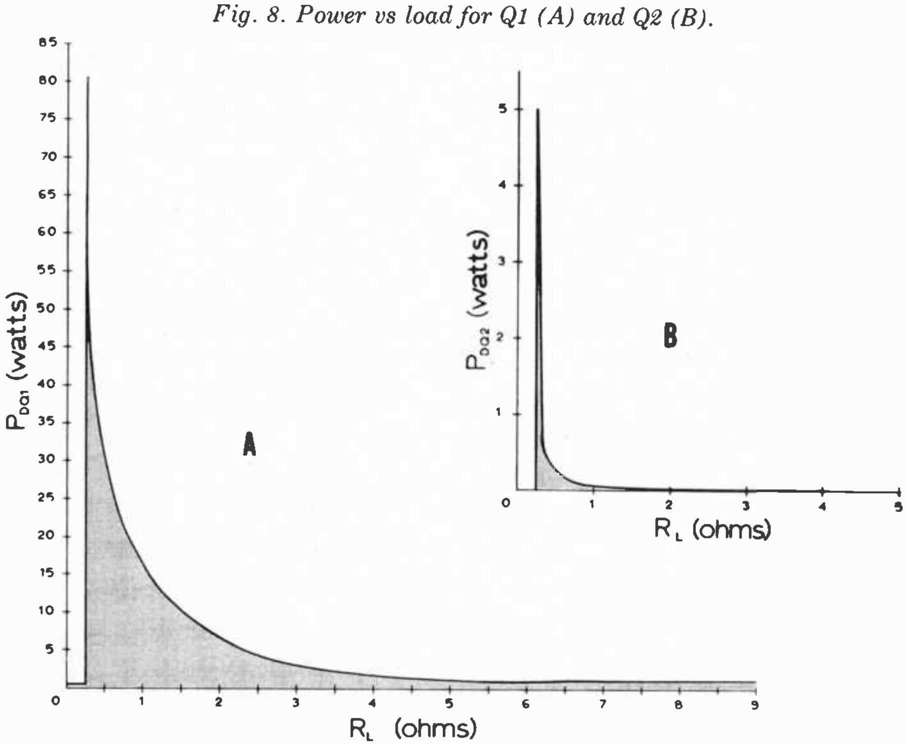
For intermediate values of R_L, the transistors pass through all three regions of operations. These regions and the loads that cause the transitions are listed in Table II. When R_L is reduced to 1.66 ohms, enough forward bias is applied to the base of *Q3* to bring it out of cutoff. As R_L is further reduced, $I_{B(Q3)}$ increases until, finally, when R_L is 0.296 ohm, *Q3* is shunting a large enough portion of *Q2*'s base drive to ground to cause both *Q2* and *Q1* to come out of saturation and begin operating in the active region. Eventually, when R_L is reduced to less than 0.25 ohm, *Q3* is driven into saturation and *Q2* and *Q1* go into cutoff.

TABLE II—OPERATING REGIONS FOR DIFFERENT LOAD RESISTORS

R_L (Ohms)	Region Of Operation		
	Q1	Q2	Q3
15	saturation	saturation	cutoff
1.66	saturation	saturation	active
0.296	active	active	active
0.25	unstable	unstable	unstable
0	cutoff	cutoff	saturation

Because *Q1* and *Q2* must operate in the active region, even for so narrow a range of loads as from 0.296 to 0.25 ohm, the voltage drop across these transistors over this range causes the power dissipation of the devices to increase tremendously while they are operating in the active region. Plots of P_D versus R_L for *Q1* and *Q2* are shown in Fig. 8. Plot A shows that, for maximum protection, *Q1*'s P_D rating should be greater than 80 watts at the desired operating temperature. Plot B shows that *Q2*'s P_D rating should be greater than 5 watts.

Fig. 8. Power vs load for Q1 (A) and Q2 (B).



Although the P_D ratings of *Q1* and *Q2* must be much greater than is necessary while the transistors are operating strictly at saturation, they need not handle the power dissipation that would be necessary in an unprotected series voltage regulator. For example, with a 14.5-A $I_{C(Q1)}$ and a 16-volt V_{in}, the P_D rating of a transistor used as an unprotected series regulator would have to be 232 watts at the operating temperature under shorted conditions. This would require a very expensive transistor.

Conclusion. We have proposed only a few of the many possible ways of protecting the more expensive and fragile components found in modern power supplies. Proper utilization of the proposed circuits, individually or in combination, will produce protection systems that are relatively inexpensive and reliable. ◈

Photo courtesy British Tourist Authority, 680 Fifth Ave., NY, NY 10019.

Digital Electronic "Westminster" Clock

BY ALAN ROEHL

The famous "Big Ben" tune is played every hour with portions every 15 minutes.

THERE ARE digital electronic clocks with all sorts of variations—alarms, radios, calendars, etc. Now, here is one for the music lover. It plays the famous Westminster chime tune. On the quarter-hour, the first ¼ of the tune is played; on the half hour, ½ of the tune; on three-quarters, ¾ of the tune; and the full tune on the hour. On the hour, the tune is followed by a monotone chiming of the hour. By using "surplus" parts, you can build this clock for a very low cost, though it does have 19 IC's.

How It Works. The complete circuit of the clock is shown in three parts in Figs. 1 to 3. The clock element is *IC19* an MM5316 IC that drives conventional fluorescent readouts *DIS1* through *DIS4*. This clock IC was selected because it has continuous outputs that minimize the chime circuit interface requirements. If you select a clock IC that has multiplexed outputs, additional circuits will be required. The fluorescent readouts are used because they can be driven directly by the MM5316 and they require very little operating power.

In Fig. 1, *IC1* and *IC2* decode the conditions of the 15, 30, 45, and 00 minutes. The outputs are OR'd by part of *IC4,* whose output then initiates a one-shot circuit formed by *C1, R12,* and part of *IC3* (Fig. 2). The pulse from this one-shot sets a flip-flop formed by two elements of *IC5,* which in turn, activates the tone output through part of *IC9*. The one-shot pulse also resets the remainder of the chime circuits.

The Westminster chime sequence uses four different tones. Instead of having four different frequency oscillators which may be difficult to keep correctly tuned, a single tone oscillator formed by *IC15* (Fig. 3) is used, with its output divided down to form the four required tones. In this way, even if the basic tone oscillator frequency were to vary, the relationship between the four Westminster tones will be maintained and a harmonious melody is ensured. The frequency division is performed by *IC11* and *IC12*, with portions of *IC13, IC14, IC15*, and *IC4*. The output of counter *IC3,* pin 12 (Fig. 2), consists of narrow pulses. These are used to toggle *IC9*, which divides the frequency by two and produces a square-wave output. The latter is filtered by *R20* and *C7* and is used to drive *Q1*, which is the audio output stage.

The tone sequence is programmed by a 10-stage Johnson counter formed by *IC8* (Fig. 3). This counter is driven by the 1-Hz output from *IC19* so that each tone has a 1-second duration. Since the first half of the melody is identical to the second half, a single 10-stage counter is adequate to program the eight tones and two pauses

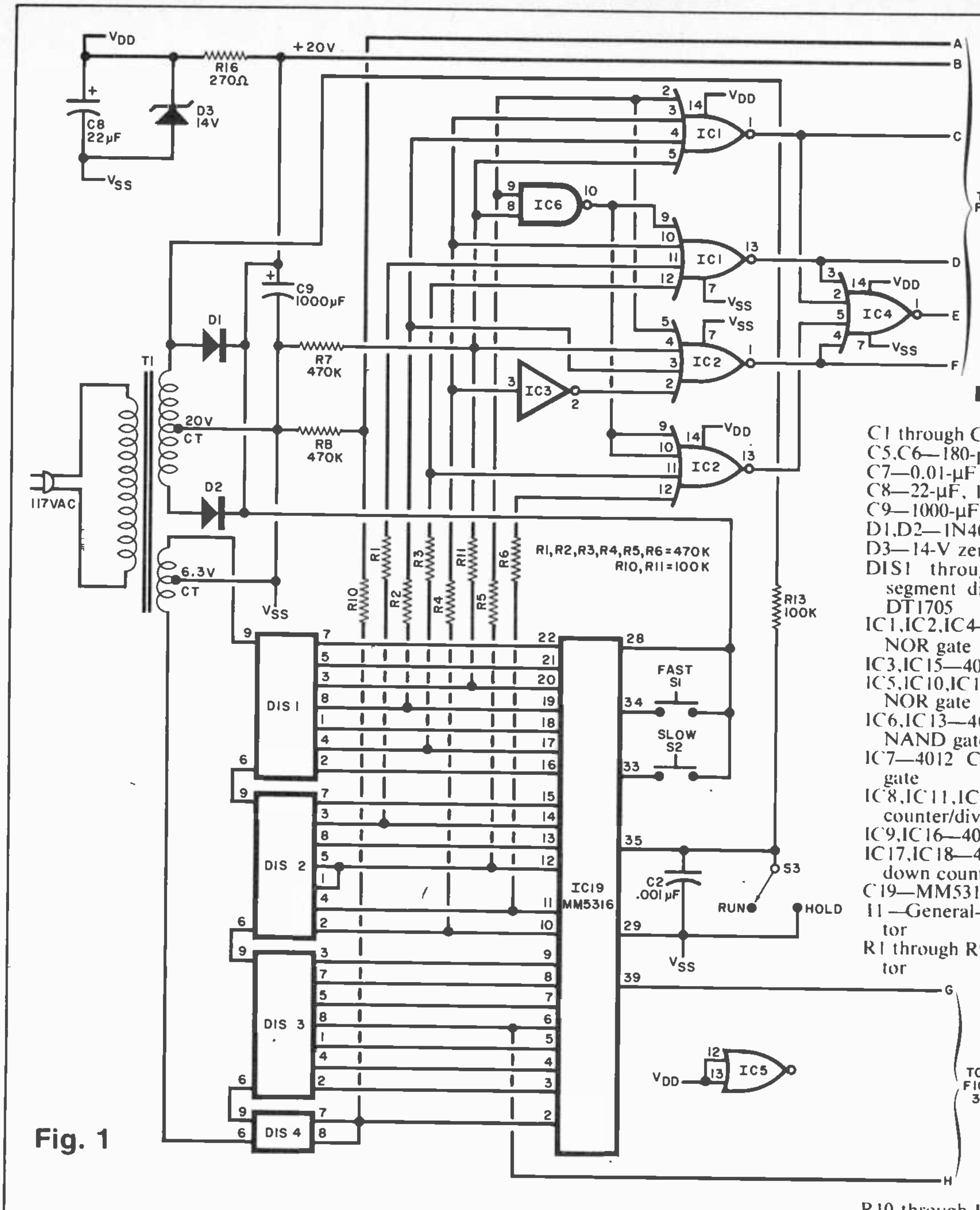


Fig. 1

Fig. 1 (left), Fig. 2 and Fig. 3 (opposite) make up the complete clock schematic.

PARTS LIST

C1 through C4—0.001-μF capacitor
C5,C6—180-pF capacitor
C7—0.01-μF capacitor
C8—22-μF, 15-V electrolytic capacitor
C9—1000-μF, 25-V electrolytic capacitor
D1,D2—1N4004
D3—14-V zener diode
DIS1 through DIS4—Fluorescent 7-segment display (Tung-Sol DT1704 — DT1705
IC1,IC2,IC4—4002 CMOS dual 4-input NOR gate
IC3,IC15—4049 CMOS hex inverter
IC5,IC10,IC14—4001 CMOS quad 2-input NOR gate
IC6,IC13—4011 CMOS quad 2-input NAND gate
IC7—4012 CMOS dual 4-input NAND gate
IC8,IC11,IC12—4017 CMOS decade counter/divider
IC9,IC16—4013 CMOS dual D flip-flop
IC17,IC18—4029 CMOS presettable up/down counter
C19—MM5316 clock IC
11—General-purpose silicon npn transistor
R1 through R9—470,000-ohm, ½-W resistor
R10 through R15—100,000-ohm, ½-W resistor
R16—270-ohm, ½-W resistor
R17—100-ohm, ½-W resistor
R18—10-megohm, ½-W resistor
R19,R20—2000-ohm, ½-W resistor
S1,S2—Single-pole normally open push-button switch
S3,S4—Spst switch
SPKR—8-ohm (or more) speaker
T1—20-V CT at 100-mA; 6.3-V at 50-mA transformer
Misc. Perforated board, flea clips, IC sockets, suitable enclosure, mounting hardware, etc.

in half of the melody. Portions of *IC6* and *IC7* are used to reset the flip-flop formed by part of *IC5* after the proper operation of the sequence has been completed, thereby disabling the output tone.

On the hour, a series of tones to count the hour is provided by *IC18*. It is reset to 1 at one o'clock and advanced one count each hour. When an hour count is called for, the content of *IC18* is transferred to *IC17* which then counts down until it reaches zero. In this way, one output tone is produced for each count. The tone may be altered by chaging the values of *R14-C5* in the *IC15* oscillator circuit.

Construction. The prototype was constructed on perforated board having 0.1" hole centers, with sockets used for all IC's and "flea clips" for other components. A wiring pencil (or other means) can be used to make the various interconnections. Handle all CMOS-PMOS IC's with care to avoid static damage, although they do have internal protection. Note that, for all CMOS devices, any unused inputs must be connected to either supply voltage—not left "floating."

Operation. With the clock completely assembled, recheck all wiring for possible errors. Then supply power to the clock and check the operation of the function switches—RUN, HOLD, FAST, SLOW. The display should be cycled through a complete "day" to ensure that the proper counting takes place. Then the clock should be cycled to 1:00 PM. At this point, the chime circuit should work. ◈

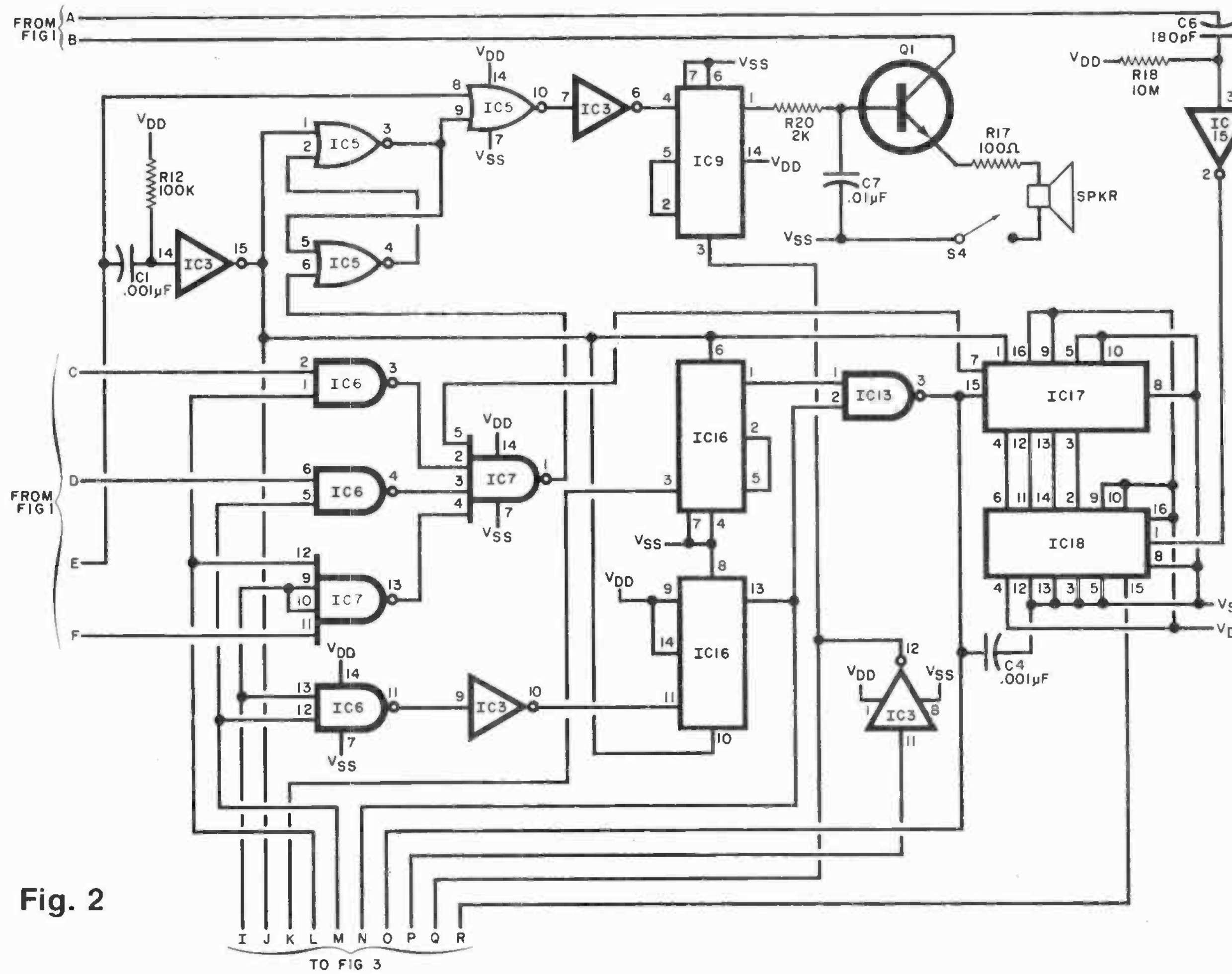


Fig. 2

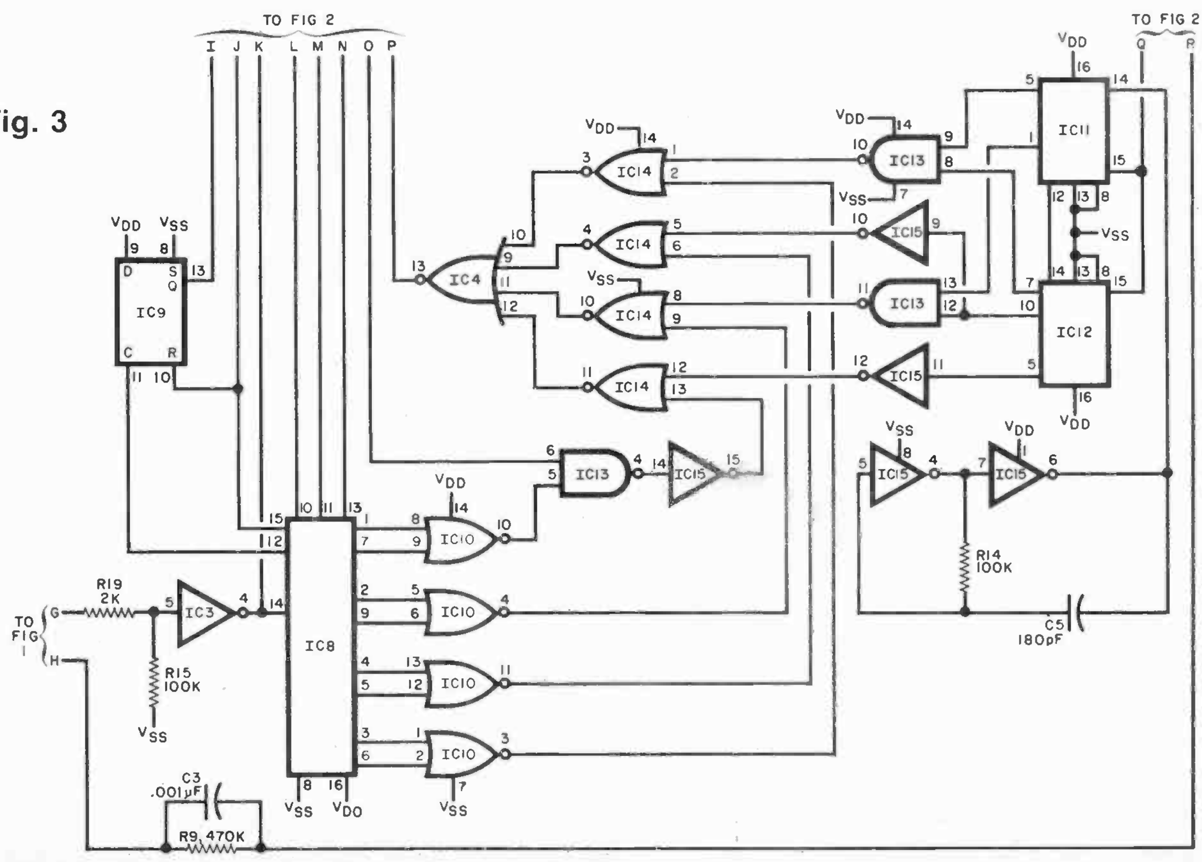


Fig. 3

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Most people think there are only two levels of careers in electronics: the technician level and that of the degree engineer.

There is, however, a third and very important level. It is that of the engineering technician or *practical* engineer. The growing importance of this career level has created what might well be called the "New Professional" in electronics.

If you look at the various levels of employment in electronics, you will understand why this "New Professional" is so important.

The average technician is a person who has had vocational training in electronics. He understands the basic principles of electronics so he can troubleshoot, repair and maintain equipment. He usually works under close supervision in performing his duties.

The engineer has college training in electronics. He usually supervises technician personnel and is responsible for planning and developing of electronic equipment and systems. Frequently, however, engineers are more heavily trained in the scientific principles of electronics and less in their practical application.

The engineering technician, by contrast, is a specialist in the practical application of electronics. His training usually consists of a two-year college program in electronic engineering technology. In many organizations, the engineering technician handles several of the responsibilities of the degree engineer. He often has the title of engineer.

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This Lab Program helps you understand advanced electronics. It also gives you practical experience in many other important areas of electronics, as in pro-

Career Training at Home

totype construction, breadboarding, test and measurement procedures, circuit operation and behavior, characteristics of electronic components and how to apply integrated circuits.

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BY DAVID L. HEISERMAN

BUILD ODDS-ON

A GAME OF CHANCE AND STRATEGY

Simple, low-cost parlor game can be challenging and interesting.

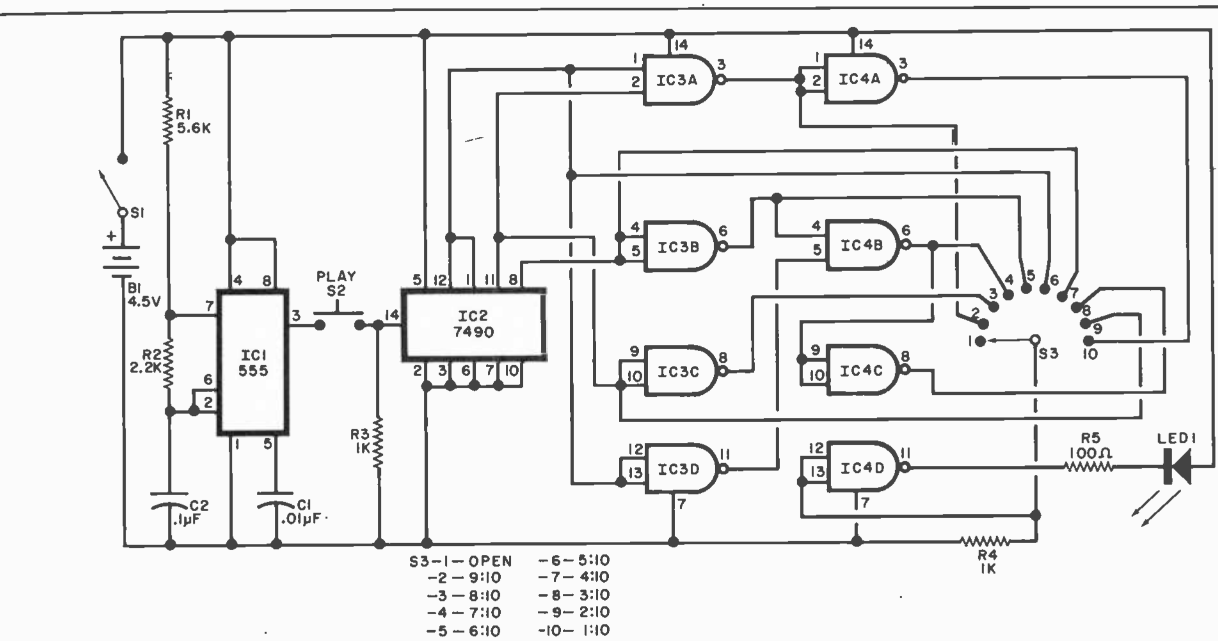
IF YOU enjoy playing electronic games, grab your soldering iron and build "Odds-On," a low-cost game that combines the best elements of chance and strategy. Even though the readout is a single LED, don't get the idea that the game is easy to beat.

Odds-On uses a relatively high-speed oscillator to drive a counter and decoding system when its PLAY button is pressed. When the button is released, the count stops. If, when it stops, the LED turns on, you win. This is the chance feature. The element of strategy enters the game when you're allowed to select your own odds of winning. In this mode, you set a rotary switch to one of nine positions, each of which gives different odds ranging from 1:10 to a conservative 9:10.

Two or more players can compete with each other. The player who selects the longest odds, and wins, wins the game. The actual scoring technique is up to the players, but keep in mind that a more conservative player can consistently score and win, if his opponent is not just lucky.

Odds-On can be used to play a variety of games, including coin toss (odds 5:10), Russian Roulette, or any other games that call for playing against odds of 1:10 to 9:10.

How It Works. Free-running oscillator *IC1* operates at a frequency of about 1000 Hz as a result of the values specified for *R1*, *R2*, and *C2*. When PLAY pushbutton *S2* is depressed, the output pulses from the oscillator drive decade counter *IC2*, which cycles from 0 through 9 (10 different output



In the circuit, IC1 operates at 1000 Hz, S2 starts the play, and S3 determines the odds.

PARTS LIST

B1—Three 1.5-volt AA cells in series
C1—0.01-μF disc capacitor
C2—0.1-μF disc capacitor
IC1—555 timer
IC2—7490 decade counter
IC3, IC4—7400 quad two-input NAND gate
LED1—Any discrete light-emitting diode
R1—5600-ohm, ¼-watt resistor
R2—2200-ohm, ¼-watt resistor
R3, R4—1000-ohm, ¼-watt resistor
R5—100-ohm, ½-watt resistor
S1—Spst Switch
S2—Normally-open spst switch
S3—Single-pole, 10-position rotary switch
Misc.—Suitable box; battery holder; perforated or pc board; hookup wire; machine hardware; solder; etc.

states). When the PLAY button is released, the counter holds its last output state.

Since *IC2* produces 10 different output states, the chances are 1 in 10 that the count will stop at any particular state. However, it is possible to use the decoding logic of *IC3* and *IC4* and switch *S3* to weight the odds. For example, if *S3* is set to the 5:10 position, there is a 50/50 chance that *LED1* will be on.

Construction. Because of the simplicity of the circuit, any type of construction will suffice, but a printed circuit board of your own design or perforated board will be most convenient. Sockets for the IC's are optional. Switches *S1, S2,* and *S3* should be mounted on the top of the box in which you house the circuit. Also mounted on the top of the box and held in place with a small rubber grommet or a bead of cement should be *LED1*. The three 1.5-volt AA cells that make up *B1* should be mounted in a suitable holder inside the box.

Game Hints. Consider a game in which two or more players are participating with one player being very conservative. Suppose the conservative player selects odds of 6:10. When he presses and releases the PLAY button, he has six chances out of 10 to score a hit (LED comes on). If this happens, he scores 6 points. If the LED remains off, his score is 10.

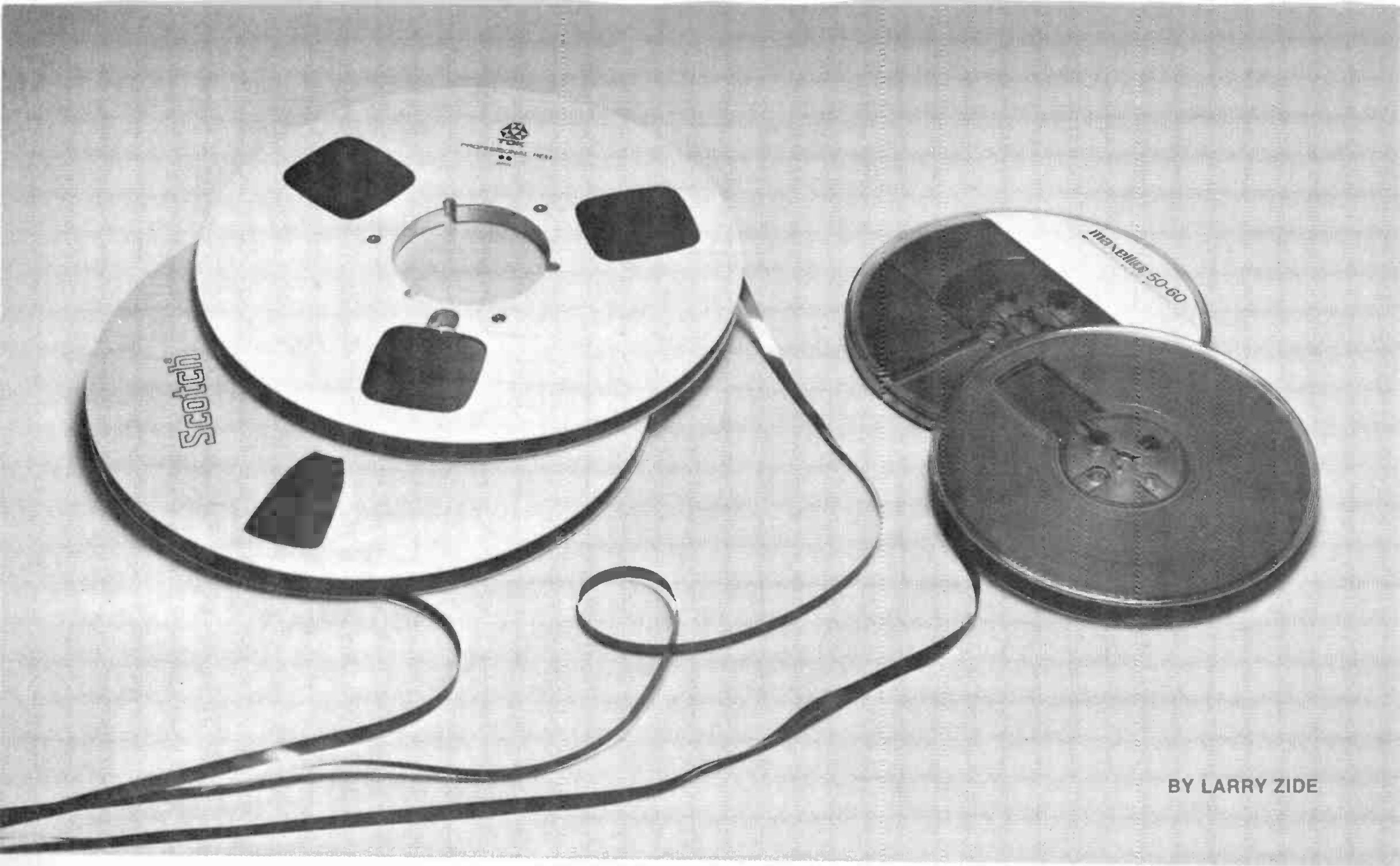
The next player selects his own odds, say, 2:10. If after pressing and releasing the PLAY button the LED comes on, he gets a score of 2; if the LED stays off, he gets a score of 10.

From the foregoing, a player gets 10 points every time he loses and the first digit of the odds figure if he wins. The play continues until one player's score reaches 100, at which time he loses. If there are more than two players, odds selection and play continue until all scores but one are 100. The one player whose score doesn't reach 100 is the winner.

To play "coin-flip," set the selector switch to the 5:10 position and operate the PLAY button. At each depression and release, there is a 50/50 chance that the LED will turn on and you win.

To play Russian Roulette, assume a six-shot revolver has a cartridge in only one chamber. The PLAY button becomes the "trigger." Set the odds selector switch to the 2:10 position. If at any time the LED comes on, you definitely lose. ◈

"What do you mean, does a horse come with it?"



BY LARRY ZIDE

Professional vs. Consumer Tape

Would there be an advantage for the home recordist in using studio-type tape?

MAGNETIC tape manufacturers optimize the characteristics of their open-reel tapes according to the requirements of the markets they serve. Professional mastering tapes, for example, provide their best performance at a speed of 30 or 15 ips, both of which are commonly used by the pro's. Consumer tapes, on the other hand, are best for the commonly used 7½ and 3¾ ips speeds of consumer decks.

One might ask if a professional tape, used on a consumer deck, will yield superior performance when compared with a consumer tape. At least one major manufacturer says no. However, might it not be possible to adjust a consumer machine to favor the professional tape? To answer this question, we embarked on a project to examine both professional mastering and consumer tapes, after idealizing a consumer tape deck for each type of tape to be used.

Bias and Equalization. We know that tape deck bias should be adjusted to suit the tape being used. What is less well known is that the precise amount of bias used in any given tape deck is a compromise of frequency re-

Frequency response curves are decibels versus frequency in hertz.

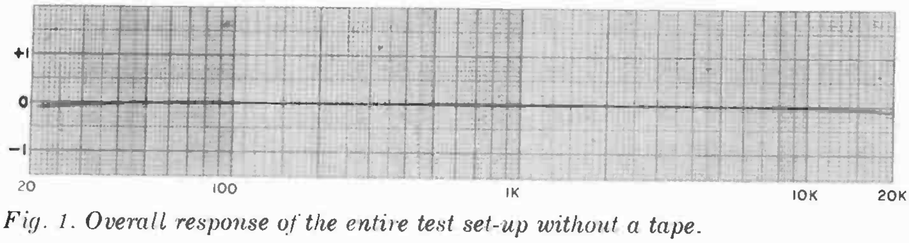


Fig. 1. Overall response of the entire test set-up without a tape.

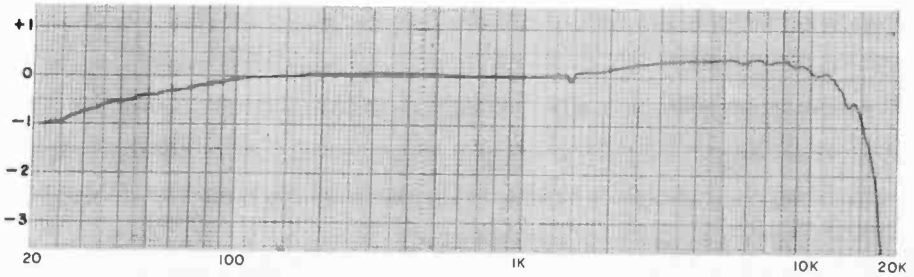


Fig. 2. Maxell UD-50 at 3¾ ips, bias 2 dB beyond peak at 10,000 Hz.

sponse versus distortion and/or noise. There is no one bias setting that will simultaneously provide both the widest absolute response and the lowest absolute distortion/noise. Bias is generally set in professional decks for lowest distortion and noise and let the frequency response fall as it may, while the bias in consumer machines is set to provide the widest frequency response.

Once the bias adjustment is made, the high-frequency equalization can be used to compensate for the record electronics so that a playback response as nearly flat as possible is obtained. All professional and many consumer tape decks, therefore, can be adjusted for high-frequency equalization. Many professional decks provide this equalization on the play side of the preamplifier, but all offer it on the record side. Playback equalization is always preset to a standard test tape. The record equalization attempts to adjust the response to match the standardized playback.

The normal manner in which bias is adjusted is to set the deck so that the tape is moving at the speed for which adjustment is to be made, with the mode set to record. An audio signal generator is then used to record a sine-wave signal and the bias is adjusted while the output of the tape is monitored. As the bias is advanced, the output of the tape increases until it reaches a point where additional bias reduces the output (particularly at the higher frequencies). This is because increased bias begins to erase very short wavelengths.

A common professional way to adjust the bias on a high-speed deck is to record a 10,000-Hz signal and adjust the bias beyond the peak until a 1-to-2-dB reduction in output occurs. This yields the lowest noise and distortion and an acceptable frequency response. If the bias were to be set at peak, the response might be so good at the high end that there would not be enough equalization to bring it down, but distortion would be high and noise might suffer.

Our Test Setup. The basic tape deck we selected for making our tests was the Revox Model A-700. This deck has 15, 7½, and 3¾ ips speeds, covering both the consumer and the professional ranges, and provides complete bias and equalization adjustment con-

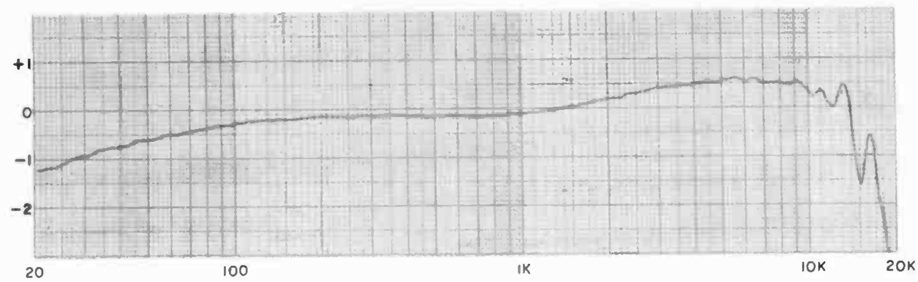


Fig. 3. Same as Fig. 2, but with bias set to peak at 1000 Hz.

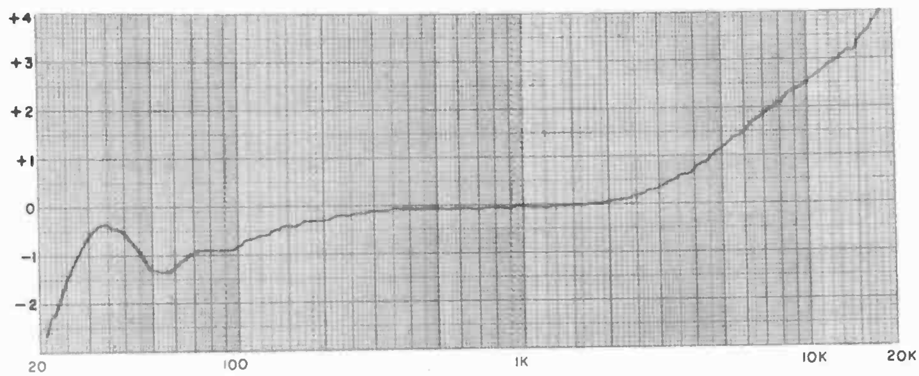


Fig. 4. Same as Fig. 2, with 15-ips speed.

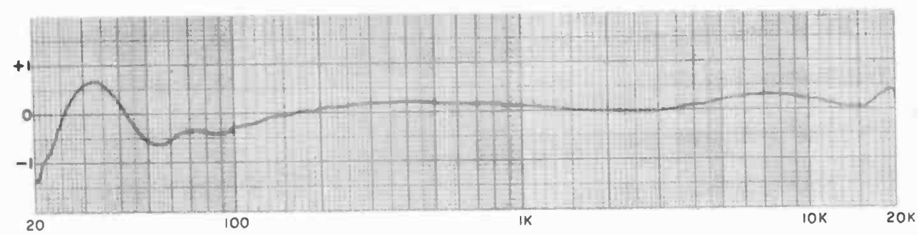


Fig. 5. Same as Fig. 3, with 15-ips speed.

Fig. 6. 3M's Scotch 250 at 15 ips with bias 2 dB beyond peak.

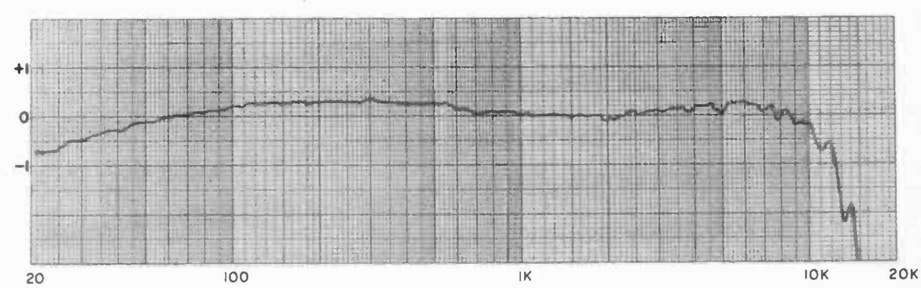


Fig. 7. Same as Fig. 6, with speed at 3¾ ips.

trols for each speed and channel. Needless to say, this deck provides all the controls and speeds required for making a meaningful study of tapes.

For the tests, we used a UREI Model 200 X-Y frequency plotter with built-in automatic 20-to-20,000-Hz sweep frequency generator. On the receive end of this instrument, the signal returns, after going through the equipment under test, and drives the X-Y plotter that operates at an exactly synchronized speed of 120, 60, 30, or 15 seconds. We selected a 60-second sweep speed and a 2-dB/vertical inch of graph paper sensitivity.

A Ferrograph Model RTS2 Record Test Set served as an auxiliary audio signal generator, total harmonic distortion (THD) analyzer, and also as noise meter.

The tapes selected for testing included the consumer Scotch Classic and professional 250 types from 3M, the consumer Maxell UD-50, and the professional Ampex Grand Master 456. We believe these tapes to be representative examples of the tapes available on today's market.

The Tests. The method of setting up for each tape was as follows: bias was adjusted and frequency-response pretests were run before plotting by sweeping between 1000 and 10,000 Hz. The recording equalization was then adjusted to bring the 10,000-Hz response as much in line with that of the 1000-Hz response as possible.

For the tests conducted at 15 ips, all testing was performed at 0 VU recording input, including those for noise and distortion. When we performed out tests at 3¾ or 7½ ips, the input was reduced to −10 VU. Distortion and noise were measured by increasing the input to 0 VU.

Our first frequency plot made on the UREI recorder is shown in Fig. 1. This is the overall response of the entire system without a tape running. As you can see, variations between 20 and 20,000 Hz are negligible.

The graph in Fig. 2 is the response of the Maxell UD-50 tape at the speed of 3¾ ips, with the bias set 2 dB beyond peak at 10,000 Hz. The signal-to-noise (S/N) ratio was −52 dB unweighted. (Our S/N measurements were all referenced to the 0-VU point on the deck's meters. Had we used the common 3% distortion point, the S/N figures for this and all subsequent tapes would have been better by 7 to 8 dB.)

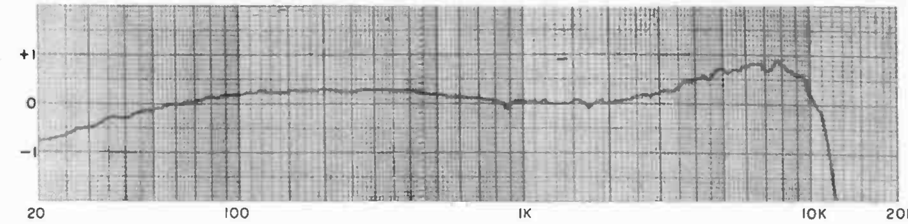


Fig. 8. Same as Fig. 7, with bias set to peak at 1000 Hz.

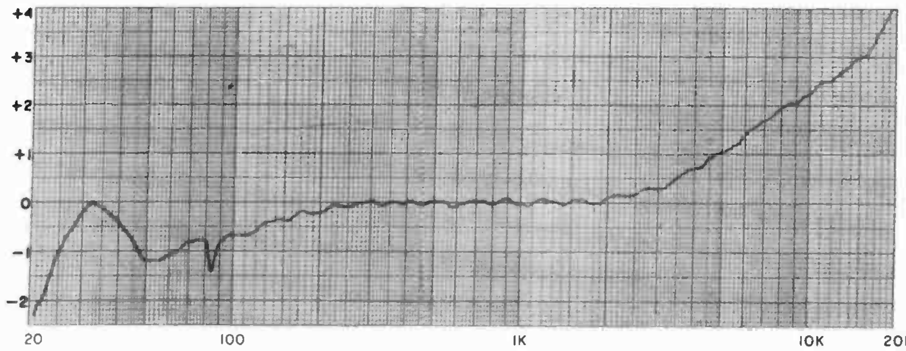


Fig. 9. Scotch Classic at 15 ips and minimum equalization.

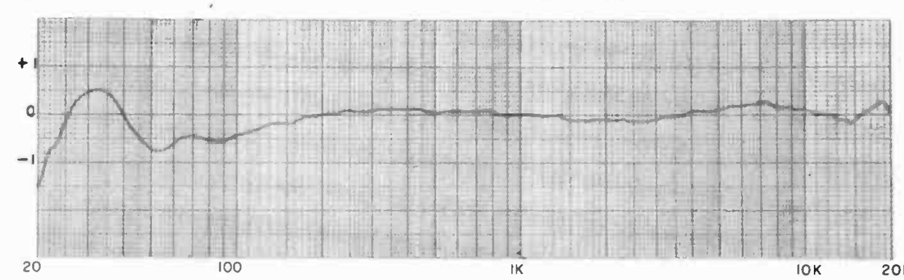


Fig. 10. Same as Fig. 9 with bias to peak at 1000 Hz.

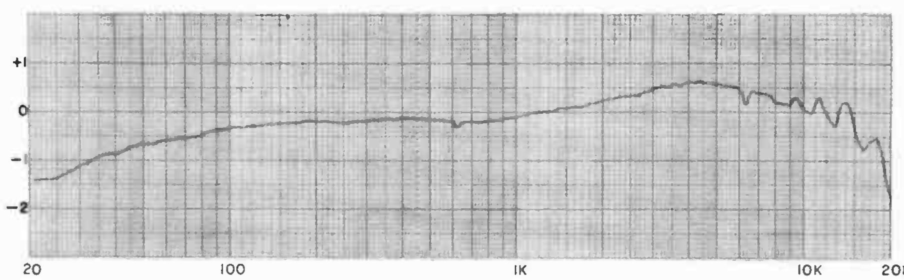


Fig. 11. Scotch Classic at 3¾ ips, bias 2dB beyond peak at 10,000 Hz.

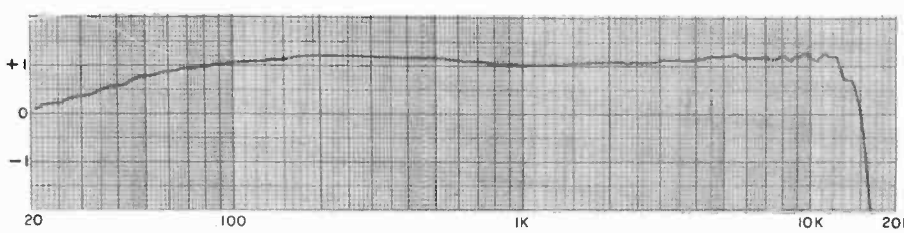


Fig. 12. Same as Fig. 11, with bias set to peak.

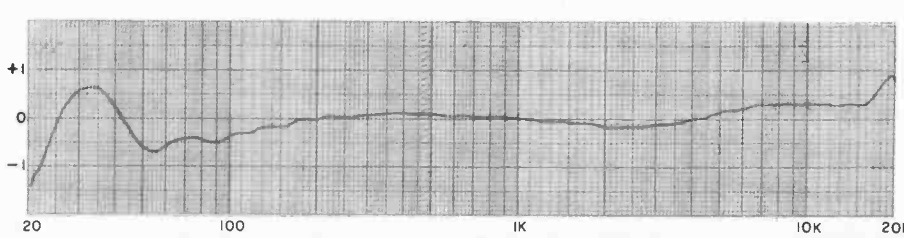


Fig. 13. Ampex 456 at 15 ips, bias 2 dB beyond peak at 10,000 Hz.

Note that the response of this tape is essentially flat to −2 dB at 17,000 Hz.

When we adjusted the bias to peak at 1000 Hz, note, in Fig. 3, the slight roughness of the high end, although the actual response is still about the same. At 1.2%, the distortion was slightly greater, but the S/N remained the same at −52 dB.

Changing the speed to 15 ips produced the curve shown in Fig. 4 at 10,000 Hz and bias set at 2 dB beyond peak and Fig. 5 at 1000 Hz and bias set to peak. The Fig. 4 curve was obtained with minimal setting of the high-frequency equalization. The sharply rising high end is obvious, almost 5 dB at 20,000 Hz. At this setting, the THD was 1% and the S/N was −55 dB. The bass end response of the Fig. 5 curve is typical of many tapes and is well within ±1 dB from 22 Hz. At the high end, the response is smooth and goes well beyond 20,000 Hz. This time, distortion was 0.75% and S/N was −55 decibels.

3M's Scotch 250 studio mastering tape, first tested at 15 ips, responded very well when the bias was set 2 dB beyond peak, as seen in Fig. 6. S/N was −58 dB and distortion measured 0.7%. We saw no reason to alter the bias and left the setting alone.

The curve shown in Fig. 7 is for the Scotch 250 tape at the consumer speed of 3¾ ips. At 2 dB beyond peak, the response is 2 dB down at 15,000 Hz, while S/N was −53 dB and distortion was 1.1%. The curve in Fig. 8 is for the same tape and speed, but this time, the bias was set to peak at 1000 Hz. The high end suffers, S/N remains at −53 dB, and distortion improves to 0.9%—not a very significant gain. It can certainly be assumed that this is not a tape to use at low speeds.

The response of the consumer-grade Scotch Classic tape is shown in Fig. 9. The tape speed was 15 ips and high-end equalization was at a minimum. While the S/N figure is a healthy −57 dB, distortion is an unhealthy 2.8%. Obviously, with the bias set at 2 dB beyond peak, this is not a good tape to use at the higher speed.

Setting the bias to peak at 1000 Hz and correcting the equalization provided the curve shown in Fig. 10. Note that the response has smoothed out to professional-grade full range; S/N remains at −58 dB; and distortion has dropped to an excellent 0.7%. Classic can obviously qualify as a good professional tape.

Now, operating Scotch Classic at the consumer speed of 3¾ ips, as shown in Fig. 11, the response was flat to −2 dB at 20,000 Hz. However, at 2 dB beyond peak at 10,000 Hz, S/N was −53 dB and distortion was 2.5%. With the bias set to peak, the response was −2 dB at 16,000 Hz, with distortion down to 1.1% and S/N −54 dB (Fig. 12). These two settings clearly reveal the tradeoffs of bias versus distortion and frequency response.

The professional mastering Ampex 456 tape was very similar to the Scotch 250 tape in its bias requirements and performance characteristics. We performed our Ampex 456 tape tests with the bias set 2 dB beyond peak at 10,000 Hz. The Fig. 13 curve was obtained at 15 ips; S/N was −57 dB and distortion was 0.8%. This is clearly a professional tape. At 3¾ ips, the tape's response was rough but actually only 2 dB down at 20,000 Hz. The tape had a response of 1 dB at about 10,000 Hz at the minimum setting of the tape recorder's equalization adjustment. The distortion was an unimpressive 2.4% and S/N was a good but not impressive −53.5 dB. Ampex 456 is a superb studio mastering tape, but much like the Scotch 250, it is not an idealized slow-speed tape.

Summing Up. What have our tests proved? Depending on the bias and equalization settings of the tape deck, Scotch Classic, Scotch 250, and Maxell UD-50 performed very much the same at 3¾ ips. We expected this of the Classic and UD-50 tapes, but seeing the performance of the 250 at this speed came as a bit of a surprise. At the high, and presumably professional, speed of 15 ips, each of the tapes tested was capable of nearly identical frequency response, distortion, and noise performance.

We feel, therefore, that part of our original contention that, at low speeds, tapes designed for that speed range are best, has been proven. But at high speeds, it would appear that the best buy is the lowest priced and most readily available tape—at least among those tested by us.

It is evident that proper performance from any tape means that the tape deck on which it is used must be properly set up for it. Bias must be set for distortion versus frequency response, but the setting must permit an acceptable normalizing of the high-end response. ◈

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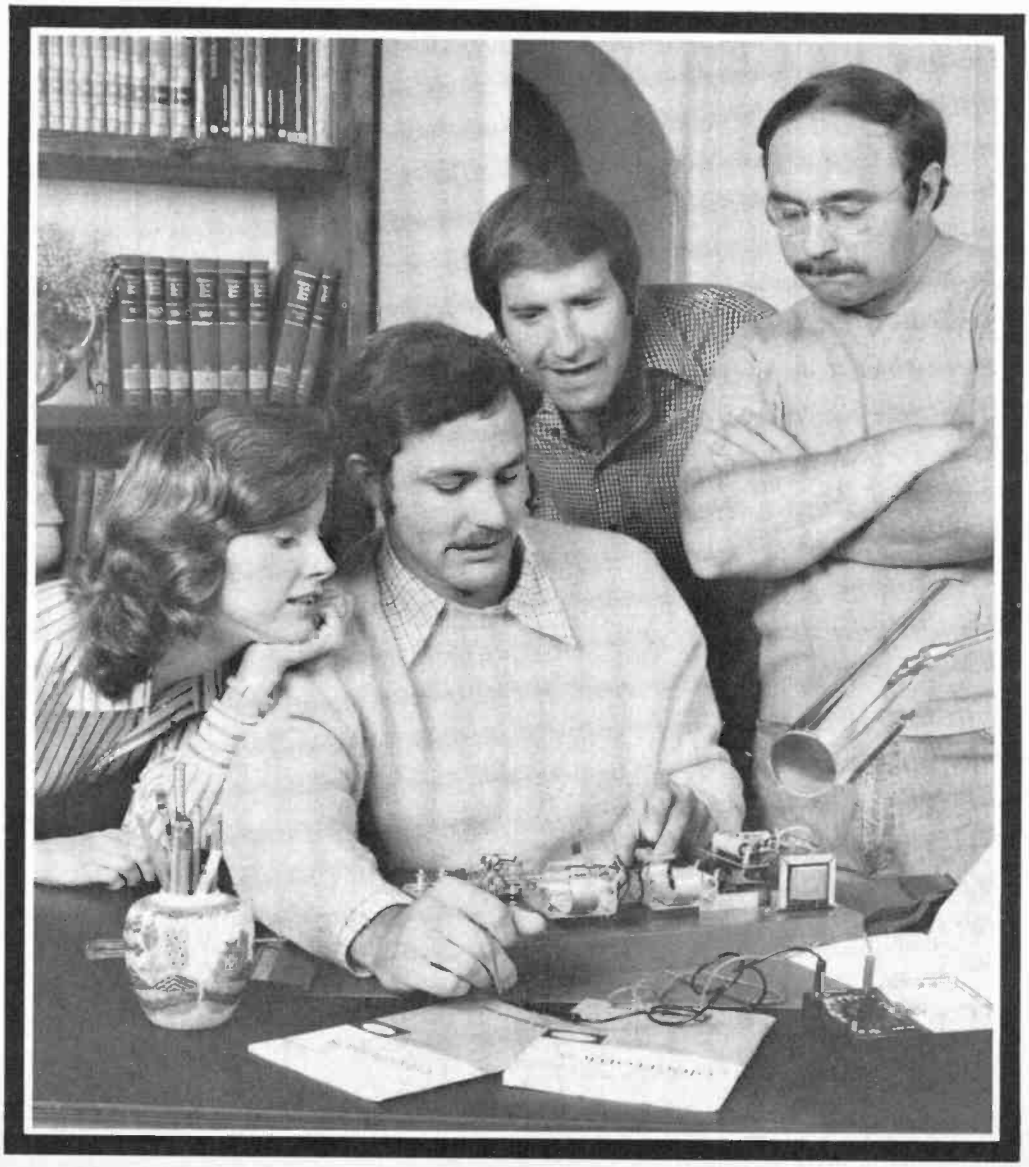

BY HARRY LOWENSTEIN

BUILD THE 35-mm Slide Syncer

A low-cost programmer for audio-visual presentations.

THE Slide Syncer is a programming device which enables you to record musical or talking material and a slide projector advance signal on the same tape track. It can be built using readily available, inexpensive parts, and will provide reliable and quiet performance. Incorporated into the Slide Syncer is a speaker for use with the external speaker jack on a cassette or open-reel tape recorder. The self-contained power source consists of four "AA" cells which should last for one year with moderate use.

About the Circuit. As shown in Fig. 1, *IC1*, a 567 tone decoder phase-locked loop, is the heart of the Slide Syncer. This eight-pin DIP contains a

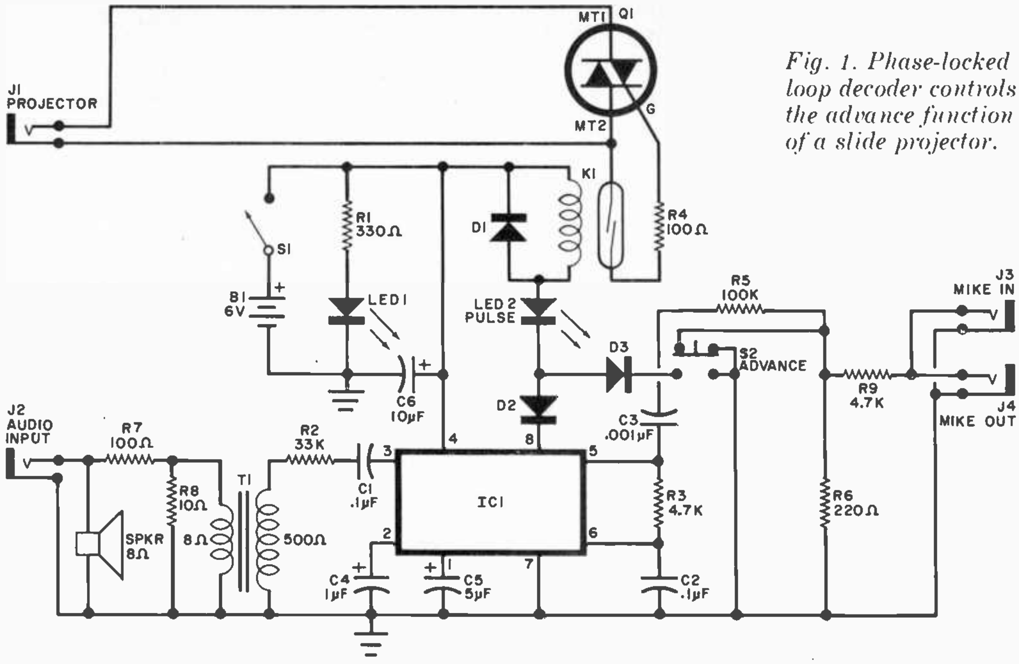

Fig. 1. Phase-locked loop decoder controls the advance function of a slide projector.

PARTS LIST

C1, C2—0.1-μF Mylar or disc ceramic capacitor
C3—0.001-μF disc ceramic capacitor
C4—1-μF, 10-volt electrolytic capacitor
C5—5-μF, 10-volt electrolytic capacitor
C6—10-μF, 10-volt electrolytic capacitor
D1, D2, D3—1N4001 diode
IC1—567 tone decoder PLL IC
J1—¼" insulated phone jack
J2, J3, J4—miniature two-conductor open-circuit phone jacks
K1—4.8-volt reed relay with SPST contacts
LED1, LED2—20-mA light emitting diode
Q1—200-volt, 6-ampere triac (Radio Shack 276-1001 or equivalent)
The following resistors are ¼-watt, 10% tolerance components.
R1—330 ohms
R2—33,000 ohms
R3, R9—4700 ohms
R4, R7—100 ohms
R5—100,000 ohms
R6—220 ohms
R8—10 ohms
S1—Spst switch (see text)
S2—Spdt pushbutton switch
SPKR—8-ohm, 4" × 2⅝" (10.2 × 6.7 cm) oval speaker — Sanyo R-S6367A or equivalent
T1—8-ohm/500-ohm audio transformer (Radio Shack 273-1381 or equivalent)
Misc.—Suitable enclosure, shielded cable, hookup wire, dry transfer lettering, printed circuit or perforated board, IC socket or Molex Soldercons, hookup wire, solder, machine hardware, etc.

control oscillator, phase-locked circuitry, and an output stage that can sink up to 100 mA of direct current.

It is customary to use an external tone generator to trigger the 567. However, the output of an external oscillator would have to be very close to the response frequency of the tone decoder for proper triggering to occur. This means that high-tolerance, low-drift components would have to be used. Fortunately, the output of the internal oscillator of the 567 can be picked off at pin 5 so the tone generated can be coupled from pin 5 to the microphone input of the tape recorder. Then it will be recorded on the same track as the commentary. The frequency at pin 5, determined by *R3* and *C2,* is exactly that which is required as an input signal to trigger the phase-locked loop.

When *S2,* a spring-loaded SPDT pushbutton switch, is tapped, the "beep" at pin 5 is coupled onto the microphone line (the hot side of *J3* and *J4)* through *C3* and the attenuating network *R5R6R9.* This switch also allows current to flow through the coil of reed relay *K1, LED2,* and *D3.* When the relay contacts close, gate current is provided for triac *Q1* if a low-voltage source is connected to jack *J1.* This triac is used to control the slide advancing mechanism in the projector, which is most often an ac-actuated circuit.

However, there is no need to have the projector set up when you are recording a program. When *LED2,* the PULSE indicator, is lit, the command tone is being recorded on the audio track at about 10 dB down from the commentary level. The Slide Syncer eliminates the need for a two-track recorder (one track for the commentary, the other for the advance tone). But you will find that the tone is not loud enough to be distracting.

On playback, the audio output of the recorder is taken from the external speaker jack and applied to the Slide Syncer's internal speaker and transformer *T1* through *J2,* the audio input jack. Resistors *R7* and *R8* attenuate the audio to a level that *IC1* can handle. The drive signal for the phase-locked loop is coupled from the secondary of *T1* through *R2* and *C1.* When the tone that was taken from pin 5 and recorded on the tape appears at pin 3, pin 8 is grounded and sinks current for the coil of *K1* and *LED2* through *D2.* Then the contacts of *K1* close, and *Q1* turns on and activates the advance mechanism in the projector. The 567 will not sink current unless a sustained tone of the proper frequency appears at pin 3, so normal speech and music will not cause the projector to advance to the next slide.

Most inexpensive cassette recorders have better audio sections than their small speakers would lead you to believe. For this reason, the 8-ohm speaker is included in the Slide Syncer circuit. It is a 4" × 2⅝" (10.2 × 6.7 cm) oval speaker, and should improve the sound quality of your audio-visual presentations.

The Slide Syncer requires +6 volts dc at about 25 mA quiescent current, which increases to 47 mA when *S2* is depressed. At these low current levels, four AA penlight cells mounted in a battery holder form an inexpensive power source.

Construction. The circuit is not too complex, so you can use perforated board or printed circuit construction techniques. Be sure to observe polarities on the electrolytic capacitors and the semiconductors. It is suggested that an IC socket or Molex Soldercons be used in mounting the 567 IC on the board. This will avoid heat damage to the chip. All LED's, jacks, and switches are mounted off the board. Use shielded cable for all audio lines.

The Slide Syncer should be mounted in an enclosure about 6½" × 5½" × 2" (16.5 × 14 × 5.1 cm). The speaker cutout can be made with a nibbling tool. Current limiting resistor *R1* is mounted on the lugs of *S1*. (The author used a DPDT slide switch wired as an SPST, with the unused contact lugs for tie points to the power leads and *R1* and *LED1*.) Jack *J1* should be insulated from the front panel if a metallic enclosure is used. Rubber or fiber washers can be used for insulation and mechanical support. A small bracket can be fashioned from a piece of scrap aluminum stock to secure the battery holder to the enclosure. Dry transfer lettering can be used to label all jacks, LED's, and switches. Spray the lettering with clear Krylon spray after it has been transferred to the panel.

Prepare shielded jumper cables for the audio inputs and outputs (external speaker jack to *J2*, microphone jack to *J4*) and terminate them with plugs compatible with your cassette recorder. Connect a ¼" phone plug to the advance control cable from your projector.

Checkout and Use. Insert all plugs into their corresponding jacks, and plug the recorder microphone into jack *J3*. Record a short test program on the cassette recording, pushing *S2* each time you want the projector to advance to the next slide. Then turn the projector on and play back the tape. The projector should advance each time the control "beep" is heard.

The 567 tone decoder requires an input level of 100 to 500 μV for reliable operation. The Slide Syncer is designed so that normal audio levels from a small cassette recorder placed in an average-sized living room will consistently advance the projector. Resistors *R8*, *R7*, and *R2* attenuate the audio to the working level of the IC. For high-volume audio-visual use — say, in a classroom — *R2* should be increased to a value between 68 and 82 kilohms. For low-level use, *R2* can be reduced to 10,000 ohms or so. If you prefer, you can mount these three attenuating resistors on the foil side of the printed circuit board so they can be easily changed (if necessary) to prevent false triggering.

The tone output from the Slide Syncer is very low, but is sufficient to trigger the tone decoder. However, if you have a recorder with automatic gain control, the advance tone will be loud on playback. If possible, use a recorder with a manual gain control to keep the tone almost inaudible. But the Slide Syncer will work with either type of tape recorder. The advance tone, using the values given for *R3* and *C2*, is about 2200 Hz. You can change it to any other frequency simply by using different values for these two components. You can also build two decoders sharing a common audio input and output to trigger two projectors. In that case, the two tones should be somewhat removed from each other—say, 1000 and 2200 Hz—so that each projector will advance only on its proper tone command. ◈

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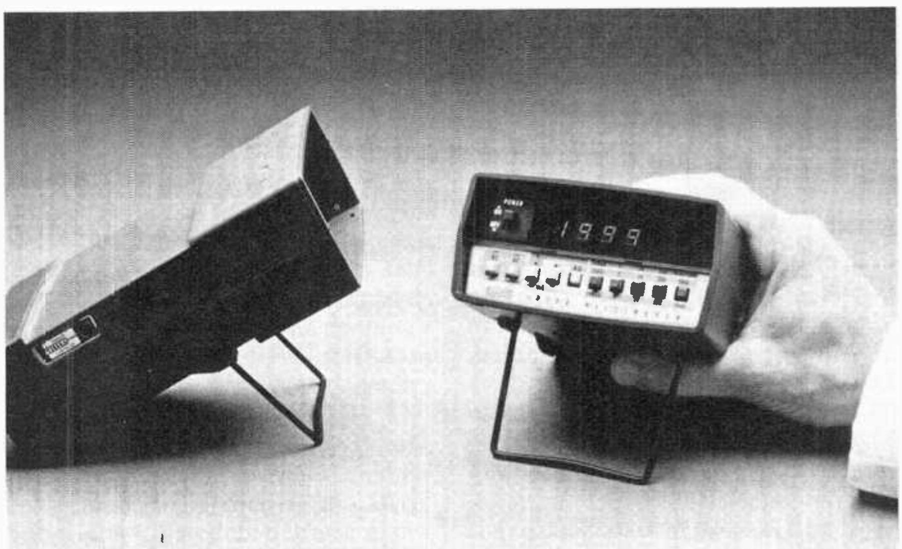


A NEW ADVANCE. 8030A DMM. FLUKE®

Product Test Reports

ABOUT THIS MONTH'S HI-FI REPORTS

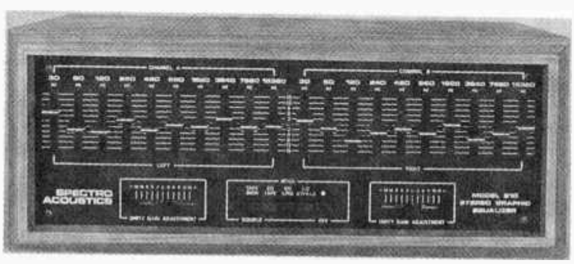
In addition to being a very fine 10-octave equalizer, the Spectro Acoustics Model 210 has enough front-panel switching to permit completely flexible operation. It can be used with a tape deck or any other program source you can use with your amplifier. Part of the excellent performance of the Model 210 can be credited to its gyrator inductors, which replace the usual bulky, hum-sensitive wire-wound components.

Pickering, in its broad line of cartridges, offers units that share a common body and electrical configuration, differing only in stylus parameters and prices. The XV-15 series illustrates this philosophy. The newest member of the series, the XV-15/625E, is third from the top of the line in tracking ability, yet has frequency response and sonic characteristics almost identical to other members of the family. However, this cartridge tracks at forces between 1 and 1.5 grams, making it ideal for use in high-grade automatic record players. Our tests also show that it has above-average ability to play heavily recorded discs with low distortion.

—Julian D. Hirsch

SPECTRO ACOUSTICS MODEL 210 GRAPHIC EQUALIZER

Features great versatility; uses gyrator inductors.



HIRSCH-HOUCK LABS REPORT

On the Spectro Acoustics Model 210 stereo graphic equalizer there are 10 separate octave-band controls to adjust the frequency response of each channel. The center frequencies of the octave filters are at 30, 60, 120, 240, 480, 960, 1920, 3840, 7680, and 15,360 Hz. The slide-type potentiometers in each octave range provide a boost/cut range of ±13 dB within each filter passband. The Q of the filters, which is 2.5 ±10%, has been selected to provide maximum versatility in shaping the frequency response with a minimum of ripple.

The equalizer measures 17″W × 6½″D × 6″H (43.2 × 16.5 × 15.2 cm) and weighs 6 lb (2.7 kg). It is also available with a 19″ × 7″ (48.3 × 17.8 cm) rack-mounting panel. The equalizer is finished in black with white and blue markings and control knobs. It retails for $295, plus $40 for an optional wood cabinet.

General Description. The equalizer employs active circuit elements called "gyrators" to simulate inductors in its filters. The elimination of actual inductors in the signal-processing circuits makes it completely immune to induced hum from external fields. Since the overall gain of the signal channels can be considerably changed when several of the equalizer potentiometers are moved from their zero positions, there is a small horizontally oriented pot under each group of filter controls to change the gain of each channel by ±15 dB and reestablish a unity-gain condition. With all controls centered, the gain of the equalizer is unity and its response is flat to within ±0.5 dB from 20 to 20,000 Hz.

The operating mode of the equalizer is controlled by five pushbutton switches located at the lower center of the front panel. One button controls the power and has adjacent to it a red LED that glows when power is on.

The equalizer is normally connected into an audio system via the recording inputs and outputs, but it can also be installed between the preamplifier and power amplifier. A duplicate set of tape input and output jacks is provided on the rear apron of the equalizer so that the tape facility is not lost when the equalizer is connected to an amplifier or receiver. The TAPE MON pushbutton switch connects the tape recorder playback into the signal path for playing tapes or monitoring a recording while it is being made.

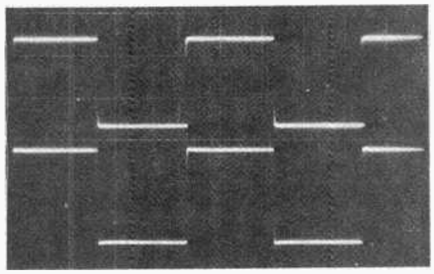
The EQ BYPASS pushbutton completely bypasses all of the equalizer's circuits. (The power need not be applied to the equalizer when this button is depressed.) The EQ LINE button is pressed for most normal operation of the equalizer, inserting the equalizer's circuits into the signal path and returning the equalized program to the amplifier. A most useful feature is the EQ TAPE button, which places the equalizer in the signal path going to the tape recorder. The program played through the amplifier can be either the unequalized input signal or the playback from the equalized recording. It is also possible to record an unequalized signal and place the equalizer in the recorder's playback line.

On the rear apron of the equalizer are all the input and output jacks, the tape recorder jacks, and a single unswitched ac accessory receptacle.

The equalizer is designed to do only one thing—modify the frequency response of a program to compensate for sound-system or listening room deficiencies. Its noise and distortion have been reduced to the point where they can barely be measured, much less heard. With all controls centered, the signal-to-noise ratio is rated at better than 90 dB below 2 volts. Since the equalizer can deliver a maximum of 10 volts rms, its total dynamic range can be greater than 105 dB. The 600-ohm output impedance makes it possible for the equalizer to drive a 10,000-ohm load (the lowest that will be presented by any power amplifier) at full output. The input impedance of 30,000 to 50,000 ohms is compatible with any commercially made preamplifier or tape deck.

The distortion of the equalizer is specified at less than 0.05% at 1 volt output over the full 20-to-20,000-Hz audio range when the controls are set to the flat, or zero, positions. The IM distortion is rated at less than 0.0075% at any output up to 10 volts equivalent sine-wave signal with the standard 60- and 7000-Hz test signals.

Laboratory Measurements. Measuring the distortion of the equalizer taxed the capabilities of our test instruments. Up to a 1-volt output, the distortion was less than 0.005% between 20 and 20,000 Hz. At 2 volts output, the results were the same, except that at the high end, the distortion reached 0.01%. At a 3-volt output, it was 0.01% to 0.018% over the entire audio range, while at 10 volts, just before clipping occurred, it was between 0.022% and 0.056%. The IM distortion reading was the residual of our Crown IM analyzer—0.002% to 0.003%—up to 3 volts output, reaching 1% at a 10-volt output. At the minimum measurement level of 60 mV, the IM was a negligible 0.01%.



Response of the equalizer to 1000-Hz square-wave input.

At 120 Hz, the hum was 82 dB below 1 volt, or 88 dB below the rated 2-volt output. The noise was not measurable, being less than the 100-µV minimum indication of our meter. We could only determine that it was much better than 90 dB down, referred to a 2-volt output.

Each of the equalizer's filter controls had a range of ±13 dB, and the shape of their individual response curves conformed to the expected response with a filter Q of 2.5. With the controls centered, the response was flat to within ±0.25 dB from 20 to 20,000 Hz. A check with a 1000-Hz square-wave signal revealed that the phase characteristics of the equalizer were as good as its amplitude response (controls centered). The square-wave signal output was virtually indistinguishable from the input signal.

User Comment. It is generally agreed that an octave-band equalizer is the most practical and effective means for correcting normal hi-fi system aberrations caused by speaker system and listening-room characteristics. Fewer than 10 bands would sacrifice versatility, while more bands would make adjustment too difficult. The center frequencies of the filters in this equalizer have been well chosen.

The equalizer comes with an instruction manual that could serve as an excellent primer on equalization techniques. It is also a model of how an instruction manual should be written. Only the omission of the equalizer's schematic diagram prevents us from giving the manual a 100% rating.

We experimented at some length with the equalizer and are convinced that it can do anything any other equalizer we have used can do and that it can do more than most of the others. The control switching is especially versatile, making it possible to equalize before or after a tape recorder, to listen to an equalized or unequalized signal (whether or not the recorded program is being equalized), or to replace the equalizer's circuits with, literally, a straight wire connection.

Our only criticism of the equalizer's design is that it has no center detents on the controls to simplify locating the flat positions. Otherwise, the equalizer represents an excellent hi-fi system accessory that is well worth its price.

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PICKERING MODEL XV-15/625E PHONO CARTRIDGE

Excellent tracking ability at moderate price.

HIRSCH-HOUCK LABS REPORT

Pickering's XV-15 series of stereo phono cartridges includes a number of models that share a common body and coils but have different stylus characteristics. The interchangeable styli are designed for use with tracking forces as high as 5 grams and as low as 0.75 gram. They are rated according to what Pickering calls "Dynamic Coupling Factor" (DCF), which is essentially a measure of tracking ability, called "Track-A-Bility" by the company.

The latest addition to the XV-15 family is the Model XV-15/625E cartridge whose 0.3 × 0.7-mil elliptical stylus is designed to track with a force between 0.75 and 1.5 grams, with a nominal 1-gram rating. It is best suited for the higher-grade automatic turntables with low-friction tonearms as well as with manual players. The nominal output at 5.5 cm/s is 4.4 mV; recommended load is 47,000 ohms in parallel with 275 pF.

As with other Pickering cartridges, this new cartridge's stylus assembly has an integral hinged "Dustmatic" brush that rides on the record surface to remove surface dust. The brush can easily be removed if desired. When it is used, however, the indicated tracking force of the tonearm must be set 1 gram higher than the actual tracking force desired to compensate for the upward thrust of the brush.

The cartridge is supplied with snap-in plastic mounts that simplify installation in several popular record-player tonearms, including models from BSR, Dual, and Garrard. With the snap-in mounts, screws are not required to fasten the cartridge to the tonearm shell. Without the mounts, the cartridge can be installed in any tonearm in the conventional manner.

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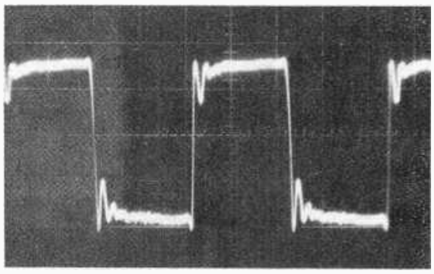
The retail price of the Pickering Model XV-15/625E cartridge is $59.95.

Laboratory Measurements. With the recommended load and the cartridge installed in the tonearm of a popular high-quality record player, the output signal level was about 3.5 mV at a velocity of 3.54 cm/s. The levels from the two channels differed by only 0.4 dB. The vertical tracking angle of the stylus measured 24°.

The cartridge tracked our high-velocity test records, including the low-frequency Cook 60 and the mid-frequency Fairchild 101 records, at its nominal 1-gram force. The 30-cm/s 1000-Hz tones of the Fairchild record were played with virtually no visible waveform distortion. At 1 gram, the cartridge played the 60-micron level of the German Hi-Fi Institute record. With an increase in stylus force to 1.5 grams, it played the 80-micron level. The performance at 1 gram is typical of many good-quality and medium-priced cartridges, while only a few of the best cartridges can cope with the 80-micron level of the 300-Hz tones on the test record. We used a 1-gram force for all other tests.

The frequency response of the cartridge, using the CBS STR 100 record, was very closely matched between the channels, sloping slightly downward at frequencies beyond 500 Hz and a small-amplitude high-frequency stylus resonance at about 18,000 Hz. The overall frequency response was a very good ±2 dB from 40 to 20,000 Hz. Channel separation was somewhat better than that of most cartridges over the major portion of the audible range, measuring 25 to 30 dB up to nearly 10,000 Hz. It was still a good 12 dB at 20,000 Hz. The low-frequency resonance in the tonearm we used was at about 10 Hz.

We measured the tracking distortion with the aid of two Shure test records. The TTR-102 is an IM record that contains 400- and 4000-Hz tones recorded in a 4:1 level ratio at velocities from about 7 cm/s to 27 cm/s. The cartridge revealed a smoothly rising IM distortion characteristic over



Square-wave response using CBS STR112 test record.

that full range, increasing from about 1.7% at the lower velocities to 6% at the maximum level. This contrasts with the behavior of some cartridges, which may have slightly less distortion at low velocities but often mistrack and severely distort well below the maximum level on the record. There is probably little to choose from between the two types of cartridge distortion, since both have satisfactorily low levels at the velocities found on most commercial recordings, which rarely exceed about 15 cm/s.

The second test used the Shure TTR-103 record, a high-frequency tracking test involving 10,800-Hz tone bursts at a 270-Hz repetition rate. Failure to track the specially shaped bursts results in an increase in the 270-Hz component of the cartridge's output. In this test, the Pickering cartridge had low distortion, measuring less than 1% up to about 20 cm/s and a smooth rise to 3.8% at 30 cm/s.

The square-wave response, using the CBS STR112 record, revealed an almost perfectly square output waveform, with one or two cycles of moderate-amplitude ringing at the 18,000-Hz stylus resonance. A listening test of tracking ability, using the Shure TTR-110 "Audio Obstacle Course—Era III" record, confirmed the excellent tracking ability of the cartridge. At 1.5 grams, the cartridge handled everything on the record with ease; but at 1 gram, it mistracked on the highest level of the sibilance test and sounded strained at the highest levels of bass drums and violins.

User Comment. The cartridge sounded much as one would expect it to from its measured performance. The sound was very smooth and natural. In fact, those listeners who expect sparkle and dazzle from a cartridge will be disappointed in the Model XV-15/625E's relatively bland sound. To us, however, this is a sign that the cartridge is not significantly altering either the waveform or the frequency balanceof a record it is playing at the time.

Perhaps if one selected some especially difficult recording, it would be possible to find something the cartridge could not track. But among the various records we heard, the cartridge was always unstrained and thoroughly unflappable, even when operated at a 1-gram tracking force. Our conclusion, therefore, is that this moderately priced cartridge for today's market represents an excellent value for any purse.

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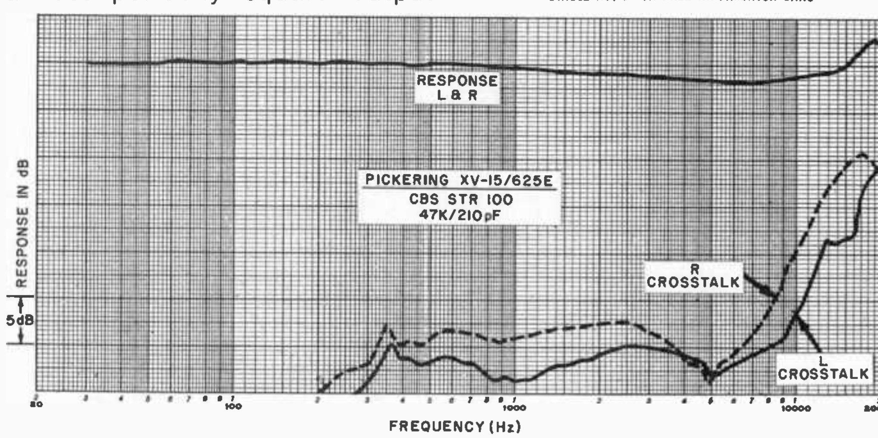


Left and right response and crosstalk.

SILTRONIX MOHAWK AM CB MOBILE TRANSCEIVER

Popularly priced, compact unit with frequency synthesis.

THE Siltronix Mohawk is a compact AM CB mobile transceiver, employing crystal frequency synthesis to provide operation on all 23 CB channels. Among its standard features are adjustable squelch, volume control with on/off switch, r-f gain control, switchable automatic noise limiter (anl), S/r-f meter, PA operation, external-speaker jacks, full legal power, and detachable high-impedance dynamic microphone. The transceiver is designed to be operated from any nominal 12-volt dc positive- or negative-ground mobile electrical system. Built into its power supply are a line filter and reverse-polarity protection.

The transceiver measures 9½"D × 6½"W × 2 7/16"H (24.1 × 16.5 × 6.2 cm). It retails for $169.95.

General Description. The receiver section employs dual conversion with a first i-f of 10.000, 10.010, 10.020, or 10.040 MHz, obtained by heterodyning the CB signal with one of six crystals in the 16.965-to-17.215-MHz range, depending on the channel selected. The first i-f signal is then converted to a 455-kHz i-f by beating the first i-f signal with one of four crystal frequencies in the 9.545-to-9.585-MHz range and using the difference frequency that results.

The receiver's grounded-base r-f stage is diode protected. The r-f gain control is a potentiometer that functions as a variable attenuator at the antenna input. Grounded-emitter transistors are used in the remaining stages that make up the receiver. There are two mixers, followed by a ceramic filter that feeds the two i-f stages. The filter provides the i-f bandpass and selectivity. R-f selectivity for good image and other unwanted-signal rejection, while maintaining a uniform bandpass over the CB range, is ensured with a double-tuned antenna-input circuit.

A voltage-doubling detector and a series-gate anl precede the audio section that consists of three stages, including a class-B output section that is also used for PA operation and modulating the transmitter. Voltage-doubling diode rectifiers provide a high degree of agc. A single diode rectifier at the i-f output provides voltmeter action for the S meter. An amplified squelch is activated by a separate voltage-doubling agc-type setup.

The transmitter frequency is obtained by using the sum of one of the nominal 17-MHz synthesizer crystal frequencies and one of four crystal frequencies in the 10.000-to-10.040-MHz range. The transmitter mixer for this purpose is a dual-gate FET, followed by a triple-tuned bandpass circuit for minimizing spurious output responses.

An unusual setup is that there is a buffer stage preceding the r-f section. The r-f section consists of predriver, driver, and power-amplifier stages. The output section for matching to a 50-ohm load consists of a multisection network that includes a TVI trap.

Another not often found arrangement is that the driver and power-amplifier stages are operated in a grounded-collector configuration and are both emitter modulated. Automatic modulation control (amc) is built-in. Antenna and other switching is accomplished with a relay.

Test Results. We measured the receiver sensitivity at 0.4μV (rated 1 μV) for 10 dB (S + N)/N at 30% modulation and 1000 Hz. Image rejection and i-f signal rejection were 72 and 80 dB, respectively. Other unwanted spurious-signal rejection was a minimum of 60 dB. Adjacent-channel rejection and desensitization measured 40 to 45 dB. The overall 6-dB audio response was 300 to 3000 Hz. Audio output power with a 1000-Hz sine-wave test signal at the onset of clipping was 2 watts at 8% THD into 8 ohms.

The squelch threshold sensitivity range was from 0.3 to 1000 μV. The agc figure of merit exhibited only a 4-dB audio output change with an r-f input change of 80 dB at 1 to 10,000 μV. The meter registered S9 with a nominal input signal of 100 μV.

With the transceiver operated in the receive mode from a 13.8-volt dc source, the current drain was 0.2 to 1.5 ampere.

ng the same 13.8-volt dc source, nsmitter carrier output measured 4 watts. (This was also the power indicated on the rig's r-f output meter, which is calibrated in actual watts when working into a 1:1 SWR.)

Raising the microphone inpt level 16 dB above that required for 50% modulation held the modulation to a sine wave at 100% modulation with 12% THD at 1000 Hz. Adjacent-channel splatter under this condition was 50 dB down. The mike gain with voice operation was quite high, resulting in greater than 16 dB of compression and a tendency toward clipping and negative-peak overmodulation. Nevertheless, the splatter still held to within 50 dB down.

User Comment. The selector control is a good size and easy to manipulate. The r-f gain, volume, and squelch controls are rather small, with a bar-like grip to make it easy to "feel" or see their positions. The PA/CB and ANL ON/OFF switches are miniature toggles types.

The pointer of the edgewise-mounted meter is readily visible. A lamp illuminates the meter on transmit to provide an indication that the transmitter is live. Although the channel selector's numerals are quite small, they are easy to read under most conditions.

When operating the transceiver, the setting of the volume control is a bit critical, requiring only a slight advance for normal output volume. The S meter was very sensitive, moving about 25% upscale with r-f input signal level of nominally 1 µV. The performance of the anl was most effective in the presence of low-level signals (less than 5 µV), for which it is mostly needed. In this respect, noise attenuation could be improved even more by reducing the r-f gain while still maintaining an adequate signal level for good readability. This is also a good measure for reducing normal background noise since the overall gain of the receiver is quite high.

There is no volume control for PA operation. The speaker, as usual, faces down.

SCHOBER THEATRE ORGAN KIT

Produces true cinema-organ sound in a compact, curved step-board design.

THE OLD cinema pipe organ, sometimes called a "theatre organ," never failed to entertain and intrigue listeners. The rich, wide-ranging sounds and special effects produced by those instruments are still available today in some electronic organs.

The Schober Theatre Organ kit is an example of the genre—in compact form. It can give an excellent impression of the exciting tones and special effects reminiscent of the original theatre pipe organ. Moreover, it suggests the pipe organ's appearance through a curved stop board that has 48 colorful, illuminated tongue tablets—including 35 voice stops with five pitch registers and eight percussion stops. The solid-state organ's two 61-note keyboards and 25 flat, radiating pedal claviers cover eight octaves of tone. There are also four couplers, three intensity settings of vibrato, pedal balance control, manual balance control, and percussion balance control.

The Theatre Organ is available as a series of sub-kits. Kit No. ETC-1 consists of all the electronic sections that make up the organ ($849.50). Kit No. BTC-1 includes all the special organ parts such as keyboards, stop tablets, swell shoe, and final-assembly materials ($907.50). Kit No. PTC-4 includes the pedal clavier assembly made up of a 25-note, full-length pedal/switch assembly ($199.50). Kit No. CTT-1, priced at $529.50, includes the organ console and bench that must be assembled from precut and preshaped pieces of walnut and walnut-veneered lumber, plus all materials needed for furniture finishing. A considerable number of options are available. Included here are the percussion group kit, and a variable echo device Schober calls the "Reverbatape" kit.

The organ measures 50"H × 44"W × 41"D (1.3 × 1.1 × 1.0 m) with pedals. It weighs approximately 225 lb (102 kg).

Kit Assembly. According to Schober, the estimated assembly time for the organ is between 200 and 300 hours, which gives some idea of the complexity of the kit. We spent slightly more than 250 hours assembling our kit. In essence, this is a two-step kit: assembly of the electronic portion and assembly and finishing of the fine-furniture cabinet. One must exercise patience in accomplishing both steps.

Each of the printed circuit boards that make up the kit comes in a separate package that contains all the components to be mounted on the board with assembly instructions.

The pc boards are well made. All component locations are clearly identified on the top sides of the boards, and in many cases the foil sides too. Sockets are provided for every transistor, numbering in the hundreds. All components appear to be of the highest quality.

The circuit-board assemblies are more densely packed that in most other kits we have assembled. Even so, the boards are easy to wire. Each board has rubber feet to facilitate proper mounting and spacing. External connections to the pc board assemblies are made via tubular terminals, each clearly identified.

Because of the interlocking nature of the many circuits that make up the organ, the only elements that can actually be tested after assembly are the power supply and the 12 tone-generator boards. (The tone generators are stand-alone audio oscillators.) After checking that the power supply is delivering the proper output, each generator board is in turn connected to it; any type of audio amplifier is used to check for the various tone outputs. At this time, each board can be tuned to the correct frequency. Although the use of a frequency counter is suggested for the tuning procedure, it is not really needed because the coil/capacitor tuning elements come pretuned from the factory. If they need adjustment, only a minimum of "touching up" is required. In our kit, the tone oscillators were pretty much "on the nose" during testing.

At first glance, the various wood pieces look as though they are impossible to assemble into the finished organ console. In reality, however, the console goes together quite easily.

Each piece of wood is supplied carefully cut to size, drilled and shaped as required. Pieces exposed to view are either solid walnut or walnut veneer.

Lots of glue and screws are used in assembling the console. This results in a very rigid, durable structure. After assembling the main body of the console, one gets a pretty good idea of what the finished organ will look like and how much it weighs. We recommend that if you decide to build this organ, you assemble it in the same location where it will be used—it is that large and heavy.

Before the keyboards, stop-tablet horseshoe, pedal assembly, and electronics are installed, the exterior of the console must be finished. This involves the use of several grades of fine sandpaper, special stain and finishing compounds, and plenty of elbow grease. Once the console is sanded and stained, the first finish coat is applied. By this time, if care was exercised on the sanding and staining process, the console will reveal its fine-furniture qualities. (Schober supplies enough material for many finish coats, but leaves the number up to the builder.)

The 12 tone-generator assemblies fit into a small wooden "card cage" enclosure inside the console. The remaining board assemblies mount in various locations inside the console, each secured in place by its rubber feet. Then the keyboards mount in place, also with the aid of rubber feet.

Interconnections between the circuit-board assemblies, keyboards, power supply, and decoupling board are accomplished with lengths of color-coded hookup wire. It would have been nice if a wiring harness had been supplied, but we can understand the practicality and economy behind the decision not to provide one. In any event, interconnecting the various elements is not a difficult task. It is merely time-consuming.

The audio output of the organ is brought to a phono connector mounted on a small bracket on the back of the console. We connected the output to the AUX input of a home hi-fi system, crossed our fingers, and turned on the power. The small lamps over the voice-switch stop tablets in the horseshoe came on and illuminated the colored tabs. We then depressed a couple of tablets for each keyboard, put a foot on the swell pedal, and depressed it slightly, and touched a few keys on the keyboards. Happily, there was the full sound of a real theatre organ filling the room. Once we knew the organ was operating properly, all we had to do was adjust the various trimmer potentiometers in accordance with the detailed instructions.

With the organ working, we put together the curved-leg bench and assembled the pedal clavier kit. The 25-note clavier kit keyboard is meant to be played with the toe of one foot, while the other foot is operating the swell shoe pedal. It contains 25 full-length maple struts and sharps made from unbreakable black plastic. The pedal clavier assembly slides into a slot on the bottom of the organ and is screwed into place. This completes the assembly of the basic organ.

The optional percussion group produces the sounds of a celesta, chrysoglott (organ harp), orchestral bells that can also be played with reiteration, piano, harpsichord, xylophone, and mandolin. It consists of a number of almost identical pc boards that mount inside the organ console along the rear brace. The activating switches for the percussion group mount directly below the top keyboard.

A considerable amount of wiring is required to install the optional percussion group, but the organ would really be incomplete as a theatre instrument without it. Schober suggests using a separate audio amplifier for this option, which we did.

The other option built and installed in the organ was Schober's "Reverbatape," a form of modified endless-loop tape recorder that provides a variable echo.

User Comment. Assembling the Schober Theatre Organ kit is obviously a major undertaking. Although a knowledge of electronics is not really necessary to complete the project, time and patience are. However, once completed, one has a magnificent-sounding musical instrument worth thousands of dollars more than the basic kit price. Moreover, the organ is a striking piece of furniture.

Although the organ is compact for its type, it does require more space than, say, a "spinet" organ. For example, its pedals, which are pivoted front and back, jut rather far out into the room. But the benefits of easier heel-and-toe playing are worth it if you have the space.

Most importantly, the "sound" of this Theatre Organ is very impressive especially if you use good-quality audio equipment, which includes speaker systems with full, powerful bass response. This is truly a theatre-type organ, with the number and types of voices needed for full musical appreciation of light music of all types. (It can also be used to play organ classics, of course, but the choice of voices was not made for playing mostly "church" music.)

The organ's vibrato sound is very satisfying, with ample adjustment of the range achieved through a potentiometer that changes the frequency of a phase-shift oscillator. With this system, vibrato does not operate on the pedals, unlike most commercial types of popularly priced electronic organs. This is as it should be, since low pedal notes sound terrible with tremolo added.

The instrument's four couplers, which add stops from one manual to another and change pitch registers,

SCHOBER THEATRE ORGAN VOICES

Solo (upper manual):

Tibia 16′	Oboe 8′
Cello 16′	Diapason 8′
Stentorphone 16′	Brass Trumpet 8′
Tuba Mirabilis 16′	Violina 4′
Viola d'Amore 8′	Tibia 4′
Vox Humana 8′	Tromba Clarion 4′
Solo String 8′	Piccolo 2′
Clarinet 8′	Fifteenth 2′
Tibia 8′	Flageolet 1′
Fife 1′	

Accompaniment (lower manual):

Tibia 16′	Diapason 8′
Dulciana 8′	Harmonic Tuba 8′
Vox Humana 8′	Harmonic Flute 4′
Tibia 8′	Octave 4′
Orchestral Strings 111	Tuba Clarion 4′

Couplers:

Solo to Solo 16′
Solo to Solo 4′
Solo Unison Off
Solo to Accompaniment 8′

Pedal:

Dulciana 16′	Tuba Profunda 16′
Tibia 16′	Brass Flute 8′
Diaphone 16′	Tuba 8′

Percussion Group (optional):

Celesta	Piano
Chrysoglott	Harpsichord
Orchestra Bells	Xylophone
Orchestra Bells (reit)	Mandolin

We are particularly pleased with the Percussion Group option. It provides eight special effects that give the feel and substance of the old cinema pipe organs (see box). The percussive "strike" is made when the key is pressed and the voice decays even if the key is held down. Thus, any other organ stops can be used when a key is held down. Two percussion voices—mandolin and xylophone—repeat constantly, while a separate orchestra bells reiteration tab is employed to repeat bells. Each voice represents the finest percussive simulation we have heard. For an authentic Theatre Organ sound, we would not be without this option.

Another option, Schober's Reverbatape unit in kit form, is an excellent means of achieving artificial reverberation. It uses a continuous loop of tape upon which a series of time-spaced repetitions of the program being played is recorded and reproduced in succession by three playback heads. Another head erases the material, and the cycle continues. A reverb control varies the time delay for a 60-dB decay of 0 to 6 seconds. To appreciate the effect of this reverb unit in combination with the organ, you must play an electronic organ with a spring-type reverb device. The former produces a realism that genuinely simulates a large room or hall, while the latter, although an improvement at low volume levels (it "twangs" at high volume levels) does not really fool the listener. But beware! Once you hear the Reverbatape unit, you will never again be satisfied without it.

There are other options available from Schober that we have not tried. For example, a proficient organist would probably wish to add Combination Action, an electro-pneumatic system of 10 buttons that can preset stop tablets and a cancel button to turn all present stops off. Less competent players could well add a rhythm assembly to imitate bongos, cymbals, snare drums, etc., and possibly an automatic rhythm device to provide a myriad of rhythms.

To fully appreciate the Schober Theatre Organ's potential, the audio gear used should be top notch, with at least 20 watts rms per channel power amplifiers for relatively high-efficiency speaker systems. Be sure, however, that your woofers can handle sustained 32-Hz tones without burning out.

CIRCLE NO. 83 ON FREE INFORMATION CARD

Solid State

By Lou Garner

RARA AVIS

IN CASE you've forgotten your high school Latin (or didn't study it), the title of this column, loosely translated, means "rare bird." And that's exactly what we're going to discuss this month—some of the "rare birds" among semiconductor devices. Not rare in the sense of availability, for most may be obtained through the larger industrial and better-stocked mail order distributors, but in terms of familiarity among hobbyists and experimenters.

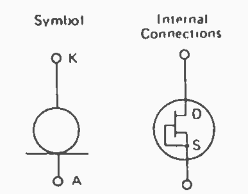


Fig. 1. The constant-current diode.

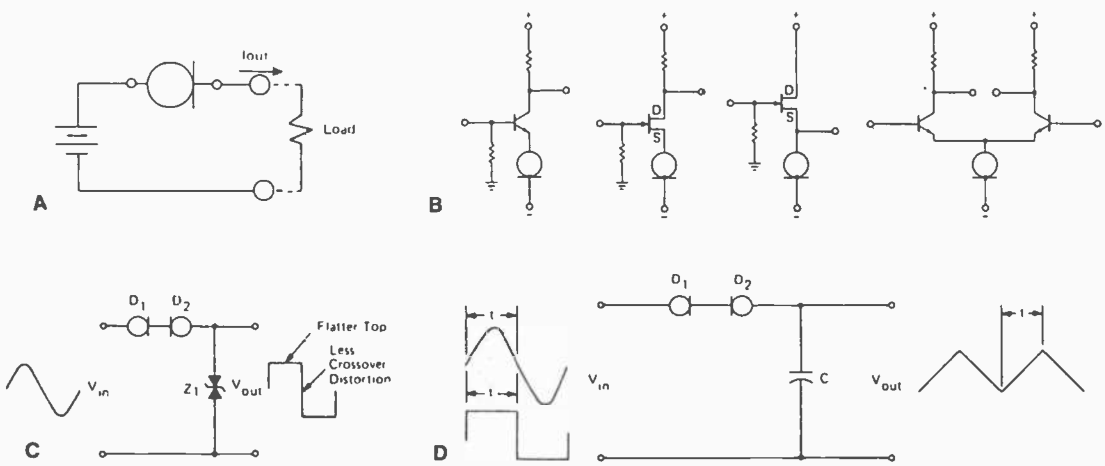


Fig. 2. Some applications for the constant-current diode.

Offered by several manufacturers, including Teledyne Crystalonics (147 Sherman St., Cambridge, MA 02140), the *constant current diode* is identified by a special schematic symbol as shown in Fig. 1. It is essentially a field effect transistor (FET) with an internal connection between its source and gate electrodes. Some firms refer to the device as a "current regulator diode." Regardless of its name, however, the internal short maintains a gate-to-source voltage of zero, causing the device to act as a high-impedance, constant-current source when operated at drain voltages higher than its pinch-off rating. Typical units are types 1N5283 through 1N5314, all of which are basically n-channel JFET's with on-chip metallization to provide the source-gate short and a nominal pinch-off of six volts. Depending on type, current ratings range from 0.22 mA to 4.23 mA.

A sampling of constant-current diode applications is given in Fig. 2. Perhaps the simplest and most obvious is the constant current power supply, Fig. 2A. Here, the prime dc power source, whether batteries or a line operated power supply, is set for a voltage greater than pinch-off (i.e., 6 volts for the types listed above). Under these conditions, the load current will remain essentially constant at the value set by the diode regardless of variations in load impedance. The device also can serve as a constant-current bias source for bipolar transistors, FET amplifiers, FET emitter followers, and differential amplifiers, as shown in Fig. 2B.

For a change of pace, connect a pair of the devices back-to-back, add shunt back-to-back zener diodes, and you have a simple, but effective, square-wave generator or clipper, as shown in Fig. 2C. Due to the current limiting

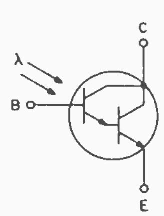


Fig. 3. Photo-Darlington.

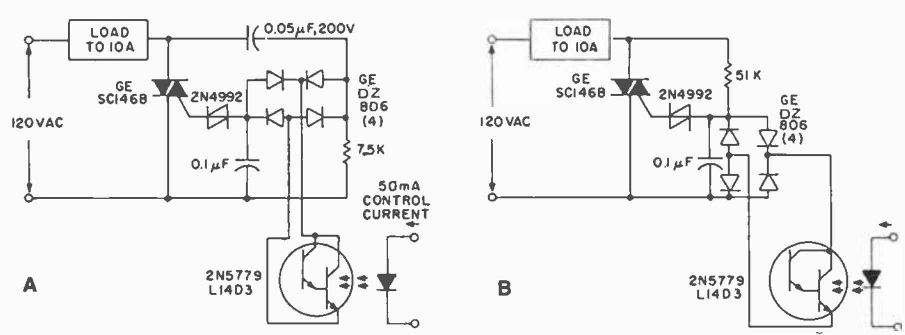
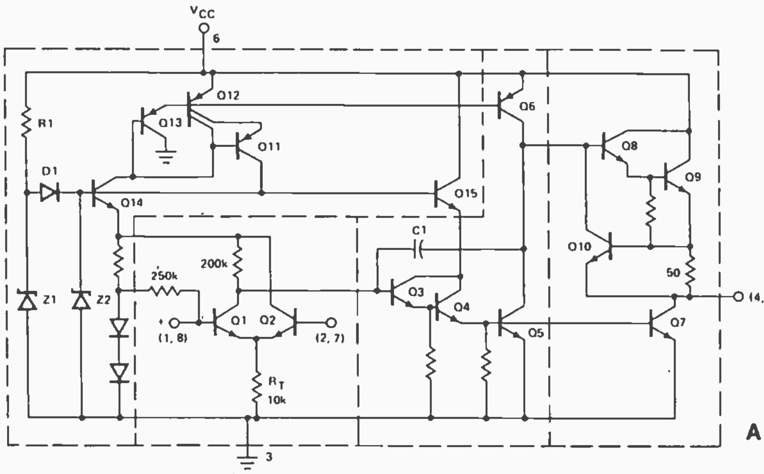


Fig. 4. Photo-Darlington applications: NO and NC relays.

action of diodes *D1* and *D2*, this circuit provides an output waveform with a flatter top and less crossover distortion than the more conventional resistor-zener clipper. What's more, with a lower power dissipation, it's also a more efficient circuit. For optimum performance, the square-wave clipper should be driven with a signal several times larger than the zener diodes' voltage rating. Replace the zeners with a capacitor, and the circuit becomes a triangular wave shaper, as in Fig. 2D. Triangular output signals will be produced with either sine- or square-wave inputs, but the latter will provide a cleaner output waveform at zero crossover. The circuit's output amplitude is directly proportional to the diode current and the time period of a half-cycle is inversely proportional to the value of the shunt capacitor.

the LED, illuminating the photo-Darlington, the latter starts conducting. This allows the diode bridge to conduct and apply voltage through the SBS to the triac's gate, switching this device On and permitting current flow through the load. In the normally closed circuit, Fig. 4B, the action is reversed. Here, the diode bridge is between the SBS's voltage source and circuit "ground." With the photo-Darlington dark and in a nonconducting state, the bridge also acts as a high impedance, allowing full drive voltage to be applied to the triac's gate through the SBS, thus holding the triac On and permitting current flow through the load. When the photo-Darlington is illuminated, however, it and, of course, the bridge shift to a low-impedance state, dropping the SBS's source voltage across the 51k series resistor and reducing the triac's gate drive below the level



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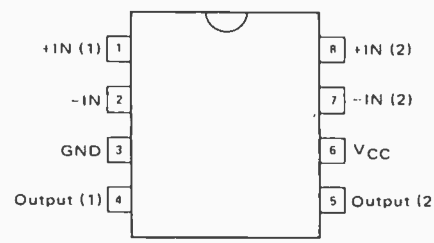


B

Fig. 5. Equivalent schematic (A) and pin connections (B) for LM387.

The photo-Darlington in another of our rare birds. Comprising photosensitive and amplifier transistors in a single package, (Fig. 3), the device behaves as if it were a single, but highly sensitive, phototransistor. It is capable of detecting changes in light levels as well as the absolute presence or absence of light. Photodarlingtons can be used in virtually all types of light-controlled systems and serve as rate sensors, frictionless potentiometers, smoke detectors, thickness gauges (for translucent materials), modulated-light-beam detectors, and sound-on-film detectors.

With suitable support circuitry, photo-Darlingtons can be used in solid-state relays, choppers, intruder alarms, card and tape readers, door openers, liquid level indicators and controls, safety interlocks, vehicle light controls, and various types of test equipment. Typical units are GE types 2N5777 through 2N5780, with V_{CEO} ratings of 25 and 40 volts and minimum h_{FE} (gain) specifications of 2500 and 5000, depending on type.

Two of the photo-Darlington's many possible applications are shown in Fig. 4—normally open (A) and normally closed (B) ac line-operated solid-state relays. Both circuits employ medium-current (10 A) triacs in conjunction with silicon bilateral switches (SBS). In each, the photo-Darlington is activated by a LED source to provide full line isolation.

In Fig. 4A, the photo-Darlington is connected across a diode bridge between the ac source and the SBS serving to trigger the triac. When the photodarlington is dark, it acts as a high impedance, preventing conduction through the bridge circuit and, therefore, the application of gate drive voltage through the SBS. The triac, then, remains in a nonconducting state. When a control current is applied to

needed to maintain conduction. When this happens, the triac switches to a high-impedance or Off condition, blocking load current. In either of the light-controlled ac power switching circuits, the load can be a solenoid, lamp, heater, or other device, as long as the triac's maximum ratings are observed.

Although not "rare" in the same sense as the constant current diode and photo-Darlington, the LM387 dual preamplifier probably is not as familiar to most experimenters as are such devices as the 741 op amp or 555 timer, yet

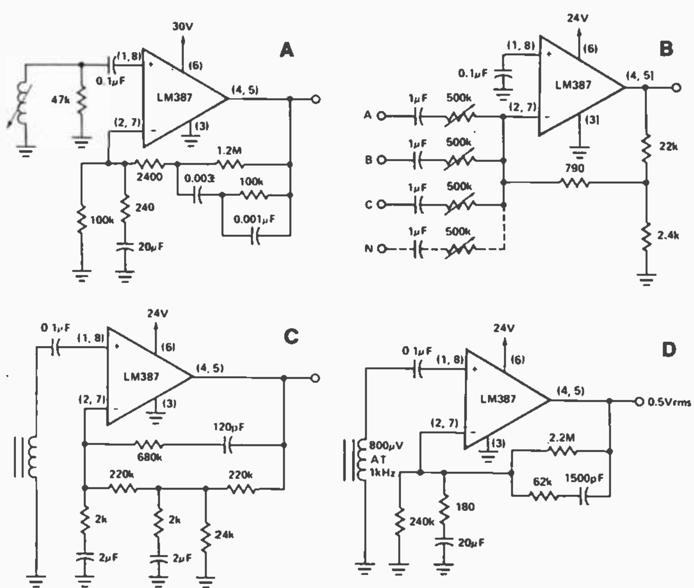


Fig. 6. Applications for the LM387 preamplifier.

it can be just as useful in quite a variety of projects. Manufactured by the Signetics Corporation (811 East Arques Ave., Sunnyvale, CA 94086), the LM387 is a low-noise device comprising some thirty transistors, four zeners, and six diodes in an 8-pin mini-DIP. Half of these are used in each of the independent preamp circuits, as shown by the equivalent single-channel schematic diagram, Fig. 5A. Actual lead connections are identified in Fig. 5B. The device features an internal power supply decoupler-regulator which provides 110 dB power supply rejection and 60 dB channel separation. In addition, it offers an open-loop gain of 104 dB, a noise level of only 0.8 μV, an output voltage swing within 2 V of the dc source, and unity gain bandwidth of 15 MHz. With internal short circuit protection, the unit can dissipate up to 500 mW, and can be operated on single-ended dc supplies from 9 to 40 volts. It is internally compensated for all gains above 10, offers an input resistance of 100,000 ohms (or more), an output resistance of only 150 ohms, and a THD at 75 dB gain of only 0.1%.

Four of the LM387's many possible applications are illustrated in Fig. 6. A magnetic phono preamplifier is shown in Fig. 6A, a multi-channel audio mixer in Fig. 6B, a two-pole fast-turn-on NAB tape preamplifier in Fig. 6C, and a tape playback preamplifier in Fig. 6D. Only one channel is shown in each schematic, although both sets of input and output lead connections are identified. In addition to the suggested circuits, the LM387 can be used in the audio sections of radio transmitters and receivers, in TV sets, in intercoms, in hearing aids, in PA systems, and in many types of test instruments.

Chances are you have at least a nodding acquaintance with operational amplifiers, but how about *power* op amps—those with outputs specified at *multiwatt* rather than milliwatt levels? Such devices are offered by a number of manufacturers. Regardless of manufacturer or specific type, most of these share certain common characteristics. Most of them are hybrid rather than monolithic IC's, have comparatively limited bandwidth (though more than adequate for general audio applications), require heat sinks to realize their full output potentials, and are relatively expensive, although not overly so when compared to the cost of assembling an amplifier with comparable power output using discrete devices. The 833-21C is a typical unit. Manufactured by Beckman Instruments, Inc. (2500 Harbor Boulevard, Fullerton, CA 92634), the device can deliver output currents in excess of ±1 A when operated on a ±12-V dc power source. With an open-loop gain of 100 dB, a full power bandwidth of 15 kHz, and a typical input impedance of 1 megohm, the 833-21C requires only one external compensation capacitor and two current-limiting resistors for proper operation. A hybrid device comprising a small-signal monolithic op amp and a complementary-symmetry power output stage using chip transistors, the unit is supplied in an 8-pin TO-3 package and is, therefore, no larger physically than a conventional power transistor.

Reader's Circuits. Indicating that he would welcome pen pals, one of our overseas readers, Ulf Nordquist (Frejas Väg 34, 240 21 Löddeköpinge, Sweden), contributed the circuits shown in Figs. 7 and 8. Ulf has specified standard American devices in his designs, implying that these must be readily available in Europe. In Fig. 7, a 555 timer (*IC1*) is used as the basis for an electronic "coin flipper" featuring red (*LED1*) and green (*LED2*) visual readouts.

With power on, the circuit is operated simply by touching a small metallic plate. In addition to the 555 and the two standard LED's, all that is required for assembly is four half-watt resistors, two small ceramic or plastic film capacitors, a spst switch (*S1*), a 9-to-15 volt battery (*B1*), a small touch plate (about 1 cm on each side), and, of course, wire, solder, a suitable case, and mounting hardware. Component values are not overly critical and, if desired, 1-k resistors can be substituted for the 470-ohm units specified for *R1* and *R2* to reduce battery current drain.

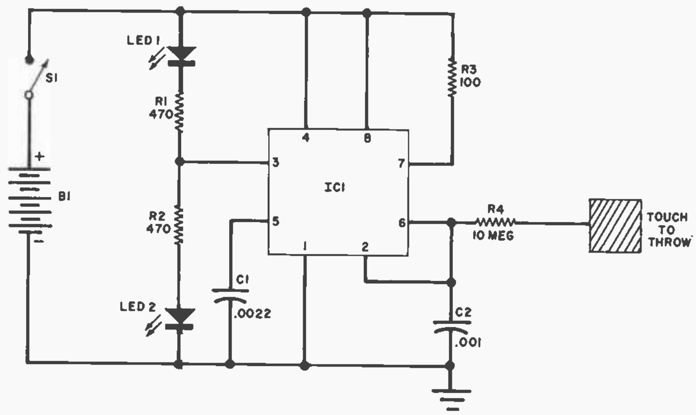


Fig. 7. Electronic coin flipper is operated by touching metallic plate.

Ulf's second circuit, Fig. 8, is an alternate LED flasher featuring a standard 7400 quad NAND gate IC. Here, a 5-volt dc power source is required and a large electrolytic feedback capacitor is employed to achieve a low flashing rate. According to Ulf, the value specified in Fig. 8 establishes a flashing rate of about 1 Hz. This rate may be increased by using a lower value or decreased (made slower) by using a higher value capacitor for *C1*.

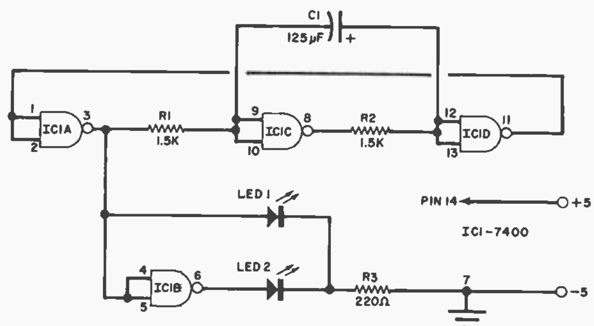
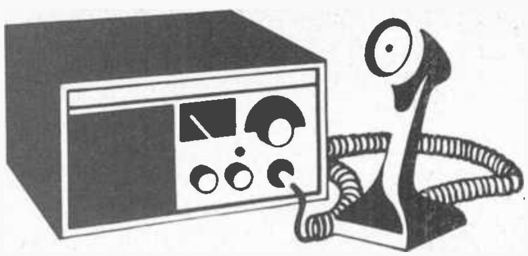


Fig. 8. Flashing rate of LED circuit is determined by value of large capacitor.

Device/Product News. Working with Tate Audio, Ltd. (4324 Promenade Way, Suite 311, Marina del Rey, CA 90291), the National Semiconductor Corp. (2900 Semiconductor Drive, Santa Clara, CA 95051) has developed a group of integrated circuits which will accurately separate and reproduce "quadraphonic" four-channel audio programs from phonograph records and tape cassettes. Designed to decode SQ™ (CBS) type programs, the Tate/National system employs three different IC's and is said to provide separation of channels in any direction approaching 40 dB from 20 Hz to 30 kHz while maintaining a signal-to-noise ratio of 70 dB and a THD of 0.05 percent.



CB Scene

By Ray Newhall, KWI6010

40-CHANNEL EXPANSION AND PURAC II

THE LATEST FCC rule-making decision adds 17 new AM/SSB channels to the existing 23, effective January 1, 1977. Thus, the new frequency band for Class D CB will extend from 26.965 to 27.410 MHz, a bandwidth of 445 kHz.

The FCC has decided that no manufacturer should have a headstart in placing 40-channel units on the market. Consequently, all manufacturers will have an opportunity to present 40-channel CB transceivers for type acceptance by the FCC between Sept. 10 and Nov. 1, 1976. The FCC indicates that any transceivers received during this period that are accepted will get the go-ahead for selling Jan. 1, 1977. After Nov. 1, it will be the first come, first served. However, there is a debate concerning to whom these new units can be sold. The FCC appears to mean selling to distributors, while some manufacturers feel that the date restriction should apply to consumers, not distributors or dealers. Consequently, that first batch of 40-channel CB models may not see the light of dealers' shelves too quickly.

It will likely be many months after Jan. 1, 1977 before extended-channel rigs start crowding out 23-channel ones in dealers' showcases. Indications are that 40-channel units will probably be in short supply until next summer. Furthermore, the new rigs (mobile) are expected to sell for about $20 to $40 more than the 23-channel transceivers. That's on the basis of a suggested selling price. In the marketplace, however, prices of 23-channel rigs will undoubtedly be reduced. So you will do well to pick up some 23-channel units at bargain prices before the end of 1976.

Led by Pathcom and Hy-Gain, a growing number of CB radio manufacturers have announced that anyone buying one of their phase-locked loop (PLL) types of transceivers will be able to have it "re-manufactured" so that frequencies can be extended to 40 channels and interference radiation can meet new FCC requirements. Cost of the re-manufacturing ranges from "up to 20%" of the unit's original suggested selling price to a flat $25 or $30, depending on the manufacturer.

Other Changes. FCC Docket 20120 made several other changes to the FCC Rules, also. For example, it will no longer refer to channels by number, specifying them, rather, by frequency only. Note that two of the new frequencies will be added between present channels 22 and 23, while channels 26 through 40 (15 channels) will be added at 10-kHz intervals above channel 23. However, the EIA has suggested an industry standard that will doubtlessly be adopted—to have the frequencies numbered as consecutive channels, with the new frequencies numbered 24 through 40. The two out-of-order frequencies would be channels 24 and 25, with internal changes that won't be apparent to users.

Other revisions are as follows:

- Channel 11 has been released for general communications, leaving channel 9 the only one of the 40 channels reserved for specific use (emergency and mobile assistance). Technical specifications for type-acceptance have been tightened, requiring that harmonic radiation be suppressed at least 60 dB below the base frequency, with the stipulation that the CB operator is responsible for reducing harmonic radiation even further by the use of external low-pass filters where specific TVI complaints have been filed against him. The Docket makes it evident to the manufacturers that even more stringent standards will be imposed in the near future.
- As of January 1, 1977, all new rigs must be *engraved* with a permanent serial number. The Commission also urges all users to engrave their own personal identification numbers into the equipment, as well, to reduce the saleability of stolen equipment.
- A copy of Part 95, as well as Forms 505 and 555-B, must be shipped with all new rigs.

The PURAC Meeting. The second general meeting of the Personal Use Advisory Committee (PURAC) was held last July at the FCC Laboratory Facility at Guilford, Maryland. The PURAC group consists of leaders of user groups, CB journalists, and companies that have a vital interest in CB. These people volunteer their time and their organizations' facilities to develop joint recommendations to guide the FCC in future rule-making for the Citizen's Radio Service.

Many of the new FCC Rules were in accordance with earlier PURAC recommendations, and much of the business of this PURAC meeting dealt with interpretations of new regulations. Some highlights follow:

Local Interference. Task coordinator, Richard E. Horner, President of E.F. Johnson Co., and his subcommittee leaders presented a dramatic picture of the interference problems being created by the proliferation of CB transceivers. These problems are real, devastating and on an uncontrollable increase. The primary effects of local interference are felt on TV channels 2, 5 and 6, and also on unshielded solid-state audio equipment.

Causes of local interference are numerous. Some are caused by insufficient harmonic suppression, while others are caused by excessive spurious emmissions from CB *receiver* sections. However, the biggest interference problems result from insufficient filtering incorporated into commercial entertainment equipment. It is evident that interference problems must be attacked on two fronts: the technical specifications for CB equipment must be tightened considerably (even though tighter specs will result in higher prices), and TV and audio equipment manufacturers must be required to include adequate filtering and shielding in their equipment in order to exclude unwanted harmonics and spurious interference.

Information Dissemination. There are actually three subcommittees studying the problems of information, education and training. One of the least understood informational problems deals directly with interference. Both the CB public and the general public must be made aware of the causes of interference and actions which can be taken to prevent it. TV service technicians must also be educated to recognize the various types of TVI, and know the cures for each. At least one group of TV stations has agreed to produce educational TV programming to acquaint TV viewers with the problems of TVI.

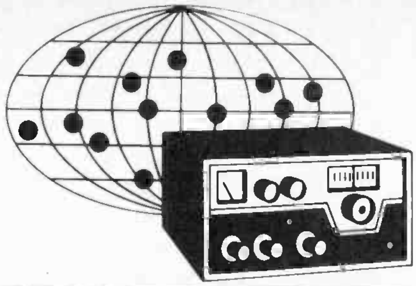
Personal Use Radio Needs. This "blue-sky" subcommittee is charged with examining the future needs of the public for personal radio communications. It is headed-up by Ted Andros, Executive Vice President of Hy-Gain Electronics. Ted has recruited CB notables such as Dave Thompson, President of SBE, to work with him on this important project. He plans to enlist the aid of psychologists, sociologists and economists to predict the future course of personal radio communications. His subcommittee may have a major effect on the future course of CB radio. He asks the logical question, "Why should the general public, in this day of personal mobility, be tied to the end of a telephone line?"

Personal Observations. While at the Guilford Laboratory, I spent some time checking out rumors regarding the extent of FCC activities. One such rumor suggested strongly that the Commission has not adhered strictly to its own type-acceptance policies. I believe that if type acceptance is to succeed, it must be stringently controlled. Because CB is a nontechnical service the CB'er must place his trust in the manufacturer's advertised specs and its compliance with type-acceptance requirements. I feel that type-acceptance testing must extend to random sampling of production models as well as pre-production prototype examination. The manufacturer must share some of the blame if type-accepted rigs fail to meet FCC performance specifications, unless it can be proved that the rig has been tampered with.

I questioned Milton Mobley, Chief Engineer at the FCC Laboratory, on this subject. He assured me that he, personally, had conducted type-acceptance tests on all submitted samples since April, 1976, and that every model receiving a type-acceptance certificate had earned it by passing all aspects of these tests. He would not comment on type-acceptance testing procedures in effect before that date, even though the regulation has been in effect since 1974. Mr. Mobley concedes that it has not been FCC practice to retest production samples unless complaints had been filed. But he explains that testing will be automated in the near future and that production models will be sampled at that time. We certainly hope so.

Congressmen, Please Note. We are all aware that the FCC is "taking in" about $2,000,000 each month in new CB licensing fees. Many of us are not aware that these fees go directly into the U.S. Treasury, not to the FCC. The Commission continually blames many of its short-falls upon the lack of budgeting to cope with the CB problem.

It is about time that Congress recognized the Citizen's Band as a new national force which encompasses from 5% to 10% of all Americans, and growing fast. The FCC must be budgeted to accommodate the growth of CB, and should certainly receive a lion's share of its own proceeds *allocated* for use to administer the Citizen's Band. ◈



DX Listening

By Glenn Hauser

CHANGE IN THE AIR

REALLOCATION of the radio spectrum, on an international basis, is long overdue. Despite some adjustments, the frequency ranges allocated at the World Administrative Radio Conference in Atlantic City in 1947 have remained essentially the same ever since. Many of the developments in radio communications which have taken place in the last few years were not foreseen at that time.

Consider, for instance, the advent of satellite communications, which require a lot of space in the spectrum at super-high-frequencies and reduce the need for some high-frequency circuits. Other factors include the growth of CB in the USA, the prolonged trough in the sunspot cycle, and informed speculation that subsequent peaks in the cycle will not attain previous levels. (The latter means there will be less need for the higher part of the hf spectrum and more need for the already overcrowded lower part.

Groundwork for the 1979 WARC conference has been underway for several years. Each administration wants to have its position solidified, in time for the multi-national negotiations, where third-world nations are expected to hold the balance of power.

To arrive at the U.S. position, the FCC has been sponsoring meetings in Washington of various interest groups. International broadcasting is but one of the subject areas of these meetings. Representatives of FCC-licensed hf broadcasters, listeners' groups such as the North American Shortwave Association and the Association of North American Radio Clubs, and interested individuals have worked toward formulating U.S. policy. At this writing, some proposals have been made, but are not formally adopted. The FCC will have the final say, after several more meetings. However, it is not too soon to discuss some of the initial ideas.

Satellite communications are so superior, both in capacity and quality, to hf point-to-point links, that the latter seems destined to be used mainly as backup, and for contacting the few spots on the globe still without earth stations. This means that a very large fraction of the hf spectrum, presently allocated to international fixed public service (point to point) is no longer needed for that purpose.

International broadcasting, next to CB, suffers most from overcrowded bands. Much of this is the broadcasters' fault because they use more power and more frequencies than are necessary. It's a vicious cycle. Radio Nederland's Jim Vastenhoud pointed out at a meeting of the European DX

Council last May that there were about 600 shortwave transmitters in the world with 250 kW or more of power. And many more were being installed, especially in China and the Middle East. Yet there are at present only about 400 channels available on the hf bands, and many of these in the 21- and 25-MHz bands are of little use during the sunspot trough.

There is no prospect that nations will voluntarily cut back their broadcasting to alleviate the present average level of three mutually interfering transmissions at once on each channel. So the solution is to expand the broadcasting bands into regions presently occupied by IFPS.

Out of Band. Band limits cannot be enforced (though one imaginative layman suggested jamming as a means of enforcement). Many stations already operate outside the allocated broadcasting bands. Some have historical precedent on their side—using frequencies that were theirs before the 1947 limits were established. Others have taken up *OOB* (out of band) broadcasting more recently, as a strategy to escape in-band congestion.

Until this year, Voice of America broadcast strictly in-band, while employing more and more PTP channels OOB. Some of the latter are independent sideband (ISB), with different programs on each side; others are compatible single sideband (CSSB). Domestic in-band transmitters themselves are considered by the VOA to be feeders for relay, with the exception of some broadcasts to Oceania and Latin America.

Last summer, VOA decided to make use of a loophole in ITU regulations (which the U.S. adheres to, though it is not forced to), allowing OOB broadcasting, as long as no interference is caused to the primary service on a given frequency. The VOA relay in Liberia began using 12000 kHz, which is 25 kHz above the nominal limit of the 11-MHz band. There could hardly be any PTP complaints, as the frequency was already used by Radio Moscow! This new VOA policy lessens its competitive disadvantage against Radio Moscow, which has always felt free to use any channel it pleases.

Though there is no sign that Radio Moscow is giving up OOB, a number of Soviet regional stations have begun a minor counter-trend toward in-band broadcasting. Alma Ata on 9380 and 10,530 and Magadan on 12,240 kHz recently vacated those long-established frequencies far OOB.

The bands have already been widened, *de facto*. But the proposal is to make it *de jure*. If this is done, all countries will feel free to use the new frequencies, not just those bold ones leading the way. Before long, the congestion would also expand, (though, we hope, at a reduced level). The International Broadcasting Service Group proposes the following band expansion, to be used *worldwide*. (At present, one of the problems is usage of certain bands in certain regions only.)

Present kHz	*Proposed kHz*
3900-4000	3900-4060
none	4450-4650
5950-6200	5740-6200
7100-7300	7300-7700
9500-9775	9400-9900
11700-11975	11500-12000
none	13600-14000
15100-15450	15050-15700
17700-17900	17500-18000
21450-21750	21450-21850
25600-26100	no change

◈

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ENGLISH-LANGUAGE SHORTWAVE BROADCASTS FOR NOV. THRU FEB.

by Richard E. Wood

TO EASTERN NORTH AMERICA

TIME-EST	TIME-GMT	STATION	QUAL*	FREQUENCIES, MHz
5:00-6:00 a.m.	1000-1100	**Montreal, Canada	G	5.97, 9.57
6:00-6:25 a.m.	1100-1125	Tirana, Albania	F	9.50, 11.865
6:00-7:30 a.m.	1100-1230	London, England	G	5.99 (via Sackville), 15.07
6:00-8:00 a.m.	1100-1300	Melbourne, Australia	G	9.58
6:00-9:00 a.m.	1100-1400	**VOA, Washington, USA	G	5.955, 9.73
6:05-7:25 a.m.	1105-1225	Trans-World Radio, Bonaire, N.A.	G	11.815
6:15-7:15 a.m.	1115-1215	Montreal, Canada	G	5.97, 9.655
6:30-9:00 a.m.	1130-1400	**Montreal, Canada (Northern Service)	G	5.96, 9.625 (includes French, etc.)
7:00-7:30 a.m.	1200-1230	Jerusalem, Israel	F	11.655, 15.10, 15.485
7:00-7:55 a.m.	1200-1255	Peking, China	F	11.685
7:10-7:30 a.m.	1210-1230	**Santiago, Chile	F	9.566, 11.81, 15.15
7:15-7:30 a.m.	1215-1230	Athens, Greece	F	15.345
7:15-11:30 a.m.	1215-1630	HCJB, Quinto, Ecuador	G	11.745, 15.115
7:30-8:30 a.m.	1230-1330	London, England	G	15.07
7:30-9:00 a.m.	1230-1400	Trans-World Radio, Bonaire, N.A.	G	15.255 (Sat., Sun.)
8:00-8:30 a.m.	1300-1330	**Bucharest, Rumania	G	11.94, 15.25
8:15-8:45 a.m.	1315-1345	Berne, Switzerland	G	15.14
8:30 a.m.-3:00 p.m.	1330-2000	**London, England	G	9.41, 15.07
8:30-9:00 a.m.	1330-1400	Helsinki, Finland	G	15.11
9:00-9:30 a.m.	1400-1430	Oslo, Norway	G	17.80 (Sun.)
		Stockholm, Sweden	G	15.305
9:00 a.m.-7:00 p.m.	1400-2400	**Montreal, Canada (Northern Service)	G	9.625, 11.72 (includes French, etc.)
10:00-11:15 a.m.	1500-1615	London, England	G	17.84 (via Ascension)
10:15-10:30 a.m.	1515-1530	Athens, Greece	F	15.345
11:00-11:30 a.m.	1600-1630	Oslo, Norway	G	15.175 (Sun.)
11:00 a.m.-12:09 p.m.	1600-1709	London, England	G	9.58 (via Sackville, Sun. from 1500)
12 noon-3:00 p.m.	1700-2000	**Kuwait, Kuwait	F	9.555, 11.845
12:04-12:56 p.m.	1704-1756	**Paris, France	G	9.52, 9.63, 11.705, 11.73, 11.735, 11.745, 11.89, 11.905, 11.94, 15.30, 15.425, 17.72
1:00-1:57 p.m.	1800-1857	**Montreal, Canada	G	11.865, 15.325, 17.82
1:45-3:00 p.m.	1845-2000	**Abidjan, Ivory Coast	F	11.92 (Mon.-Sat.)
2:00-3:00 p.m.	1900-2000	**Algiers, Algeria	F	11.91, 15.42
2:00-5:00 p.m.	1900-2200	**Jeddah, Saudi Arabia	F	11.855
2:45-5:30 p.m.	1945-2230	**Delhi, India	F	9.525, 9.912, 11.62
3:00-3:30 p.m.	2000-2030	**Tehran, Iran	F	9.022 (11.77 alternate)
		Jerusalem, Israel	G	5.90, 7.395
3:00-4:00 p.m.	2000-2100	Accra, Ghana	F	11.85
3:00-4:15 p.m.	2000-2115	**London, England	G	9.41, 11.75, 15.07
3:00-4:20 p.m.	2000-2120	**Hilversum, Holland	F	11.73 (via Talata)
3:45-4:15 p.m.	2045-2115	**Valletta, Malta	F	6.035 (Sat.)
3:50-4:50 p.m.	2050-2150	**Havana, Cuba	G	11.865, 17.75
4:00-4:45 p.m.	2100-2145	**Rawalpindi, Pakistan	F	9.445, 11.672
4:00-4:50 p.m.	2100-2150	**Johannesburg, S. Africa	G	7.27, 9.585, 11.80, 11.90
4:00-5:00 p.m.	2100-2200	**Brasilia, Brazil	G	11.78
		**Montreal, Canada	G	9.64, 11.895
4:15-5:00 p.m.	2115-2200	London, England	G	5.975, 9.58, 15.26 (via Ascension)
4:30-5:00 p.m.	2130-2200	Sofia, Bulgaria	G	6.07, 9.70
4:30-5:50 p.m.	2130-2250	Hilversum, Holland	G	9.715, 11.73 (Sun.: Dutch)
5:00-5:15 p.m.	2200-2215	**Belgrade, Yugoslavia	F	6.10, 7.24, 9.62
5:00-5:30 p.m.	2200-2230	Oslo, Norway	F	9.645 (Sun.)
5:00-6:15 p.m.	2200-2315	**Cairo, Egypt	G	9.805
5:00-7:30 p.m.	2200-0030	**Ankara, Turkey	F	11.88
5:00-10:30 p.m.	2200-0330	London, England	G	5.975, 7.325, 9.58 (via Ascension)
5:30-6:00 p.m.	2230-2300	Jerusalem, Israel	G	5.90, 7.395, 9.412, 9.435
		Vilnius, U.S.S.R.	G	5.915, 5.94, 7.31, 7.355, 7.44 (Sat., Sun.)
5:30-6:20 p.m.	2230-2320	Johannesburg, S. Africa	G	5.98, 9.585, 11.80, 11.90
5:50-6:10 p.m.	2250-2310	**Santiago, Chile	F	9.566, 11.81, 15.15
6:00-6:30 p.m.	2300-2330	Stockholm, Sweden	F	6.12, 9.605, 11.705
		Moscow, U.S.S.R.	G	5.94, 6.02, 6.045, 7.205, 7.235, 7.355, 9.635, 9.79, 9.80, 12.05, 15.14, 15.18, 15.45, 17.72
6:00-6:50 p.m.	2300-2350	**Buenos Aires, Argentina	G	11.71 (Mon.-Fri.)
6:00-8:00 p.m.	2300-0100	Montreal, Canada	G	6.04 (Mon.-Fri.)

6:30-7:00 p.m.	2330-2400	Moscow, U.S.S.R.	G	4.86, 5.94, 6.02, 6.02, 6.045, 7.105, 7.115, 7.15 7.205, 7.235, 7.355, 9.635, 9.79, 9.80, 12.05, 15.14, 15.18, 15.45, 17.72
6:45-7:00 p.m.	2345-2400	**Voice of Org. of American States, Washington, USA	G	6.13, 9.64, 11.74
6:45-7:45 p.m.	2345-0045	Tokyo, Japan	F	11.705, 15.30
7:00-7:25 p.m.	0000-0025	Tirana, Albania	G	7.065, 9.75
7:00-7:30 p.m.	0000-0030	Oslo, Norway	F	6.18, 9.55 (Sun.)
		Moscow, U.S.S.R.	G	4.86, 5.94, 6.045, 7.105, 7.115, 7.15, 7.165, 7.205, 7.355, 9.80, 12.05, 15.14, 15.18, 15.45, 17.72
7:00-7:55 p.m.	0000-0055	Sofia, Bulgaria	F	9.70
		Peking, China	F	9.94, 11.675, 11.945
7:00-9:00 p.m.	0000-0200	**Luxembourg	F	6.09
7:00-8:00 p.m.	0000-0100	**VOA, Washington, USA	G	6.19, 9.67, 11.83, 11.895
7:00 p.m.-12:06 a.m.	0000-0606	**Montreal, Canada (Northern Service)	F	5.96, 9.625 (includes French, etc.)
7:15-7:30 p.m.	0015-0030	Athens, Greece	F	9.76
7:15-7:45 p.m.	0015-0045	Brussels, Belgium	F	9.73
7:30-7:55 p.m.	0030-0055	Prague, Czechoslovakia	F	6.055, 9.74
7:30-8:00 p.m.	0030-0100	Stockholm, Sweden	F	6.035
		Kiev, U.S.S.R.	G	6.02, 7.15, 7.205, 7.26, 9.78, 12.05, 15.14, 15.18, 15.455
		Vilnius, U.S.S.R.	G	5.94, 7.355 (Sat., Sun.)
7:40 p.m.-12 mdt.	0040-0500	HCJB, Quito, Ecuador	G	6.095, 9.56, 11.915
8:00-8:15 p.m.	0100-0115	Vatican City	G	5.995, 6.015, 9.605
8:00-8:20 p.m.	0100-0120	Rome, Italy	G	6.01, 9.575
8:00-8:30 p.m.	0100-0130	Moscow, U.S.S.R.	G	4.86, 5.94, 6.02, 6.045, 6.175, 7.105, 7.115, 7.15, 7.205, 7.355, 9.635, 9.78, 9.79, 9.80, 12.05, 15.14, 15.45
8:00-8:45 p.m.	0100-0145	Berlin, Ger. Dem. Rep.	F	9.73
8:00-8:55 p.m.	0100-0155	Peking, China	G	7.12, 9.78 (via Tirana), 9.94, 11.945, 12.055
8:00-8:57 p.m.	0100-0157	Montreal, Canada	G	6.085, 9.65
		Prague, Czechoslovakia	G	5.93, 7.345, 9.54, 9.63, 11.99
8:00-10:00 p.m.	0100-0300	Melbourne, Australia	P	15.32, 17.795
8:00-10:30 p.m.	0100-0330	Havana, Cuba	G	11.725, 11.93
8:00-11:00 p.m.	0100-0400	Madrid, Spain	G	6.065, 11.88 (Mon.-Sat.)
8:10-8:30 p.m.	0110-0130	**Santiago, Chile	F	9.566, 11.81, 15.15
8:30-8:50 p.m.	0130-0150	Cologne, Ger. Fed. Rep.	G	6.04, 6.075, 6.10 (via Malta), 9.565, 9.69, 9.745, 11.865 (via Malta)
8:30-8:55 p.m.	0130-0155	Tirana, Albania	G	6.20, 7.30
		Vienna, Austria	P	6.155, 9.77
8:30-9:00 p.m.	0130-0200	Moscow, U.S.S.R.	G	4.86, 5.94, 6.02, 6.045, 7.105, 7.115, 7.15, 7.205, 7.355, 9.635, 9.78, 9.79, 9.80, 11.86, 12.05, 15.14
8:30-9:25 p.m.	0130-0225	Bucharest, Rumania	F	5.99, 9.57, 9.68, 11.775, 11.94
8:45-9:15 p.m.	0145-0215	Berne, Switzerland	G	5.965, 6.135, 9.725, 11.715
9:00-9:30 p.m.	0200-0230	Budapest, Hungary	G	6.00, 7.215, 9.585, 9.833, 11.91 (Exc. Sun.)
		Oslo, Norway	F	6.18 (Sun.)
		Warsaw, Poland	P	6.095, 6.135, 7.27, 9.675, 11.815, 11.84, 15.12
9:00-9:55 p.m.	0200-0255	Peking, China	F	7.06, 9.94, 12.055
9:00-10:00 p.m.	0200-0300	Moscow, U.S.S.R.	G	4.86, 5.94, 6.02, 6.045, 7.105, 7.115, 7.205, 7.26, 7.355, 9.635, 9.78, 9.79, 9.80, 11.86, 12.05, 15.14
9:00-10:20 p.m.	0200-0320	Hilversum, Holland	G	6.165 (via Bonaire)
9:00-10:30 p.m.	0200-0330	Cairo, Egypt	G	9.475
9:10-9:30 p.m.	0210-0230	**Santiago, Chile	F	9.566, 11.81, 15.15
9:15-9:30 p.m.	0215-0230	Athens, Greece	F	9.76
9:30-9:55 p.m.	0230-0255	Tirana, Albania	G	6.20, 7.30
9:30-10:00 p.m.	0230-0300	Libson, Portugal	G	6.025, 11.935
10:00-10:30 p.m.	0300-0330	Helsinki, Finland	F	6.12
		Budapest, Hungary	G	6.00, 7.215, 9.585, 9.833, 11.91
		Kiev, U.S.S.R.	G	5.98, 6.02, 7.245, 7.26, 7.40, 9.58, 9.78, 11.86
10:00-10:35 p.m.	0300-0335	Warsaw, Poland	P	6.095, 6.135, 7.27, 9.675, 11.815, 11.84, 15.12
10:00-10:55 p.m.	0300-0355	Peking, China	G	7.12, 9.78 (via Tirana)
10:00-11:00 p.m.	0300-0400	Buenos Aires, Argentina	G	9.69 (Mon.-Fri.)
		Prague, Czechoslovakia	G	5.93, 7.345, 9.54, 9.63, 11.99
		Moscow, U.S.S.R.	G	4.86, 5.94, 6.045, 7.115, 7.205, 7.355, 9.70, (via Sofia)

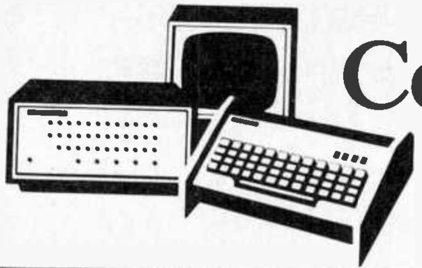
10:00-11:25 p.m.	0300-0425	**Johannesburg, S. Africa	G	3.995, 5.98, 7.27, 9.585
10:10-10:30 p.m.	0310-0330	**Santiago, Chile	F	9.566, 11.81, 15.15
10:30-10:55 p.m.	0330-0355	Tirana, Albania	G	6.20, 7.30
		Vienna, Austria	P	6.155, 9.77
10:30-11:30 p.m.	0330-0430	London, England	G	5.975, 9.58 (via Ascension)
10:30-11:50 p.m.	0330-0450	Havana, Cuba	G	11.725, 11.76, 11.93
11:00-11:15 p.m.	0400-0415	Budapest, Hungary	G	6.00, 7.215, 9.585, 9.833, 11.91 (Tue., Fri.)
11:00-11:25 p.m.	0400-0425	Bucharest, Rumania	F	5.99, 6.155, 6.19, 9.57, 9.68, 11.775, 11.94
11:00-11:30 p.m.	0400-0430	Oslo, Norway	F	6.18, 9.55 (Sun.)
		Sofia, Bulgaria	G	9.70
11:00 p.m.-12 mdt.	0400-0500	Moscow, U.S.S.R.	G	4.86, 5.94, 6.045, 7.115, 7.15, 7.205 7.355
11:00 p.m.-1:00 a.m.	0400-0600	Montreal, Canada	G	6.135, 9.655
11:30 p.m.-12 mdt.	0430-0500	**London, England	G	6.005, 9.58 (via Ascension)
11:50 p.m.-1:00 a.m.	0450-0600	Havana, Cuba	G	11.725, 11.76
12 mdt.-12:15 a.m.	0500-0515	Jerusalem, Israel	G	5.90, 7.395, 7.412
12 mdt.-1:00 a.m.	0500-0600	**London, England	G	6.005, 7.27, 9.60 (via Ascension)
12 mdt.-2:00 a.m.	0500-0700	HCJB, Quito, Ecuador	G	6.095, 9.56
1:45-3:35 a.m.	0645-0835	**Lagos, Nigeria	G	7.275, 15.12

TO WESTERN NORTH AMERICA

TIME-PST	TIME-GMT	STATION	QUAL*	FREQUENCIES, MHz
3:00-3:15 a.m.	1100-1115	Tokyo, Japan	G	5.99
3:00-4:25 a.m.	1100-1225	Trans-World Radio, Bonaire, N.A.	G	11.815
3:00-5:30 a.m.	1100-1330	London, England	G	5.99 (via Sackville), 11.75 (via Tebrau)
3:00-6:00 a.m.	1100-1400	**VOA, Washington, USA	G	5.955, 9.73
4:00-4:15 a.m.	1200-1215	Tokyo, Japan	P	5.99
4:00-4:30 a.m.	1200-1230	**Tashkent, U.S.S.R.	F	9.60, 11.925
4:10-4:30 a.m.	1210-1230	**Santiago, Chile	F	9.566, 11.81, 15.15
4:15-8:30 a.m.	1215-1630	HCJB, Quinto, Ecuador	G	11.745, 15.115
4:30-6:00 a.m.	1230-1400	Trans-World Radio, Bonaire, N.A.	G	15.255 (Sat., Sun.)
5:00-5:15 a.m.	1300-1315	Tokyo, Japan	F	5.99
5:30-7:00 a.m.	1330-1500	**Delhi, India	F	11.81, 15.335
5:30-8:15 a.m.	1330-1615	**London, England	F	9.74, 11.75, 15.31 (via Tebrau)
6:00-6:30 a.m.	1400-1430	Tokyo, Japan	G	5.99
		**Tashkent, U.S.S.R.	F	9.60, 11.925
6:00-7:20 a.m.	1400-1520	**Hilversum, Holland	G	11.73 (via Talata)
6:00-8:55 a.m.	1400-1655	Manila, Philippines	F	9.58 (closes 1555 Sun.)
7:00-7:15 a.m.	1500-1515	Tokyo, Japan	G	5.99
7:00-8:15 a.m.	1500-1615	London, England	G	17.84 (via Ascension)
8:00-8:15 a.m.	1600-1615	Tokyo, Japan	G	5.99
8:00-8:30 a.m.	1600-1630	Oslo, Norway	F	11.895 (Sun.)
8:00-9:09 a.m.	1600-1709	London, England	G	9.58, 15.365 (via Sackville, opens 1500 Sat.)
8:42-8:51 a.m.	1642-1651	Hilversum, Holland	G	11.82, 15.19 (via Bonaire, Mon.-Fri.)
9:00-9:15 a.m.	1700-1715	Tokyo, Japan	F	5.99
10:00-10:15 a.m.	1800-1815	Tokyo, Japan	F	5.99
10:30-11:30 a.m.	1830-1930	Taipei, Taiwan	F	9.51, 11.86, 15.37
10:30 a.m.-12 noon	1830-2000	**London, England	F	11.82 (via Ascension)
11:00-11:07 a.m.	1900-1907	**Papeété, Tahiti	F	11.825, 15.17 (exc. Sun.)
11:00-11:15 a.m.	1900-1915	Tokyo, Japan	G	9.505
12 noon-12:15 p.m.	2000-2015	Tokyo, Japan	G	9.505
12 noon-1:20 p.m.	2000-2120	**Hilversum, Holland	G	11.73 (via Talata)
1:00-1:15 p.m.	2100-2115	Tokyo, Japan	F	9.505
1:15-3:00 p.m.	2115-2300	London, England	G	9.58 (via Ascension)
2:00-2:15 p.m.	2200-2215	Tokyo, Japan	G	15.105
2:00-4:00 p.m.	2200-2400	**VOA, Washington, USA	G	17.82, 17.895, 21.61
2:30-3:00 p.m.	2230-2300	Jerusalem, Israel	F	5.90, 7.395, 7.412, 9.435
2:30-3:20 p.m.	2230-2320	Johannesburg, S. Africa	G	5.98, 9.585, 11.80, 11.90
2:50-3:10 p.m.	2250-2310	**Santiago, Chile	F	9.566, 11.81, 15.15
3:00-3:30 p.m.	2300-2330	Tokyo, Japan	G	15.105
3:00-4:30 p.m.	2300-0030	London, England	G	6.175, 9.51 (via Sackville), 9.58 (via Ascension)
3:00-5:00 p.m.	2300-0100	Montreal, Canada	F	6.04
3:45-4:00 p.m.	2345-2400	**Voice of Org. of American States, Washington, USA	G	6.13, 9.64, 11.74
4:00-4:15 p.m.	0000-0015	Tokyo, Japan	G	15.105
4:00-5:00 p.m.	0000-0100	**VOA, Washington, USA	G	11.83, 11.895, 15.40

4:30-5:30 p.m.	0030-0130	**Trans-World Radio, Bonaire, N.A.	G	11.925
4:30-7:30 p.m.	0030-0330	London, England	G	6.175 (via Sackville) 9.51 (via Greenville) 9.58 (via Ascension)
4:40-9:00 p.m.	0040-0500	HCJB, Quito, Ecuador	G	6.095, 9.56, 11.915 (includes some Eskimo)
5:00-5:15 p.m.	0100-0115	Tokyo, Japan	G	15.105
5:00-7:00 p.m.	0100-0300	Melbourne, Australia	G	15.32, 17.795
5:00-8:00 p.m.	0100-0400	Madrid, Spain	F	6.065, 11.88 (Mon.-Sat.)
5:10-5:30 p.m.	0110-0130	**Santiago, Chile	F	9.566, 11.81, 15.15
5:30-6:30 p.m.	0130-0230	Tokyo, Japan	G	15.195, 15.42, 17.725, 17.825
6:00-6:15 p.m.	0200-0215	Tokyo, Japan	G	15.105
6:00-7:50 p.m.	0200-0350	Taipei, Taiwan	G	11.825, 15.345, 17.89
6:10-6:30 p.m.	0210-0230	**Santiago, Chile	G	9.566, 11.81, 15.15
6:30-7:00 p.m.	0230-0300	Stockholm, Sweden	F	6.045, 9.695
7:00-7:15 p.m.	0300-0315	Tokyo, Japan	G	15.105
7:00-7:30 p.m.	0300-0330	Kiev, U.S.S.R.	G	5.98, 6.02, 7.245, 7.26, 7.40, 9.58, 9.78, 11.86
7:00-7:55 p.m.	0300-0355	Peking, China	G	7.12, 9.78 (via Tirana), 9.46, 9.94, 11.65, 12.055
7:00-8:25 p.m.	0300-0425	**Johannesburg, S. Africa	G	3.995, 5.98, 7.27, 9.585
7:10-7:30 p.m.	0310-0330	**Santiago, Chile	G	9.566, 11.81, 15.15
7:20-8:25 p.m.	0320-0425	**TIFC, San José, Costa Rica	F	6.035, 9.645 (opens 0300 Sat., Sun.)
7:22-7:28 p.m.	0322-0328	Erevan, U.S.S.R.	G	11.69, 11.96, 15.13, 15.18, 15.455 (Sat., Tue., Wed., Fri.)
7:30-8:00 p.m.	0330-0400	Moscow, U.S.S.R.	G	5.905, 6.02, 7.26, 9.54, 9.58, 9.61, 9.635, 9.735, 9.78, 11.69
7:30-8:15 p.m.	0330-0415	Berlin, Ger. Dem. Rep.	P	5.955, 6.08, 9.56, 9.73
7:30-8:30 p.m.	0330-0430	London, England	G	6.175 (via Sackville) 9.58 (via Ascension)
8:00-8:15 p.m.	0400-0415	Tokyo, Japan	G	9.505
8:00-8:30 p.m.	0400-0430	Sofia, Bulgaria	P	9.70
		Budapest, Hungary	P	6.00, 7.215, 9.585, 9.833, 11.91, (Tues., Fri.)
		Seoul, Rep. Korea	F	9.64, 11.86
8:00-8:55 p.m.	0400-0455	Peking, China	G	9.46, 9.94, 11.65, 12.055
8:00-9:00 p.m.	0400-0500	Moscow, U.S.S.R.	G	5.905, 6.02, 7.175, 7.26, 9.54, 9.58, 9.61, 9.635, 9.735, 11.69
8:00-10:00 p.m.	0400-0600	Montreal, Canada	G	6.135, 9.655
8:30-9:00 p.m.	0430-0500	Vienna, Austria	P	6.015
		Berne, Switzerland	F	6.045, 9.725
8:30-11:30 p.m.	0430-0730	London, England	G	6.175 (via Montserrat)
9:00-9:15 p.m.	0500-0515	Jerusalem, Israel	F	5.90, 7.395, 7.412
		Tokyo, Japan	G	9.505
9:00-9:30 p.m.	0500-0530	Lisbon, Portugal	P	6.025, 11.935
9:00-10:20 p.m.	0500-0620	Hilversum, Holland	G	6.165, 9.175 (via Bonaire)
9:00-9:30 p.m.	0500-0530	Moscow, U.S.S.R.	G	5.905, 6.02, 7.11, 7.26, 9.52, 9.54, 9.58, 9.61, 9.635, 9.735
9:00-11:00 p.m.	0500-0700	HCJB, Quito, Ecuador	G	6.095, 9.56
		**London, England	G	6.005, 7.27, 9.60 (via Ascension)
9:30-9:50 p.m.	0530-0550	Cologne, Ger. Fed. Rep.	G	6.10 (via Malta), 6.185, 9.545
9:30-10:00 p.m.	0530-0600	Moscow, U.S.S.R.	G	5.905, 6.02, 7.11, 7.175, 7.22, 7.26, 7.30, 9.52, 9.54, 9.58, 9.635, 9.735
10:00-10:15 p.m.	0600-0615	Tokyo, Japan	G	9.505
10:00-10:30 p.m.	0600-0630	Oslo, Norway	P	9.645 (Sun.)
		Moscow, U.S.S.R.	G	5.905, 6.02, 7.11, 7.15, 7.175, 7.22, 7.26, 9.52, 9.54, 9.58, 9.635, 9.735
10:00-11:00 p.m.	0600-0700	Buenos Aires, Argentina	G	9.69 (Mon.-Fri.)
10:30-11:30 p.m.	0630-0730	Moscow, U.S.S.R.	G	6.02, 7.11, 7.15, 7.175, 7.22, 7.26, 7.30, 9.54, 9.58, 9.635, 9.735
10:30 p.m.-12:30 a.m.	0630-0830	Havana, Cuba	G	9.525
10:30 p.m.-12:55 a.m.	0630-0855	Kuala Lumpur, Malaysia	G	7.22, 11.90, 15.275
11:00-11:15 p.m.	0700-0715	Tokyo, Japan	G	9.505
11:00-11:30 p.m.	0700-0730	**London, England	G	6.005, 9.60 (via Ascension)
11:30 p.m.-12:15 a.m.	0730-0815	**London, England	G	9.60, 11.86, 15.40 (via Ascension)
11:30 p.m.-2:30 a.m.	0730-1030	**Wellington, New Zealand	G	6.105
12 mdt.-12:15 a.m.	0800-0815	Tokyo, Japan	G	9.505
1:00-1:15 a.m.	0900-0915	Tokyo, Japan	G	9.505
2:00-2:30 a.m.	1000-1030	Seoul, Rep. Korea	F	9.635, 11.86
		Tokyo, Japan	G	5.99
2:00-3:00 a.m.	1000-1100	Pyongyang, Dem. Rep. Korea	G	9.42, 11.535

* Reception quality, East Coast (West Coast) location: G-good, F-fair, P-poor
** Not intended for North America, but receivable satisfactorily.
Days refer to local date in target area.



Computer Bits

By Hal Chamberlin

MASS-STORAGE SYSTEMS

MANY interesting and useful applications of hobbyist computers require a program-controlled mass-storage device. Although a simple audio-cassette interface can be used, there are other more automatic, practical storage systems.

Applications Needing Mass Storage. Home accounting is a computer application that is often mentioned as needing a mass storage. One would expect a double-entry bookkeeping method to be used here, with all incomes and expenditures divided into a number of accounts according to the nature of the transaction. Once a week, or as needed, new transactions would be added to the appropriate accounts. Ideally, a verbal description of each transaction would be retained with the account record as well as the amount and date. Monthly, or as required, the system could be instructed to compute and print a personal financial statement. Also, if the accounts were set up properly, preparing a tax return could be a relatively simple task. The amount of mass storage needed, however, can become substantial. Assuming a moderately detailed system of 30 accounts and an average of 25 transactions per account per year, yields a total of 2250 transactions to save for the 3-year record-holding period required by the IRS. Allowing 30 bytes for a description, 4 bytes for a date and 4 bytes for an amount, gives a total of 85k bytes required for the application.

Learning games are an exciting application that benefit from mass storage. A learning approach to implementing complex game-playing programs such as checkers is often easier and can give better results than a direct approach. Such a program, when first run, would only be cognizant of the game rules. As it plays human opponents, files of data concerning fatal mistakes made by the program and winning tactics employed by the opponent would be accumulated. Eventually the program would acquire a skill level just below that of the best opponent and would not suffer from "stupid" mistakes. Additionally, intermediate data files at various skill levels may be retained. Such files may get rather large. They are also subject to frequent change as the program learns. High-speed access to the data is helpful in keeping the game moving along.

Text editing for letters, reports, and other documents is another mass-storage-oriented application. The editing process may involve frequent changes, insertions, and deletions of blocks of text in the document. Also, it may be desirable to move a block of text from one portion of a document to another. The amount of storage needed varies with the type of document. A thesis may require 300k bytes, an article 30k and a letter 3k. Large insertions in the middle of a document may cause problems with certain types of mass storage.

Mass-Storage Terminology. Over the years, many terms have been developed to describe mass-storage systems. Perhaps most fundamental is the *on-line storage capacity* of a system. On-line storage capacity is the amount of data that can be accessed automatically by the program without requiring human intervention to change tapes, etc.

On all mass-storage systems, data is organized into blocks called *records*. When a data transfer between the storage system and the computer is performed, an entire record must be transferred. Some systems utilize a fixed record size, which means that all records are of the same length. Most tape systems, however, allow a variable record size, which means that a record may be as short as one byte or as long as desired. Note that the use of short records may reduce the storage capacity substantially due to gaps between records.

The *transfer rate* of a system is a measure of how fast data can be read from, or written into, the storage media. Often this is qualified further by specifying a "burst" transfer rate and an "average" transfer rate. The burst rate is the actual speed during reading or writing. The average rate is measured for a long transfer of several thousand bytes. It is usually less than the burst rate because of the gaps between blocks of data or time spent searching for the next block of data.

In a *sequential access* storage system, all of the data is stored as one long string of records. The access mechanism (usually a magnetic head) can be located at any point in the string. In the simplest systems, only two operations are allowed; rewind (place the head at the beginning of the string); and read forward, starting at the current head position. Writing of new data is always done at the end of the string. More sophisticated sequential-access systems may allow reading backward and high-speed search in both directions. Some may even allow records in the middle of the string to be updated.

Data records in a *random-access* storage system are organized in a rectangular array consisting of a number of rows and columns. A particular record is read or written simply by giving its row and column numbers. The storage device goes directly to the requested location, usually without any searching. Individual records may be rewritten at will. Random-access storage systems almost always utilize fixed record lengths.

Tape Mass-Storage Systems. Tape, particularly in cassettes, is a popular, inexpensive mass-storage medium. The on-line storage capacity of a C60 cassette, for example, ranges from 50k bytes using the Computer Users Tape System or CUTS (see "Computer Bits," March, 1976) audio format (also known as Kansas City format) to approximately 600k bytes using the Digital Group's "group coded recording" digital format. Transfer rates range from about 25 bytes per second for standard audio to over 1000 bytes per second for high-performance digital recording. Most tape systems for hobbyist use allow variable-length records with perhaps a maximum allowable length.

Magnetic tape is inherently a sequential-access storage medium. Here, data records are strung out along the length of the tape with enough blank space between records to allow for starting and stopping the tape. Finding a desired record on the tape and reading it into the computer's memory is a fundamental operation. If the record's location is not known, about the best that can be done is to rewind the tape and start reading until the needed record is reached and read. This, of course, can take several minutes even on a high-performance digital cassette system. One possibility for speeding up is to maintain an "index record" at the beginning of the tape that contains the location of all of the other records on the tape. The program would keep the index in memory while that particular tape is loaded on the drive. Then, on a simple system, at least a decision between reading forward and rewinding and starting over can be made. On a system with read-backward capability, the average search time may be shortened further by reading backward when appropriate, rather than rewinding. A system with high-speed search allows records to be *counted* at two to ten times the normal tape speed in either direction. When the required number of records has been skipped, normal read speed is resumed and the desired record is read. Using the high-speed search feature allows average random-access times of less than 30 seconds on a 600k byte tape with one currently available cassette system.

All three applications described earlier required data records to be updated (read, modified, and rewritten) frequently. With a simple tape system the only possible method of updating is to make a copy of the "old" tape onto a "new" tape, changing the records to be updated during the copying. Besides requiring two tape drives, the process can be quite slow if individual, random updates are required, as in the game application. Some sophisticated systems will allow records to be updated in the middle of the tape provided the updated record length is the same as the original. One possibility, if records are expected to grow as in the accounting application, is to start with a long record padded with zeroes and then gradually replace the zeroes with new data as updates take place. Large insertions and deletions such as in the text-editing application are still best handled by the update/copy technique when using a tape mass-storage system.

Disk Mass-Storage Systems. A disk-based mass-storage system has several very desirable characteristics. On-line storage capacity ranges from about 300k bytes for a floppy-disk system to over 200M bytes for some high-performance commercial systems. The range on transfer rates is considerably less, being from 32k bytes per second for the floppy to about 1.5M bytes per second for large hard-surfaced disk systems.

Although most disk mass-storage systems are very expensive, floppy-disk systems are reasonable and are becoming much more numerous among hobbyist users. The components to build a floppy-disk system cost about $600 while complete kits list for around $1500. The disk itself is housed in a flexible plastic envelope measuring eight inches square and one-sixteeth-inch thick and costs seven to ten dollars each. Each disk holds over 300k bytes and can be inserted into or removed from the disk drive in a couple of seconds.

Unlike tape, mass-storage disks are random-access devices. The circular disk surface is divided into a number of concentric *tracks*. Each track is further subdivided into a number of *sectors*. This is equivalent to the rectangular array of records mentioned earlier. Each sector contains one data record which is fixed in size. To access a particular record, the magnetic head is first positioned to the correct track by moving it radially in or out. This is called *seeking*. Then the system waits for the proper sector to rotate under the head for reading. The amount of time necessary to do these operations varies but is relatively unaffected by where the data is on the disk. All disk systems allow individual sectors to be updated.

A floppy disk may have, for example, 77 tracks and 32 sectors on each track for a total of 2464 possible data records. Each record has 128 useful data bytes. Moving the head from one track to another takes about 10 milliseconds per track moved. At 360 rpm it takes 166 milliseconds for the disk to rotate one revolution. Thus the longest required time to find and read a record will be just under a second. The average time is less than half that figure. Since a search of the whole disk would take considerably longer than this, some kind of index is always maintained so that the exact track and sector numbers of the desired data are known.

A floppy-disk mass-storage system is nearly ideal for all three example applications. The accounting system, for example, can be set up so that each transaction would be stored on one sector. Thus three years of financial records may fit on one $7 floppy disk. In the game program, many random data accesses and updates can be performed in the time allowed for the computer to make its move. Even the large insertions and deletions required in the text-editing application are readily handled. With such quick random access to records, the inserted text may be stored in any unused positions on the disk. Deleted records are simply marked as unused and will later be overwritten. Sorting of records using a single disk drive is not only possible but is relatively easy. With a tape system, at least three drives and a number of update/copy operations are required to do sorting.

Error Handling. Unfortunately it is a fact of life that magnetic recording media can have defects and can be damaged by improper handling. The result of a defect is that data recorded over it is subject to error. Since alteration of even a single bit can be disastrous (such as a difference between $1081 and $9081 in the accounting application), methods must be employed to detect the presence of these errors and to allow recovery from them.

Errors can be detected in a number of ways. The most common employs a *checksum* byte at the end of a record. A checksum is simply the sum of all of the data bytes in the record with overflows ignored. If the sum of the data read back is the same as the checksum byte for the data written, then the data is assumed to have been read accurately.

To prevent writing over a bad spot on the media, the data is typically read back and compared immediately after it is written. If an error is detected, then the record is erased and rewritten further on or in another sector. ◈

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Experimenter's Corner

By Forrest M. Mims

THE SILICON SOLAR CELL

YOU CAN now buy silicon solar cells for less than a nickel per milliwatt of output power. This is still too costly to make high-power solar panels economically feasible in most (especially experimenters') applications. But it is low enough to allow many of us to assemble small solar panels for charging nickel-cadmium batteries.

This month, we'll take a look at the design factors and construction procedures involved in fabricating small solar batteries. But first, let's review how solar cells work and examine some of the reasons for their high cost.

Solar Cell Theory. The construction of a typical silicon solar cell is shown in Fig. 1. It is essentially a *pn*

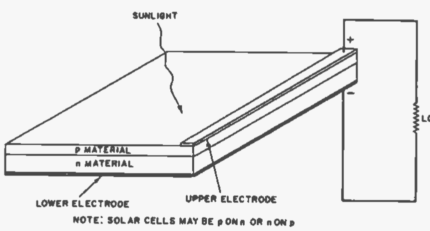

Fig. 1. Make-up of a cell.

semiconductor junction diode, and depends on the *photoelectric effect* for its operation. When the cell is in darkness, no current flows through it. The barrier potential of the junction keeps the charges from crossing from one side to the other. But when photons (light particles) strike the silicon, electron-hole pairs are created resulting in an output voltage. If the output terminals of the cell are connected to a load, a current will flow. The cell voltage is relatively independent of the light level, and is usually from 0.45 to 0.55 volt. Output current, however, is directly related to the intensity of the light striking the cell's surface.

The theoretical maximum conversion efficiency (the ratio of cell power output to light power input) of a "perfect" silicon solar cell is 20 to 25 percent. No such cell exists, but some laboratory cells have demonstrated an efficiency of nearly 20 percent. Commercially available cells range in efficiency from 8-10 percent for older devices to 10-15 percent for the superior grade of cells developed over the past few years.

How They Are Made. Silicon is the second most abundant element on earth, and, at $600 per ton, bulk metallurgical grade silicon is actually rather cheap. But silicon solar cell efficiency is directly related to the purity of the silicon used to make the cell, and ultra-pure silicon costs 100 times more than metallurgical grade material.

Materials cost is only part of the picture. The major reason for the expense of silicon solar cells are these five production steps:

- Growth of boules of silicon from molten silicon.
- Slicing of the boules into thin wafers.
- Smoothing the surface of the wafers by chemical etching or mechanical polishing.
- Formation of a pn junction by heating the wafers in a furnace in the presence of appropriate dopants.
- Affixing metal electrodes to the front and back surface of the cell.

Actually, these five steps are only the minimum required to produce a working solar cell. More efficient cells can be produced by additional etching of the front surface, formation of better electrodes, oxidizing the front surface to reduce reflection losses, and careful attention to junction formation.

Considering the materials cost and complex procedure, the high cost of silicon solar cells is certainly justified. Fortunately, improved production techniques promise to lower solar cell prices considerably in years to come.

Building Practical Solar Cell Arrays. Figure 2 shows how a silicon solar battery is connected to a nickel-cadmium storage cell. The five solar cells in the battery produce a total of about 2.75 volts *open circuit* in bright sunlight, and perhaps 1.5 volts when loaded down by the NiCd cell. Blocking diode *D1* keeps the cell from discharging through the solar battery during hours of darkness. If the NiCd cell is disconnected from the circuit during darkness, *D1* and one of the five solar cells can be omitted from the circuit. (The fifth solar cell compensates for the forward voltage drop across the diode.)

Designing practical chargers requires a knowledge of the charging requirements of the storage cells and

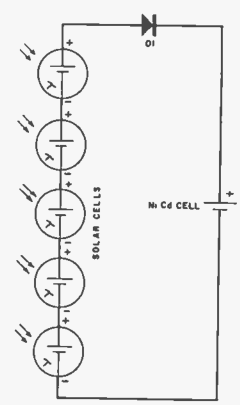

Fig. 2. Simple charging circuit.

the maximum current output of the solar battery. The maximum charging rate for most NiCd cells is 10 percent of the cell's capacity in milliampere-hours (mA-h). Therefore the maximum charging rate for a 500-mA-h cell is 50 mA. A higher charge rate can damage or destroy the cell. Most cells require 12-14 hours at the maximum charge rate to achieve full capacity. But fast-charge units which can be charged to full capacity in only about 4 hours have recently become available. They are charged at 30 percent of the mA-h rating (for example, 150 mA for a 500-mA-h battery).

With these facts in mind, here are some useful guidelines to follow when designing your own solar battery charger:

- Use 3-4 solar cells in series for each series connected NiCd cell (e.g. 2 cells in series require 6-8 solar cells in series).
- Add one solar cell if a blocking diode is used.
- When assembling the array, temporarily wire the solar cells together and connect them to the batteries through a milliammeter as shown in Fig. 3. The current level should not

exceed the maximum allowable for the NiCd cells when the solar battery is in bright sunlight. If the current level is too high, remove one or more solar cells until the current falls to a safe level. If the current is too low, add cells as required.

Remember that you can achieve any combination of voltage and current from a solar battery by employing appropriate series and parallel connections of solar cells.

Practical Chargers. I recently built two solar-cell chargers for NiCd batteries to take with me on a bicycle trip in the mountains of New Mexico.

One charger had 9 series-connected 2-cm square solar cells connected to two series-connected NiCd cells. The other consisted of 18 series-connected cells connected to 4 NiCd batteries. You can make similar chargers yourself.

In making the chargers, it is convenient to solder (carefully) the cells together in groups of three. Use a low-power soldering pencil and tinned, stranded hookup wire. Next, use small squares of masking tape to temporarily secure the strips of cells face down on a Plexiglas panel. Then apply GE RTV-108 or a similar clear silicone cement between the rows of cells. Smooth the cement across the backs of those cells not secured with masking tape.

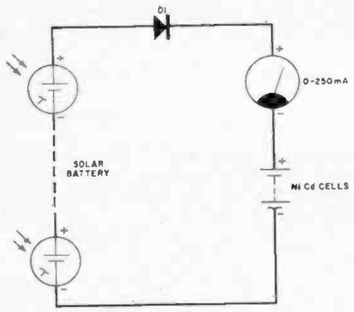

Fig. 3. Using a milliammeter.

Allow the adhesive to cure for 12 hours. Then carefully solder the strips of cells to one another to make the desired total. Attach output leads and a 1N914 blocking diode to the battery. Next, spread adhesive across the backs of all the cells (masking tape removed) and place a sheet of clear vinyl over the adhesive. Secure the vinyl in place for 24 hours with tape.

These simple assembly methods will permit you to produce a reliable NiCd solar-battery charger quickly and easily. Both of the panels I built provide 5 to 15 mA of charging current on overcast days. ◇

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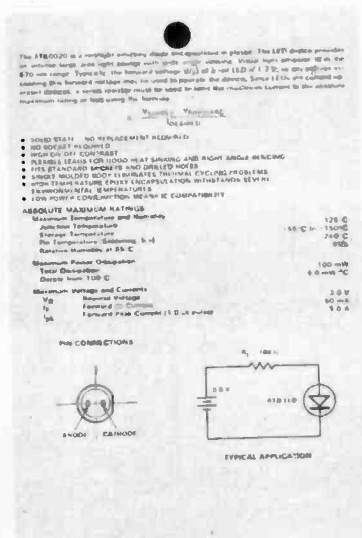

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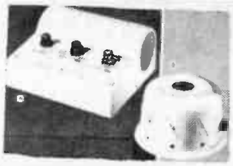

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Electronic sound conditioner simulates 4 kinds of soothing sounds of ocean surf and rain. "White sound" helps mask unwanted noise, adds restful, intriguing background sound. Program the solid-state unit to your own need: 2 surf, 2 rain; or "white sound", proven by medical tests to have analgesic effects. Great for meditation, restlessness, sleeplessness psychology.

(A)-No. 71,997AV . . . (7½×7×3½") 110V AC .... $79.95 Ppd.
(B)-AS ABOVE, BUT "WHITE SOUND" ONLY
No. 71,980AV . . . (6" Rd.×3½" Hi) .... $28.00 Ppd.

SUPER POWER FOR ANY AM RADIO

New antenna assist turns a tiny transistor into a tiger, has pulled in stations up to 1000* miles away! Just set beside radio (no wires, clips, grounding) and fine-tune Select-A-Tenna's dial to same frequency — "gangbusters"! Great for clearing weak signals in radio depressed areas, off-coast islands, crowded frequency stations. Solid state—uses no electricity, batts., tubes.

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157 mi. out in space, the Astronauts used this super 20×60 binocular (modified) to view Earth! Our biggest, most powerful for distance. Far-off objects come in big, clear & sharp to the edge through big 60mm objective lenses; 173-ft. field of view at 1000 yds. Relative brightness, 9.0. Fully coated optics; 20X spcl design eye lenses. Coated BK-7 Porro prism. Extra long All-American style with fold-down rubber eyecups. Includes case & straps.

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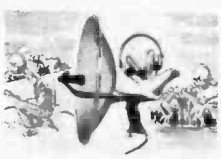

Parabolic mike w/ 18¾" transparent reflecting shield & 2 I.C.'s in amplifier magnifies signals 100x that of omni-direction mikes. Catch sounds never before heard! Highest signal to noise ratio poss. Earphones, tape recorder output, tripod socket; req. two 9v trans. batt. (not incl).

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LOW COST MODEL: NO EARPHONES, ELECTR. CIRC.
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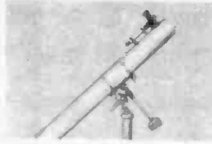
GREAT FOR CHRISTMAS GIFTS! A UNIQUE SELECTION OF MEMORABLE, LONG-LASTING GIFTS FOR ALL AGES.



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See moon craters, rings of Saturn, double stars. Features fine f/10 mirror* (verified better than 1/10 wave with a scatter plate interferometer) to insure performance to theoretical limit of resolution. Equatorial mount; rack & pinion focusing; aluminum tube, 6X finder, 25mm F.L. 45X Kellner achromatic eyepiece & Barlow lens to double and triple power to 135X. Incls FREE Star Chart plus 2 Books. *Pyrex.®

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AN *ULTRA-MINIATURE* AM RADIO!

It's about the size of a small matchbox—and your ear will light up when you hear it. Pulls in stations with amazing volume and clarity (number depends on locale), yet you can wear it on your key chain, conceal it in pocket or purse! Get news, sports, music wherever you go—listen to the game as you watch it at the stadium. Just insert the earplug (incl) and your directional AM mini marvel plays! Runs ab. 100 hrs. on 2 hearing aid batts (incl). A super gift!

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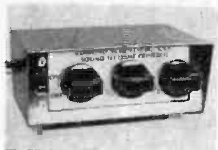

SEE MUSIC IN PULSATING COLOR

New 3-Channel Color Organ adds to music listening pleasure, lets you modulate 3 independent strings of colored lamps with intensity of your music to create an audio "light show." They flash, vary in brightness related to music's rhythm, pitch, volume—pulsating lighting performance to music! Fully assembled & priced half that of others, the Edmund Sound To Light Control is a terrific value. Plug in, turn on!

No. 42,309AV . . . (ASSEMBLED) .... $17.95 Ppd.
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For Infra-red crime detection surveillance, security system alignment, I.R. detection, laser checking, nite wildlife study, any work req. I.R. detection & conversion to visible spectrum. Self-cont. scope incls I.R. light source (90' nite vision!), 6032 I.R. converter tube, f/3.5 obj. lens, adjust. triplet eyepiece, auto lighter adapter. 1.6X focuses 10' to inf.; 6, 12v DC. *Not avail. to CA res. exc. authd. pers./sci., educ.*

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BINOCULAR STYLE: AS ABOVE, BUT 2.5X
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Poly Paks exclusive DIP SWITCHES. Provides highly reliable, low-cost means of manually programming a variety of mico-miniature electrical-electronic circuits. Each device rocker actuated, SPST. High reliability. 7 different circuits on a DIP IC type housing makes it ECONOMICAL. Housing of heat-resistant glass-filled nylon material. Fits into 14-pin IC socket, or its phosphor bronze gold-plated connections for PC board use too! Each switch rated at (non-switching) 50 VDC @ 100 ma. Meets MIL specs. Size 3/4 x 3/8 x 3/8".

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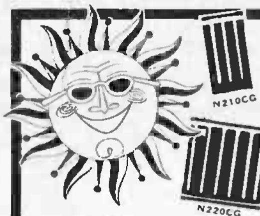

N210CG

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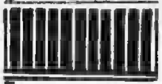

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Cat. No.	Type	Size	MA	MW	Sale	3 for
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11E3232	N120S	2 x 2	100	†	2.49	5.50
11E3231A	N240CG*	2 x 4	200	85	3.50	8.00
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† Two 1 x 2's shingled together; equals 1 volt
* State 1st and 2nd grid choices. 1 oz

We are stocking 4 sizes: measured in centimeters 1 x 2, 2 x 2, 2 x 4, 1 x 2 linked together. Silicon "thin plate" forms the basis of the cell. It's a Space Saver! Each cell (chip) generates 0.5 volts, but at different current capabilities. Solder edges for easy "multiple chip building". Each cell has blue-reflective-coated-surface and with transparent protection.

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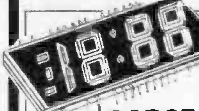


- 1.2" HIGH, 4-DIGIT, 7-SEGMENT
- Orange, gas discharge!
- AM-PM indicators!
- Pulsating seconds!
- 12 hour!

Interfaces directly to MM5316 chip which we are offering FREE! Cat.No. 11E3248

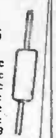
Panel 'N Chip **$13.95** ☐

FREE! FREE! Each Clock panel purchase we give MM5316 chip—no charge.

We have never seen a digital clock panel with characters so high, orange color so bright. It's by far the finest panel we've sold. The substrate is "sandwiched" between 1/8" thick panels of glass. Each of the printed circuit pins is lettered or numbered to correspond pin-for-pin interfacing with the famous MM5316 clock chip, which WE GIVE FREE! Power requirements 170 volts for anode, 1½ mils per segment. Includes colon too! Size 4¼ x 1-9/16". Makes a nifty looking digital clock for home, office, ham or radio station, lab, etc. Wt. 8 oz.

CHOOSE ANY BARREL KIT LISTED IN THIS MAGAZINE **FREE WITH $25 ORDERS**

"BLASTAWAY" ON 1N4000 RECTIFIER PRICES

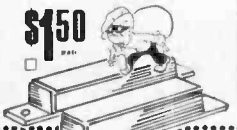


Type	PIV	Sale
☐ 1N4001	50	10 for 45c
☐ 1N4002	100	10 for 55c
☐ 1N4003	200	10 for 65c
☐ 1N4004	400	10 for 75c
☐ 1N4005	600	10 for 85c
☐ 1N4006	800	10 for 99c
☐ 1N4007	1000	10 for 1.29

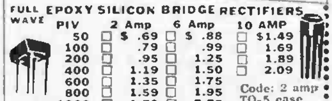
PROXIMITY REED SWITCHES FOR BURGLAR ALARMS

These small magnetic proximity reed switches are ideal for all types of burglar alarms. One case contains an Alnico magnet, which actuates a Normally Open reed switch in the other case within a distance of 1". Mount on windows & doors, on back of valuable equipment, etc. Protect your home, car, and shop. Cat.No.11E3163

$1.50 pair ☐



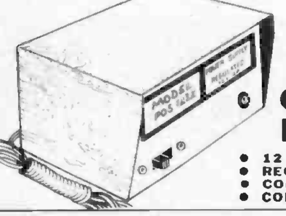
FULL WAVE EPOXY SILICON BRIDGE RECTIFIERS



PIV	2 Amp	6 Amp	10 AMP
50	☐ $ .69	☐ $ .88	☐ $1.49
100	☐ .79	☐ .99	☐ 1.69
200	☐ .95	☐ 1.25	☐ 1.89
400	☐ 1.19	☐ 1.50	☐ 2.09
600	☐ 1.35	☐ 1.75	
800	☐ 1.59	☐ 1.95	
1000	☐ 1.79	☐ 2.25	

Code: 2 amp TO-5 case

6 Amp 1/2 x 1/2 x 3/16 sq.



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$22.50 ☐ 3 for $60.

- 12 VDC @ 3 AMPS
- REGULATED, CONTINUOUS DUTY
- CONVERTS CB, HAM RIGS TO HOME
- COMPLETELY WIRED

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$4.95 ☐

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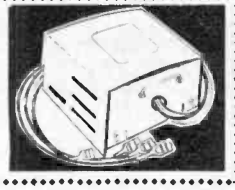


KEYBOARD & ENCODER KIT

- Uses Encoder MOS ROM
- 7 "LED" test feature
- 4 Modes

- 63-Key keyboard

- Double sided PC board

Outputs — standard ASCII 7 bits plus strobe

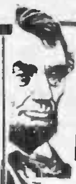
$69.95 WIRED ☐

$59.95 ☐ **KIT**

Lowest price Keyboard and Encoder kit we've seen. General purpose ASCII keyboard for data terminal applications. Could be used for TV, RTTY, Code Transmission, Altair and other Mini Computers, etc. Utilizes 2-key rollover MOS memory allowing encoded outputs to be strobed out as each key is depressed. Uses double side pc board. Electronic shift lock, not mechanical on keyboard. Keyswitches, one integral assembly not individual keys. Keyboard: 63 keys (49 encoded keys), 4 mode: normal, shift and control, 3 internal function keys: shift leach side of board, shift lock and control. 3 functions: Key Break, Here Is, Repeat. 7 additional functions (can be assigned by user).

Cat. No. 11E3208 Keyboard & Encoder Kit . . $59.95
Cat. No. 11E3209 Keyboard & Encoder Wired 69.95

Electrical specs: voltage requirements plus 5 volts and minus 12 volts, 200mw, negative or positive logic output, jumper selectable. Output connector. On the PC board we have A NEW KEYBOARD TEST FEATURE . . . . 7 LEDS! These LEDs display visually the ASCII code for the depressed key. TTL compatible. Kit includes: 63 key keyboard, pc board, ROM, 7 LEDs, resistors, capacitors, TTL IC's and SOCKETS We include diagram and wiring instructions, ROM code. Wt. 7 lbs. Size overall: 13 x 5½ x 2".



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☐ SN7402	.22	.23	☐ SN7496	.86	.87
☐ SN7403	.22	.23	☐ SN74125	1.29	1.30
☐ SN7404	.24	.25	☐ SN74126	1.29	1.30
☐ SN7406	.36	.37	☐ SN74132	1.95	1.96
☐ SN7407	.46	.47	☐ SN74141	1.12	1.13
☐ SN7408	.22	.23	☐ SN74145	1.69	1.70
☐ SN7409	.52	.53	☐ SN74146	3.25	3.26
☐ SN7410	.22	.23	☐ SN74150	1.12	1.13
☐ SN7411	.27	.28	☐ SN74153	1.10	1.11
☐ SN7417	.62	.63	☐ SN74154	1.53	1.54
☐ SN7420	.22	.23	☐ SN74157	1.09	1.10
☐ SN7421	.55	.56	☐ SN74158	1.55	1.56
☐ SN7423	.47	.48	☐ SN74160	1.59	1.60
☐ SN7425	.37	.38	☐ SN74163	1.50	1.51
☐ SN7430	.22	.23	☐ SN74164	1.79	1.80
☐ SN7432	.36	.37	☐ SN74165	1.79	1.80
☐ SN7440	.22	.23	☐ SN74173	1.69	1.70
☐ SN7442	.97	.98	☐ SN74174	1.42	1.43
☐ SN7445	.97	.98	☐ SN74175	1.45	1.46
☐ SN7446	1.10	1.11	☐ SN74176	1.59	1.60
☐ SN7447	1.10	1.11	☐ SN74177	1.59	1.60
☐ SN7448	1.10	1.11	☐ SN74181	3.75	3.76
☐ SN7450	.22	.23	☐ SN74184	2.19	2.20
☐ SN7451	.27	.28	☐ SN74190	2.75	2.76
☐ SN7473	.44	.45	☐ SN74191	2.75	2.76
☐ SN7475	1.00	1.01	☐ SN74193	1.29	1.30
☐ SN7483	.99	1.00	☐ SN74195	.89	.90
☐ SN7485	1.41	1.42	☐ SN74196	2.19	2.20
☐ SN7486	.47	.48	☐ SN74198	2.25	2.26
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☐ SN7490	1.00	1.01			
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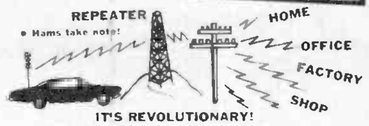

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$18.88 ☐

1.25M, 2-meter and 6-meter amateur radio operators, if your rig is mobile, convert it easily to a mobile telephone station and contact your home, shop, school, factory TTE-100 touch tone encoder kit. Kit includes: Chomerics touch tone pad, Motorola MC14410 chip, trimpot, resistors, zener, diagram, and G-10 pc board. Electrical specs: 12-16 volts, 5 mils (mas), 4 volts PP output. * Less 1-MC crystal. Cat. No. 11E3385

Cat. No.	Description	Sale
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BUY 'EM SEPARATELY 11R3383 P.C. Board 2.95

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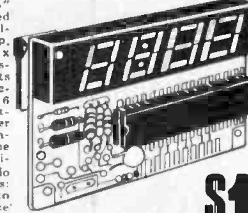
Never before offered (as far as we know), the latest in Digital Clock circuitry . . . 4-digit, 0.5" height, LED, built-in red filter, with a MM5386 multi-function alarm chip, mounted on a 3 x 1⅜ x ¼" module. Has all necessary discrete components mounted on module by factory, to require only 6 function switches, brightness and voltage divider control, 12-16 volt filament transformer, AC line cord and case. Makes easi-built-in alarm and radio output: switch functions: Seconds, Sleep timer up to 1 hour, fast set, Snooze alarm display (tells you when snooze alarm triggers), Alarm display (tells you when alarm triggers).



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Alarm ON/OFF. Instruction and hookup diagrams. Shpg. wt. 7 ozs.

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- 3-5-6 Bladers!
- 115 VAC!
- Compact!
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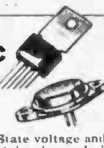
YOUR CHOICE **$1** ☐

- 1-AMP RATING
- TO-220 or TO-3 CASES
- POSITIVE OR NEGATIVE



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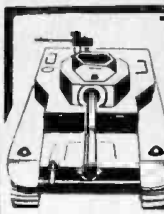

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#19—DIPPED MYLARS	Cat.No.11E2597,100% good	60 for $1.98
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#26—PLASTIC TRANSISTORS	Cat.No.11E2604,untested	100 for $1.98
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#32—TRANS WITH HOLE	Cat.No.11E2610,untested	50 for $1.98
#35—NEON LAMPS	Cat.No.11E2613,100% good	30 for $1.98
#37—1-AMP BULLET RECT	Cat.No.11E2615,untested	100 for $1.98
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#68—2 WATTERS	Cat.No.11E2735,100% good	100 for $1.98
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#83—LM340T VOLT REG	Cat.No.11E2635,untested	15 for $1.98
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#158—MAGNIFIED MAN-3s	Cat.No.11E3325,lens rejects	12 for $1.98
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#172—25 AMP ACRS	Cat.No.11E3355,100% material	3-pcs. $1.98
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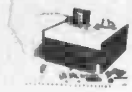

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4) AM PM and automatic power failure indications.
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All kits include components, PC Boards, Transformer, case, and construction manual.

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7408	.21	7475	.70	74163	1.24
7410	.21	7476	.44	74164	1.94
7413	.54	7483	.90	74165	1.54
7420	.21	7489	2.50	74174	1.34
7427	.29	7490	.74	74175	1.44
7430	.21	7497	.80	74181	2.80
7437	.44	7493	.80	74192	1.30
7438	.39	7495	.80	74193	1.30
7440	.21	7496	.80	74195	.84
7442	.74	74121	.43		
7447	.94	74123	.80		

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4002	.24	4020	1.59	4041	.89
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4008	1.15	4023	.24	4044	.59
4009	.59	4024	.99	4047	.59
4010	.55	4025	.24	4049	.59
4011	.24	4027	.59	4050	.59
4012	.24	4078	.99	4066	.99
4013	.59	4029	1.39	74C02	.29
4014	1.49	4030	.49	74C04	.29
4016	1.19	4034	3.25	74C107	1.29
4016	.59	4035	1.39		
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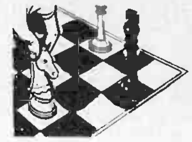
All PC display boards are multiplexed for adding and [illegible] digits

MSI



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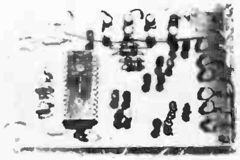
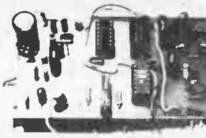


4-DIGIT DECADE COUNTER KIT
$19.95 KIT 012

One chip 4 digit decade counter kit, with both 7 segment and BCD output.

1. Chip features internal oscillator for scanning speed.
2. Overflow and count extent outputs.
3. Transfer, reset, count, blanking and true compliment control inputs.
4. PC Boards can be cascaded to 8-12-16, etc. digits.
5. Kit includes counter chip, drive circuit for 4 cathode type displays and PC Board. (For readout board see (FND70-FND503)

KIT 016 FREQ. COUNTER



Features FET input front end with trigger circuit for measuring complex waveforms. Measures from 0.1Hz to 10MHz when used with Kit 015 or 019. Measures from .01Hz to 35MHz when used with Kit 013 and 014. $24.50

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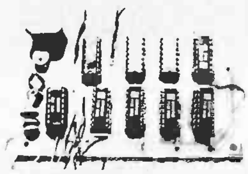
*Input voltage: 25V max. *Output current: 1 amp max. *Load regulation: 50mV. *Output voltage: 5V. *Line regulation: .01%. (requires 8-20V transformer) $4.55

(Contains all parts except transformer)



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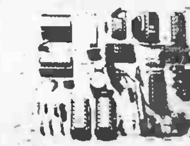

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* Mhz crystal chain time base divider. Outputs: 1Mhz 100Khz 10Khz 1Khz-100Hz-10Hz-1Hz-0.1Hz. Accuracy better than .005% with proper adjustment.

Kit 013 complete CMos with PC board $15.75
Buffer Circuit for TTL Interfacing

Kit 014 Same as Kit 013, but with TTL........ $13.75

Kit 015 50Hz or 60Hz chain time base using line frequence as reference Accuracy 0.1 0.05%. Outputs 10Hz 1Hz 0.1Hz. Complete with CMos shaping circuit and PC Board.......... $9.75

Kit 019 Same as Kit 015, but with TTL and 60Hz only.......... $7.75

Kit 018 60Hz chain time base using line frequence for Kit 020 RPM counter.

*Outputs: .6 sec = 100th of RPM
6 sec = 10th of RPM
60 sec = full revolution $9.75

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YOU GET:
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Complete kit of components
Heatsinks +5V @ 1.5A
Complete Instructions ±15V @ 200MA

$14.95

NOTE: +5 and ±12VDC supply is available at same price. Order PS-01/B.

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Complete instructions
All resistors and caps
All semiconductors

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Small (1¼ x 1 3/8 x 2 3/8")
Complete with drilled and plated board
Includes all components

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7486	.33	311	.79	2102	1.49	MAN8	1.69
7490	.39	340T-5V	.99	5203	8.95	LED's	
74107	.29	723	.39	5260	.95	JUMBO CLEAR	.13
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1/4 or 1/2 watt
455 resistors, 44 values
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RESISTOR ASSORTMENT R (OHMS)

R	QTY.	R	QTY.	R	QTY.
1.5	5	680	10	47K	10
3.3	5	1.0K	20	68K	10
6.8	5	1.5K	10	100K	20
10	10	2.2K	20	150K	10
15	5	2.7K	10	220K	10
22	5	3.3K	10	270K	5
33	5	3.9K	10	330K	10
47	10	4.7K	20	470K	10
68	5	6.8K	10	680K	10
100	10	10K	20	1.0M	20
150	10	15K	10	1.5M	5
220	10	22K	10	2.2M	5
270	5	27K	10	3.3M	5
330	10	33K	20	4.7M	5
470	20	39K	10		

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RN 60 temp coeff + 50 PPM%C
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TTL

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7402	.15	7454	.17	74155	.97
7403	.15	7460		74156	.97
7404	.16	7464	.35	74157	.99
7405	.19	7465	.35	74158	1.79
7406	.20	7470	.30	74160	1.23
7407	.28	7472	.30	74161	.97
7408	.18	7473	.35	74162	1.39
7409	.19	7474	.28	74163	1.09
7410	.16	7475	.49	74164	.99
7411	.25	7476	.30	74165	.99
7413	.43	7483	.68	74166	1.25
7414	.65	7485	.88	74170	2.10
7416	.35	7486	.40	74173	1.49
7417	.35	7489	2.25	74174	1.23
7420	.16	7490	.43	74175	.97
7422	.30	7491	.75	74176	.89
7423	.29	7492	.48	74171	.84
7425	.27	7493	.48	74180	.90
7426	.26	7494	.78	74181	2.45
7427	.29	7495	.79	74182	.79
7430	.20	7496	.79	74184	1.90
7432	.23	74100	.98	74185	2.20
7437	.25	74105	.44	74187	5.75
7438	.25	74107	.37	74190	1.15
7440	.15	74121	.38	74191	1.25
7441	.89	74122	.38	74192	.95
7442	.59	74123	.65	74193	.85
7443	.73	74125	.54	74194	1.25
7444	.73	74126	.58	74195	.74
7445	.73	74132	.89	74916	1.25
7446	.81	74141	1.04	74197	.73
7447	.79	74145	1.04	74198	1.73
7448	.79	74150	.97	74199	1.69
7450	.17	74151	.79	74200	5.45

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4007A	.26	4023A	.25	4072A	.35
4008A	1.52	4024A	.89	4073A	.39
4009A	.57	4025A	.25	4075A	.39
4010A	.54	4027A	.59	4078A	.39
4011A	.29	4028A	.98	4082A	.35
4012A	.25	4030A	.44	4518A	1.56
4013A	.45	4035A	1.27	4528A	1.56
4014A	1.27	4040A	1.39	4585A	2.10
4015A	1.27	4042A	1.47		
4016A	.48	4049A	.59		
4017A	1.01	4050A	.59		
74C00	.19	74C74	1.04	74C162	2.49
74C02	.26	74C76	1.34	74C163	2.66
74C04	.44	74C107	1.13	74C164	2.66
74C08	.68	74C151	2.62	74C173	2.22
74C10	.35	74C154	3.15	74C195	2.26
74C20	.35	74C157	1.76	80C95	1.15
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305	.71	372	2.93	567	1.95
307	.26	373	2.42	709	.26
308	.89	376	.68	710	.35
309K	1.35	380	1.30	711	.26
310	1.07	380-8	1.25	739	1.07
311	.95	381	1.75	741	.32
319	1.13	382	1.75	747	.71
3201	1.39	531	2.95	748	.35
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NS71L	1.39	CLEAR	.15

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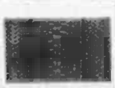

Silver plated copper circuit board 4-1/16" x 5-1/16", 2 rows of 27 holes for DIP IC's + space for transistors, resistors & capacitors. Versatile and simple for breadboarding IC circuitry **$1.50 ea.**

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60 solid dipped tantalum capacitors ± 20%
1st quality capacitors in a durable styrene utility box — with color code charts

5 each	.1 ufd	35V	.33 ufd	35V	1 ufd	35V	2.2 ufd	35V
	4.7 ufd	16V	6.8 ufd	6V	10 ufd	25V	15 ufd	20V
	22 ufd	16V	33 ufd	10V	47 ufd	6V	56 ufd	6V

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Voltage controlled oscillator — sine, square, triangular output. 16 pin DIP with data **$3.95**

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SN7421N	.33	SN7492N	.49	SN74177N	.90
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SN7425N	.29	SN7495N	.79	SN74182N	.95
SN7426N	.29	SN7496N	.89	SN74184N	1.95
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SN7437N	.27	SN74122N	.39	SN74190N	1.19
SN7438N	.27	SN74123N*	.70	SN74191N	1.25
SN7439N	.25	SN74125N	.60	SN74192N*	.89
SN7440N	.15	SN74126N	.60	SN74193N*	.89
SN7441N	.89	SN74132N	1.09	SN74194N	1.25
SN7442N	.59	SN74136N	.95	SN74195N	.75
SN7443N	.75	SN74141N	1.15	SN74196N	1.25
SN7444N	.75	SN74142N*	4.00	SN74197N	.75
SN7445N	.75	SN74143N*	4.50	SN74198N	1.75
SN7446N	.81	SN74144N*	4.50	SN74199N	1.75
SN7447N*	.69	SN74145N	1.15	SN74200N	5.59
SN7448N	.79	SN74147N	2.35	SN74279N*	.90
SN7450N	.26	SN74148N	2.00	SN74251N	1.79
SN7451N	.27	SN74150N	1.00	SN74284N	6.00
SN7453N	.27	SN74151N	.79	SN74285N	6.00
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CD4007	.25	CD4042	1.90	74C42N	2.15
CD4009	.59	CD4044	1.50	74C73N	1.50
CD4010	.59	CD4046	2.51	74C74	1.15
CD4011	.25	CD4047	2.75	74C90N	3.00
CD4012	.25	CD4049	.79	74C95N	2.00
CD4013	.47	CD4050	.79	74C107N	1.25
CD4016	.56	CD4051	2.95	74C151	2.90
CD4017	1.35	CD4053	2.95	74C154	4.00
CD4019	.55	CD4060	3.25	74C157	2.15
CD4020	1.49	CD4066	1.75	74C160	3.25
CD4022	1.25	CD4069	.45	74C161	3.25
CD4023	.25	CD4071	.45	74C163	3.00
CD4024	1.50	CD4081	.45	74C164	3.25
CD4025	.25	CD4511	2.50	74C173	2.60
CD4027	.69	CD4518	2.50	74C193	2.75
CD4028	1.65	CD4566	3.00	74C195	2.75
CD4029	2.90	74C00N	.39	MC4044*	4.50
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LINEAR

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LM301CN	.35			LM1414N	1.75
LM302H	.75			LM1458C	.65
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LM305H	.95	LM373N	3.25	LM1556V	1.85
LM307CN	.35	LM377N	4.00	LM2111N	1.95
LM308H	1.00	LM380N	1.39	LM2901N	2.95
LM308CN	1.00	LM390CN	1.05	LM3065N	.69
LM309H	1.10	LM381N	1.79	LM3900N	.55
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LM310CN	1.15	NE501K	8.00	LM3909*	1.25
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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	CA3023	2.56
LM324N	1.80	LM709N	.29	CA3035	2.48
LM339N	1.70	LM710N	.79	CA3039	1.35
LM340K-5	1.95	LM711N	.39	CA3046	1.30
LM340K-6	1.95	LM723H	.55	CA3059	3.25
LM340K-8	1.95	LM723H	.55	CA3060	3.25
LM340K-12	1.95	LM733N	1.00	CA3080	.85
LM340K-15	1.95	LM739N	1.00	CA3081	2.00
LM340K-18	1.95	LM741CH	.35	CA3082	2.00
LM340K-24	1.95	LM741CN	.35	CA3083	1.60
LM340T-5	1.75	LM74114N	.39	CA3086	.85
LM340T-6	1.75	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	.39			74LS139	1.95
74LS02	.39			74LS151	1.55
74LS03	.39	74LS74	.65	74LS153	1.89
74LS04	.45	74LS75	.79	74LS157	1.55
74LS05	.45	74LS76	.65	74LS162	2.25
74LS08	.39	74LS83	2.19	74LS163	2.25
74LS10	.39	74LS85	2.49	74LS164	2.25
74LS13	.79	74LS86	.65	74LS175	1.95
74LS14	2.19	74LS90	1.25	74LS181	3.69
74LS20	.39	74LS92	1.25	74LS190	2.85
74LS26	.49	74LS93	1.25	74LS191	2.85
74LS27	.45	74LS95	2.19	74LS192	2.85
74LS28	.49	74LS96	1.89	74LS193	2.85
74LS30	.39	74LS107	.65	74LS194	2.25
74LS32	.45	74LS109	.65	74LS195	2.25
74LS40	.49	74LS112	.65	74LS197	1.89
74LS51	.39	74LS132	1.55	74LS260	.55
74LS55	.39	74LS136	.65	74LS279	.79
74LS73	.65	74LS138	1.89	74LS670	5.95

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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
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100 PER STRIP MOLEX PINS

Intended for use as an inexpensive substitute for IC sockets. Also perfect for use as board connectors and in subassemblies.
SPECIAL — 100/1.49 — 1000/12.00

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GAMES INCLUDED IN SUPER PONG ARE:
- PONG
- CATCH
- SUPER PONG
- HANDBALL

FEATURES OF PONG AND SUPER PONG
- Incremental speed on volleys increases excitement
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- Game appears in color or in black & white, depending on television set.
- Unmistakable "PONG" sound accompanies each volley.
- Digital scoring flashes on the screen between each point
- 2 player challenge or Solitaire
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- English and other techniques can be used to make any member of the family a Pong champion.
- Battery operated by 4 size "D" flashlight batteries included with the Unit.

AC Adaptor (Eliminates Batteries) $9.95

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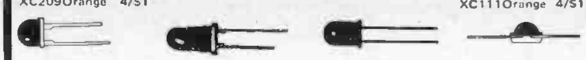
XC209Red 10/$1
XC209Green 4/$1
XC209Yellow 7/$1
XC209Orange 4/$1

.190" dia.
XC111Red 10/$1
XC111Green 4/$1
XC111Yellow 4/$1
XC111Orange 4/$1



.200" dia.
XC22Red 10/$1
XC22Green 4/$1
XC22Yellow 4/$1
XC22Orange 4/$1
SSL-22RT 4/$1

.185" dia.
XC526Red 10/$1
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XC526Orange 4/$1
XC526Clear 4/$1

.200" dia.
XC556Red 10/$1
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XC556Orange 7/$1
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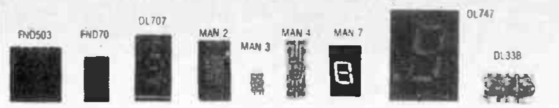
.085" dia.
MV50
.085" dia. Micro red LED
6/$1

DISPLAY LEDS



TYPE	POLARITY	HT		TYPE	POLARITY	HT	
MAN 1	Common Anode	270	2.95	MAN 3620	Common Anode-orange	.300	1.75
MAN 2	5 x 7 Dot Matrix	300	4.95	MAN 3640	Common Cathode-orange	300	1.75
MAN 3	Common Cathode	.125	.39	MAN 4710	Common Anode-Red	.400	1.95
MAN 4	Common Cathode	.187	1.95	DL701	Common Anode-red	.300	1.85
MAN 7	Common Anode	.300	1.25	DL707	Common Anode	300	1.50
MAN 7G	Common Anode-green	.300	1.95	DL 728	Common Cathode	.500	2.95
MAN 7Y	Common Anode-yellow	.300	1.95	DL 747	Common Anode	.600	2.25
MAN 52	Common Anode-green	300	1.75	DL 750	Common Cathode	600	2.49
MAN 64	Common Anode-red	.400	1.75	DL 338	Common Cathode	.110	99
MAN 72	Common Anode	.300	1.25	FND70	Common Cathode	.250	.75
MAN 74	Common Cathode	.300	1.50	FND503	Common Cathode	.500	1.29
MAN 82	Common Anode-yellow	.300	1.75	FND507	Common Anode	500	1.29
MAN 84	Common Cathode-yellow	.300	1.75				

IC SOLOERTAIL — LOW PROFILE (TIN) SOCKETS

	1-24	25-49	50-100		1-24	25-49	50-100
8 pin	$.17	.16	.15	24 pin	$.38	.37	.36
14 pin	.20	.19	18	28 pin	.45	.44	.43
16 pin	22	.21	20	36 pin	.60	.59	.58
18 pin	.29	.28	27	40 pin	.63	62	.61
22 pin	.37	36	35				

SOLOERTAIL STANDARD (TIN)

14 pin	$.27	.25	.24	28 pin	$.99	90	.81
16 pin	30	.27	25	36 pin	1.39	1.26	1.15
18 pin	35	.32	.30	40 pin	1.59	1.45	1.30
24 pin	.49	.45	.42				

SOLOERTAIL STANDARD (GOLD)

8 pin	$.30	.27	.24	24 pin	$.70	63	.57
14 pin	.35	32	.29	28 pin	1.10	1.00	.90
16 pin	.38	35	.32	36 pin	1.75	1.40	1.26
18 pin	52	.47	.43	40 pin	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLO) LEVEL #3

10 pin	$.45	.41	.37	24 pin	$1.05	95	85
14 pin	39	38	.37	28 pin	1.40	1.25	1.10
16 pin	.43	.42	41	36 pin	1.59	1.45	1.30
18 pin	75	68	62	40 pin	1.75	1.55	1.40

50 PCS. RESISTOR ASSORTMENTS $1.75 PER ASST.

ASST. 1	5 ea.	10 OHM / 27 OHM	12 OHM / 33 OHM	15 OHM / 39 OHM	18 OHM / 47 OHM	22 OHM / 56 OHM	1/4 WATT 5% = 50 PCS.
ASST. 2	5 ea.	68 OHM / 180 OHM	82 OHM / 220 OHM	100 OHM / 270 OHM	120 OHM / 330 OHM	150 OHM / 390 OHM	1/4 WATT 5% = 50 PCS.
ASST. 3	5 ea.	470 OHM / 1.2K	560 OHM / 1.5K	680 OHM / 1.8K	820 OHM / 2.2K	1K / 2.7K	1/4 WATT 5% = 50 PCS.
ASST. 4	5 ea.	3.3K / 8.2K	3.9K / 10K	4.7K / 12K	5.6K / 15K	6.8K / 18K	1/4 WATT 5% = 50 PCS.
ASST. 5	5 ea.	22K / 56K	27K / 68K	33K / 82K	39K / 100K	47K / 120K	1/4 WATT 5% = 50 PCS.
ASST. 6	5 ea.	150K / 390K	180K / 470K	220K / 560K	270K / 680K	330K / 820K	1/4 WATT 5% = 50 PCS.
ASST. 7	5 ea.	1M / 2.7M	1.2M / 3.3M	1.5M / 3.9M	1.8M / 4.7M	2.2M / 5.6M	1/4 WATT 5% = 50 PCS.
ASST. 8R	All Seven Resistor Assortment						$10.95 ea.

5-25 PCS .05 ea. 30-95 PCS .04 ea. 100-495 PCS .03 ea. 500-995 .0275 ea.

SINGLE TURN 3/4" CERMET POTENTIOMETER

- Resistance Tolerance ± 20%
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50Ω 100Ω 500Ω 1K 2K 5K 10K 20K 50K 100K 200K 500K 1 MEG

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	ON	OFF	ON	221	2.95	2.55	1.87	1.70
	ON	NONE	ON	223	2.95	2.15	1.58	1.43
	ON	OFF	ON	121	2.35	1.95	1.43	1.30
	ON	NONE	ON	123	2.05	1.80	1.21	1.10

PUSH BUTTON

SPDT — SERIES PB, PB1
Maintained Action Switch: Push To Make Contact And Push Again To Release Action
Momentary Action Switch: Normally Open or Normally Closed. If or N C circuit use terminals 2 & 1; for N O 2 & 3; for N C and N O 1 2 4 3

PB-123 $1.75
PB-126 $1.75

5 AMP RATINGS

THUMBWHEEL SWITCHES

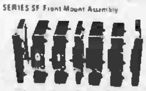
THUMBWHEEL SWITCH ONLY

Part No.	Description	Price
SF 12	Single Pole 10 Position	$2.50
SR 12	Decimal	3.00
SF 21	10 Position BCD only	2.50
SR 21		3.00

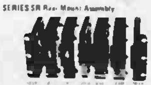
Ordering: Order desired switch or switches and add necessary accessories for your particular application.

SF — Front Mount SR — Rear Mount

SERIES SF Front Mount Assembly



SERIES SR Rear Mount Assembly



ACCESSORIES

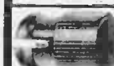
Part No.	Description	Price
SF EP	End Plate (Pair)	.50
SF DP	Divider Plate (each)	40
SF BB	Blank Body (each)	40
SF-HB	Half Body (each)	40

ACCESSORIES

Part No.	Description	Price
SR-EP	End Plates (pair)	$.50
SR-DP	Divider Plate (each)	40
SR-BB	Blank Body (each)	40
SR-HB	Half Body (each)	40

DIP SWITCH

These switches feature seven SPST slide switches in a molded dip. They are ideally suited for microprocessor applications.
$1.95



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NEW LED MOUNTING SYSTEM

- CLIPLITE mounts from the front of the Panel in a .250 hole on 3/8" centers. Panel thickness from 1/16" to 1/8".
- CLIPLITE equalizes and increases the brightness of commonly used wide beam LEDS.
- CLIPLITE is to be used with XC556 LEDS.
- Specify colors—red, green, amber, or yellow when ordering.

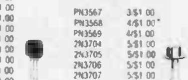
ZENERS—DIODES—RECTIFIERS

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
1N746	3.3	400m	4/1.00	1N4005*	600 PIV	1 AMP	10/1.00
1N751A	5.1	400m	4/1.00	1N4006*	800 PIV	1 AMP	10/1.00
1N752	5.6	400m	4/1.00	1N4007*	1000 PIV	1 AMP	10/1.00
1N753	6.2	400m	4/1.00	1N3600	50	200m	6/1.00
1N754	6.8	400m	4/1.00	1N4148	75	10m	15/1.00
1N959	8.2	400m	8/1.00	1N4154	35	10m	12/1.00
1N965B	15	400m	4/1.00	1N4305	75	25M	20/1.00
1N5232	5.6	500m	28	1N4734	5.6	1w	28
1N5234	6.2	500m	28	1N4735	6.2	1w	28
1N5235	6.8	500m	28	1N4736	6.8	1w	28
1N5236	7.5	500m	28	1N4738	8.2	1w	28
1N456	25	40m	6/1.00	1N4742	12	1w	28
1N458	150	7m	6/1.00	1N4744	15	1w	28
1N485A	180	10m	5/1.00	1N1183	50 PIV	35 AMP	1.60
1N4001	50 PIV	1 AMP	12/1.00	1N1184	100 PIV	35 AMP	1.70
1N4002	100 PIV	1 AMP	12/1.00	1N1185	150 PIV	35 AMP	1.70
1N4003	200 PIV	1 AMP	12/1.00	1N1186	200 PIV	35 AMP	1.80
1N4004	400 PIV	1 AMP	12/1.00	1N1188	400 PIV	35 AMP	3.00

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	25A @ 50V	FW BRIDGE REC.	1.95
MDA 980-3	25A @ 200V	FW BRIDGE REC	1.95

TRANSISTORS



MPS A05	5/$1.00	PN3567	3/$1.00	PN4249	4/$1.00
MPS A06	5/$1.00	PN3568	4/$1.00	PN4250	4/$1.00
2N2219A	3/$1.00	PN3569	4/$1.00	2N4400	4/$1.00
2N2221	4/$1.00	2N3704	5/$1.00	2N4401	4/$1.00
2N2222A	5/$1.00	2N3705	5/$1.00	2N4402	4/$1.00
2N2369	5/$1.00	2N3706	5/$1.00	2N4403	4/$1.00
2N2369A	4/$1.00	2N3707	5/$1.00	2N4409	5/$1.00
FN2415	5/$1.00	2N3711	5/$1.00	2N5086	4/$1.00
2N2484	4/$1.00	2N3724	$.65	2N5087	4/$1.00
2N2906A	4/$1.00	2N3725	$1.00	2N5088	4/$1.00
2N2907A	5/$1.00	2N3903	5/$1.00	2N5089	4/$1.00
2N2925	5/$1.00	2N3904	4/$1.00	2N5129	5/$1.00
2N3053	2/$1.00	2N3905	4/$1.00	2N5138	5/$1.00
2N3055	$.89	2N3906	4/$1.00	2N5139	5/$1.00
MJE3055	$1.00	2N4013	3/$1.00	2N5209	5/$1.00
MJE2955	$1.25	2N4014	3/$1.00	2N5951	5/$1.00
2N3392	5/$1.00	2N4123	10/$1.00	C106B1SCR	2/$1.00
2N3398	5/$1.00			2N5432	$2.00
				40673	1.75ea.

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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
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2200/16V	70	62	.55	470/25V	31	.28	26

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- 5375AB Nat. Clock Chip
- "Freeze" Feature on any Mode
- 24 Hr. Alarm w/snooze
- Field Tested over 6 months

The kit contains P.C. Boards, Xformer, and EVERY Part Required for the Clock and all options except Cabinet or Crystal Time Base for D.C. Oper. If desired, see below.

AC/DC - ALARM Clock Kit - 12/24 Hr.

$7.50 quantities of 1-5 **$6.50** quantities of 6 & up

- **Your choice of Display Colors - Red, Green, Blue, Amber**
- Displays Hrs. & Min. · Switch to Min. & Secs. on Command.
- AM/PM Indication
- Field Tested for 6 months

The kit will include a 5316 National Clock Chip, 4 Flourescent Display tubes, all electronic components, switches, controls & complete instructions, specs, etc. for clock and all optional Features. Other parts required or if desired are as follows:

- PC Board, Drilled & Silk Screened for Clock & all options $3.00
- Xformer (for AC oper.) — $1.00
- App. (SCR output) timer kit — $2.00
- Speaker Alarm Kit — $2.00
- Count Down (turn-off) timer kit — $2.00

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6 Digit LED Stop-Watch Kit

Split Time $26.95 Taylor Time

FEATURES:
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- Small enough for hand held case
- Needs only 3-AA cell batteries

KIT INCLUDES:
- Latest Technology Intersil Mos Chip # 7205
- 3.2768 MHz Crystal
- Variable Trimmer Cap.
- 2 mini slide & 3 MOM. PB Switches
- 3 pairs (6 digits) Double Digit LED Displays

P.C. BOARD for above $3.95

Clock Kit Accessories

60 Hz Crystal Time Base Kit .... $4.95 complete
Includes P.C. Board, Crystal, 17 Stage Divider IC and all camps.

Wooden Case - Walnut gr. incl. Filter .... $4.00 each
Dimension - 6 5/16" W x 2 9/16" H x 3 7/16" D (⅜" Material)

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Individual Filters - Red, Smoke, Blue, Amber and Green .... $.60 each

Blinky/Flasher/Timing Kit

$2.50 each 5 for $10.00

Kit includes:
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2N3906 PNP Si TO-92	5/$ 1.00
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4001–	.25	4018–	1.40	4047–	2.60
4002–	.25	4019–	.60	4049–	.70
4006–	1.60	4022–	1.20	4050–	.70
4007–	.25	4023–	.25	4055–	1.20
4009–	.60	4024–	1.25	4066–	1.20
4010–	.60	4025–	.25	4071–	.30
4011–	.25	4027–	.65	4077–	.70
4012–	.25	4028–	1.50	4081–	.35
4013–	.50	4029–	1.75	4076–	1.20
4015–	1.40	4030–	.90		

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600	.11	.30	.70	1.80	8.50
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7403–	.22	7447–	.69	74154–	1.05
7404–	.22	7448–	.77	74155–	1.00
7405–	.22	7472–	.40	74157–	.75
7406–	.35	7473–	.40	74161–	1.00
7407–	.33	7474–	.40	74164–	1.05
7408–	.25	7475–	.50	74165–	1.05
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7413–	.45	7486–	.45	74180–	1.00
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7417–	.33	7491–	.75	74191–	1.10
7420–	.18	7492–	.49	74192–	.80
7425–	.30	7493–	.49	74193–	.90
7426	.35	7494–	.80	74194–	1.25
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7432–	.30	74107–	.40	75324–	1.75
7437	.30	74121–	.39	75491–	.60
7438–	.30	74123–	.75	75492–	.60
7440–	.18	74125–	.60		

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200	.70	1.10	1.75	.60	.70	1.60
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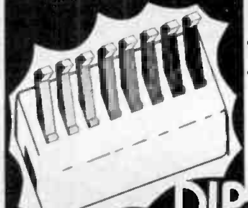

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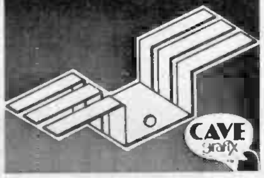

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2SC616	4.15	2SC797	2.50	2SC1237	4.50	2SC1908	.70	SK3054	1.25		
2SC617	4.25	2SC798	3.10	2SC1239	3.50	2SC1957	1.50				
2SC699	4.75	2SC781	3.00	2SC1243	1.50	2SF8	3.00	2SK19	1.75		
2SC710	.70	2SC789	1.00	2SC1306	4.75	HEP-S3001	3.25	2SK30	1.00		
2SC711	.70	2SC796	3.15	2SC1306-1	4.90	2SD235	1.00	2SK33	1.20		
2SC735	.70	2SC799	4.25	2SC1307	5.75	MRF8004	3.00				
2SC756	3.00	2SC802	3.75	2SC1307-1	6.00	4004	3.00	3SK40	2.75		
2SC765	9.50	2SC803	4.00	2SC1377	5.50	4005	3.00	3SK45	2.75		
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2SA483	1.95	2SB324	1.00	2SC491	2.50	2SC830	1.60	2SD30	.95
2SA489	.80	2SB337	2.10	2SC497	1.60	2SC839	.85	2SD45	2.00
2SA490	.70	2SB367	1.60	2SC515	.80	2SC945	.65	2SD65	.75
2SA505	.70	2SB370	.65	2SC535	.75	2SC1010	.80	2SD68	.90
2SA564	.50	2SB405	.85	2SC536	.65	2SC1012	.80	2SD72	1.00
2SA628	.65	2SB407	1.65	2SC537	.70	2SC1051	2.50	2SD88	1.50
2SA643	.85	2SB415	.85	2SC563	2.50	2SC1061	1.65	2SD151	2.25
2SA647	2.75	2SB461	1.25	2SC605	1.00	2SC1079	3.75	2SD170	2.00
2SA673	.85	2SB463	1.65	2SC620	.80	2SC1096	1.20	2SD180	2.75
2SA679	3.75	2SB471	1.75	2SC627	1.75	2SC1098	1.15	2SD201	1.95
2SA682	.85	2SB474	1.50	2SC642	3.50	2SC1115	2.75	2SD218	4.75
2SA699	1.30	2SB476	1.25	2SC643	3.75	2SC1166	.70	2SD300	2.50
2SA699A	1.75	2SB481	2.10	2SC644	.70	2SC1170	4.00	2SD313	1.10
2SA705	.55	2SB492	1.25	2SC681	2.50	2SC1172B	4.25	2SD315	.75
2SA815	.85	2SB495	.95	2SC684	2.10	2SC1209	.55	2SD318	.95
2SA816	.85	2SB507	.90	2SC687	2.50	2SC1213	.75	2SD341	.95
		2SB511	.70	2SC696	2.35	2SC1226	1.25	2SD350	3.25
2SB22	.65			2SC712	.70	2SC1243	1.50	2SD352	.80
2SB54	.70	2SC206	1.00	2SC713	.70	2SC1293	.85	2SD380	5.70
2SB56	.70	2SC240	1.10	2SC732	.70	2SC1308	4.75	2SD389	.90
2SB77	.70	2SC261	.65	2SC733	.70	2SC1347	.80	2SD-390	.75
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2SB152	4.50	2SC352	.75	2SC762	1.90	2SC1410	1.25	C106B1	.50
2SB173	.55	2SC353	.75	2SC783	1.00	2SC1447	1.25		
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2SB186	.60	2SC394	.70	2SC793	2.50	2SC1509	1.25		

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BU205	1500V	4.70	BU208	1500V	6.25	2SC308	1100V	4.95
BU206	1700V	5.90	2SC1170	1100V	4.00	2SC1325	1100V	4.95

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OEM SPECIALS

1N270	.10	2N960	.55	2N2219A	.30	2N2913	.75	2N3740	1.00	2N4401	.20		
1N914	.10	2N962	.40	2N2221	.25	2N2914	1.20	2N3771	1.75	2N4402	.20		
		2N967	.50	2N2221A	.30	2N2916A	3.65	2N3732	1.90	2N4403	.20		
2N173	1.75	2N1136	1.35	2N2222	.25	2N3019	.50	2N3773	3.00	2N4409	.20		
2N178	.90	2N1142	2.25	2N2222A	.30	2N3053	.30	2N3819	.32	2N4410	.25		
2N327A	1.15	2N1302	.25	2N2270	.40	2N3054	.70	2N3823	.70	2N4416	.75		
2N334	1.20	2N1305	.30	2N2322	1.00	2N3055	.75	2N3856	.20	2N4441	.85		
2N336	.90	2N1377	.75	2N2323	1.00	2N3227	1.00	2N3866	.85	2N4442	.90		
2N338A	1.05	2N1420	.20	2N2324	1.35	2N3247	3.40	2N3903	.20	2N4443	1.20		
2N398B	.90	2N1483	.95	2N2325	2.00	2N3250	.50	2N3904	.20	2N4852	.55		
2N404	.30	2N1540	.90	2N2326	2.85	2N3375	6.50	2N3905	.20	2N5061	.30		
2N443	1.75	2N1543	2.70	2N2327	3.80	2N3393	.20	2N3906	.25	2N5064	.50		
2N456	1.10	2N1544	.80	2N2328	4.20	2N3394	.17	2N3925	3.75	2N5130	.20		
2N501A	3.00	2N1549	1.25	2N2329	4.75	2N3414	.17	2N3954	3.50	2N5133	.15		
2N508A	.45	2N1551	2.50	2N2368	.25	2N3415	.18	2N3954A	3.75	2N5138	.15		
2N555	.45	2N1552	3.25	2N2369	.25	2N3416	.19	2N3955	2.45	2N5198	3.75		
2N652A	.85	2N1554	1.25	2N2484	.32	2N3417	.20	2N3957	1.25	2N5294	.50		
2N677C	6.00	2N557	.15	2N2712	.18	2N3442	1.85	2N3958	1.20	2N5296	.50		
2N706	.25	2N1560	2.80	2N2894	.40	2N3553	1.50	2N4037	.60	2N5306	.20		
2N706B	.40	2N1605	.35	2N2903	3.30	2N3563	.20	2N4093	.85	2N5354	.20		
2N711	.50	2N1613	.30	2N2904	.25	2N3565	.20	2N4124	.20	2N5369	.20		
2N711B	.60	2N1711	.30	2N2904A	.30	2N3638	.20	2N4126	.20	2N5400	.40		
2N718	.25	2N1907	4.10	2N2905	.25	2N3642	.20	2N4141	.20	2N5401	.50		
2N718A	.30	2N2060	1.85	2N2905A	.30	2N3643	.15	2N4142	.20	2N5457	.35		
2N720A	.50	2N2102	.40	2N2906	.25	2N3645	.15	2N4143	.20	C103Y	.25		
2N918	.35	2N2218	.25	2N2906A	.30	2N3646	.14	2N4220A	.45	C103D	.40		
2N930	.25	2N2218A	.30	2N2907	.25	2N3730	1.50	2N4234	.95	C106B1	.50		
2N956	.30	2N2219	.25	2N2907A	.30	2N3731	2.75	2N4400	.20	C106D1	.75		

SILICON UNIJUNCTIONS

2N2646	.50	2N2160	.65
2N2647	.60	2N4870	.50
2N6027	.55	2N4871	.50
2N6028	.70	2N4891	.50
D5E37	.25	2N4892	.50
		2N4893	.50
		2N4894	.50
		MU10	.40

INTEGRATED CIRC.

UA703C	.40
709C OP. AMP.	.25
741C OP. AMP.	.25
7400	.15
TA 7061P	3.50
TA 7205P	10.00
UPC 1001h2	6.00
NE 555	1.25

RECTIFIERS

	10	100
IN4001	.60	5.00
IN4002	.70	6.00
IN4003	.80	7.00
IN4004	.90	8.00
IN4005	1.00	9.00
IN4006	1.10	10.00
IN4007	1.20	11.00

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REGULATORS

Part	1-24	25up	100up
POSITIVE ADJUSTABLE			
SG100T	7.00	5.55	4.65
SG200T	6.00	4.80	4.00
SG300T	2.70	2.15	1.80
SG300N	2.30	1.85	1.52
SG105T	7.00	5.55	4.68
SG205T	6.00	4.80	3.20
SG205N	4.20	2.15	1.75
SG305T	1.45	1.15	.96
SG305AT	2.00	1.60	1.33
SG305N	1.45	1.15	.96
SG305M	1.20	.95	.80
SG723T	3.15	2.55	2.10
SG723J	5.25	4.15	3.48
SG723CJ	2.50	1.97	1.65
SG723CT	1.25	.98	.83
SG723CN	1.08	.90	.75
NEGATIVE ADJUSTABLE			
SG104T	12.00	9.50	8.00
SG204T	9.85	7.70	6.55
SG304T	3.25	2.58	2.15
SG1511T	4.05	3.00	2.65
SG1511J	6.50	4.95	3.90
SG3511T	3.85	2.75	2.35
SG3511J	5.95	4.00	3.40
REGULATING PULSE WIDTH MODULATORS			
SG1524J	20.00	15.55	13.50
SG2524J	16.45	12.85	10.75
SG3524J	10.15	8.10	6.75
☆ DUAL TRACKING ☆			
SG1501AT	10.15	8.10	6.75
SG1501AJ	11.65	9.30	7.75
SG2501AT	8.65	6.90	5.75
SG2501AJ	10.15	8.10	6.75
SG3501AT	5.95	4.75	3.95
SG3501AJ	7.45	5.95	4.95
SG3501AN	5.90	4.70	3.90
SG1568T	6.40	5.50	4.45
SG1568J	6.70	5.30	4.55
SG1468T	2.90	2.35	1.90
SG1468N	2.90	2.35	1.90
SG1468J	3.50	2.90	2.35
SG4501T	2.95	2.35	1.95
SG4501N	2.95	2.35	1.95
SG4501J	4.45	3.55	2.95
☆ ADJUSTABLE DUAL TRACKING ☆			
SG1502J	11.65	9.30	7.75
SG2502J	10.15	8.10	6.75
SG2502N	8.65	6.90	5.75
SG3502J	7.45	5.95	4.95
SG3502N	5.90	4.70	3.90
POSITIVE SPOT POWER			
SG109T	12.50	10.00	8.00
SG109K	13.50	11.00	9.00
SG209T	10.75	8.55	7.20
SG209K	12.75	10.20	8.55
SG309T	1.80	1.40	1.10
SG309K	2.25	1.90	1.50
SG123K	49.20	39.00	32.45
SG223K	25.00	19.55	16.55
SG323K	9.00	7.20	6.00
SG7805T	11.50	9.75	7.50
SG7805CT	1.80	1.40	1.10
SG7805K	13.00	10.50	8.50
SG7805CK	2.25	1.90	1.50
SG7806T	11.50	9.75	7.50
SG7806CT	1.80	1.40	1.10
SG7806K	13.00	10.50	8.50
SG7806CK	2.25	1.90	1.50
SG7808T	11.50	9.75	7.50
SG7808CT	1.80	1.40	1.10
SG7808K	13.00	10.50	8.50
SG7808CK	2.25	1.90	1.50
SG7812T	11.50	9.75	7.50
SG7812CT	1.80	1.40	1.10
SG7812K	13.00	10.50	8.50
SG7812CK	2.25	1.90	1.50
SG7815T	11.50	9.75	7.50
SG7815CT	1.80	1.40	1.10
SG7815K	13.00	10.50	8.50
SG7815CK	2.25	1.90	1.50
SG7818T	11.50	9.75	7.50
SG7818CT	1.80	1.40	1.10
SG7818K	13.00	10.50	8.50
SG7818CK	2.25	1.90	1.50
SG7824T	11.50	9.75	7.50
SG7824CT	1.80	1.40	1.10
SG7824K	13.00	10.50	8.50
SG7824CK	2.25	1.90	1.50
SG140-05T	11.50	9.75	7.50
SG140-05K	13.00	10.50	8.50
SG140-06T	11.50	9.75	7.50
SG140-06K	13.00	10.50	8.50
SG140-08T	11.50	9.75	2.50
SG140-08K	13.00	10.50	8.50
SG140-12T	11.50	9.75	7.50
SG140-12K	13.00	10.50	8.50
SG140-15T	11.50	9.75	7.50
SG140-15K	13.00	10.50	8.50
SG140-18T	11.50	9.75	7.50
SG140-18K	13.00	10.50	8.50
SG140-24T	11.50	9.75	7.50
SG140-24K	13.00	10.50	8.50
SG340-05T	1.80	1.40	1.10
SG340-05K	2.25	1.90	1.50
SG340-06T	1.80	1.40	1.10
SG340-06K	2.25	1.90	1.50
SG340-08T	1.80	1.40	1.10
SG340-08K	2.25	1.90	1.50
SG340-12T	1.80	1.40	1.10
SG340-12K	2.25	1.90	1.50
SG340-15T	1.80	1.40	1.10
SG340-15K	2.25	1.90	1.50
SG340-18T	1.80	1.40	1.10
SG340-18K	2.25	1.90	1.50
SG340-24T	1.80	1.40	1.10
SG340-24K	2.25	1.90	1.50
NEGATIVE SPOT POWER			
SG120-05K	12.50	10.00	8.00
SG120-5.2K	12.50	10.00	8.00
SG120-12K	12.50	10.00	8.00
SG120-15K	12.50	10.00	8.00
SG220-05K	7.50	5.95	5.00
SG220-5.2K	7.50	5.95	5.00
SG220-12K	7.50	5.95	5.00
SG220-15K	7.50	5.95	5.00
SG320-05K	3.00	2.38	2.00
SG320-5.2K	3.00	2.38	2.00
SG320-12K	3.00	2.38	2.00
SG320-15K	3.00	2.38	2.00

OP AMPLIFIERS

Part	1-24	25up	100up
GENERAL PURPOSE COMPENSATED			
SG107T	6.00	4.75	4.05
SG107J	12.00	9.95	8.35
SG207T	4.50	3.60	3.00
SG207J	7.20	5.75	4.80
SG207M	3.50	2.78	2.15
SG207N	3.00	2.38	2.00
SG307T	.90	.72	.60
SG307J	1.80	1.43	1.20
SG307M	.80	.64	.53
SG307N	.90	.72	.60
SG1436T	4.65	3.75	3.40
SG1436CT	2.60	2.50	1.85
SG1456T	3.40	2.70	2.20
SG1456CT	2.85	2.35	1.90
SG1536T	27.00	22.50	18.00
SG1556T	12.25	11.00	10.15
SG1760T	3.40	2.70	2.25
SG1760J	5.15	4.45	4.00
SG1760M	3.00	2.50	1.90
GENERAL PURPOSE UNCOMPENSATED			
SG101AT	5.00	3.95	3.35
SG101AJ	8.25	6.55	5.50
SG201AT	3.50	2.78	2.32
SG201AJ	3.50	2.78	2.32
SG201AN	1.95	1.55	1.30
SG201AM	2.25	1.78	1.50
SG301AT	.95	.78	.65
SG301AJ	1.25	.98	.83
SG301AN	.95	.78	.65
SG301AM	.90	.72	.60
SG748T	2.50	1.95	1.70
SG748CM	.90	.72	.60
SG748CN	.95	.75	.63
SG748CT	.97	.78	.65
DUAL COMPENSATED			
SG747T	5.70	4.50	3.80
SG747J	7.70	6.10	5.10
SG747CJ	4.00	3.20	2.65
SG747CN	2.40	1.90	1.60
SG747CT	3.00	2.35	2.00
SG1458T	1.95	1.55	1.30
SG1458M	1.72	1.35	1.15
SG1558T	5.50	4.40	3.65
HIGH PERFORMANCE			
SG108T	9.85	7.80	6.55
SG108J	12.60	10.20	8.55
SG108AT	13.00	10.35	8.65
SG108AJ	16.40	12.58	10.65
SG208T	8.50	6.80	5.70
SG208J	10.60	8.40	7.05
SG208AT	11.75	9.40	7.85
SG208AJ	14.60	11.50	9.75
SG308T	1.95	1.55	1.30
SG308J	4.00	3.20	2.68
SG308M	1.50	1.20	1.00
SG308AT	6.00	4.80	4.00
SG308AJ	12.00	9.50	8.00
SG308AM	5.00	3.95	3.35
SG1118T	13.65	10.90	9.10
SG1118J	26.00	21.80	18.20
SG1118AT	17.50	14.00	11.70
SG1118AJ	35.00	29.00	25.00
SG2118T	17.50	14.00	11.60
SG2118J	19.40	15.55	12.95
SG2118AT	15.60	12.45	10.40
SG2118AJ	28.95	24.15	20.75
SG3118T	2.55	2.00	1.70
SG3118J	5.85	4.70	3.90
SG3118M	2.40	1.95	1.65
SG3118AT	7.80	6.25	3.90
SG3118AJ	18.50	14.80	12.35
SG3118AM	13.50	10.80	9.00
☆ MICROPOWER PROGRAMMABLE ☆			
SG1250T	12.75	10.20	8.50
SG2250T	5.65	3.85	2.80
SG3250T	4.90	3.90	3.25
SG3250M	4.50	3.10	2.55
SG4250T	13.00	10.50	8.75
SG4250CT	4.90	3.90	3.25
SG4250CM	4.50	3.60	3.00
VOLTAGE FOLLOWERS			
SG110T	7.50	6.00	5.00
SG110J	19.10	15.30	12.75
SG210T	6.85	5.45	4.55
SG210J	15.75	12.60	10.50
SG310T	4.00	3.20	2.65
SG310J	5.50	4.40	3.68
SG310M	2.00	1.56	1.34
☆ HIGH SLEW RATE ☆			
SG741ST	5.05	4.00	3.35
SG741SCT	2.00	1.60	1.38
SG741SCM	1.80	1.50	1.20
QUAD			
SG124J	15.00	12.00	10.00
SG224J	7.00	5.55	4.65
SG224N	5.00	4.00	3.35
SG324J	3.50	2.80	2.35
SG324N	2.40	1.90	1.60

INTERFACE IC's

Part	1-24	25up	100up
SENSE AMPS			
SG7520J	2.50	2.10	1.80
SG7520N	2.05	1.75	1.58
SG7521J	2.00	1.67	1.44
SG7521N	1.60	1.34	1.16
SG7522J	2.50	2.10	1.80
SG7522N	2.05	1.75	1.58
SG7523J	2.00	1.67	1.44
SG7523N	1.60	1.34	1.16
SG7524J	2.50	2.10	1.80
SG7524N	2.05	1.75	1.58
SG7525J	2.00	1.67	1.44
SG7525N	1.60	1.34	1.16
SG7528J	2.50	2.10	1.80
SG7528N	2.05	1.75	1.58
SG7529J	2.00	1.67	1.44
SG7529N	1.60	1.34	1.16
SG7534J	2.50	2.10	1.80
SG7534N	2.05	1.75	1.58
SG7535J	2.00	1.67	1.44
SG7535N	1.60	1.34	1.16
SG7538J	2.50	2.10	1.80
SG7538N	2.05	1.75	1.58
SG7539J	2.00	1.67	1.44
SG7539N	1.60	1.34	1.16
☆ LINE DRIVER ☆			
SG1488J	4.95	3.40	1.95
☆ LINE RECEIVERS ☆			
SG1489J	4.00	2.50	1.90
SG1489AJ	4.05	2.80	1.95
COMPARATORS			
SG111T	8.00	6.35	5.30
SG111J	16.20	12.55	10.50
SG211T	6.35	5.05	4.20
SG211J	12.55	10.20	8.50
SG211M	5.50	4.50	3.65
SG311T	2.50	1.98	1.68
SG311J	5.50	4.40	3.65
SG311M	2.00	1.56	1.34
QUAD COMPARATORS			
SG139J	10.50	8.40	7.00
SG139AJ	18.40	14.80	12.15
SG239J	8.40	6.65	5.60
SG239AJ	14.80	11.60	9.90
SG239N	6.50	5.15	4.32
SG239AN	11.00	8.70	7.30
SG339J	2.50	1.98	1.67
SG339N	2.25	1.78	1.50
SG339AJ	5.00	3.95	3.35
SG339AN	4.50	3.55	3.00
DUAL PERIPHERAL DRIVERS			
SG55450BJ	2.95	2.30	2.00
SG75450BJ	1.40	1.25	1.05
SG75450BN	1.20	1.05	.95
SG55451BT	2.95	2.30	2.00
SG75451BT	1.40	1.25	1.05
SG75451BM	1.20	1.05	.95
SG55452BT	2.95	2.30	2.00
SG75452BT	1.40	1.25	1.05
SG75452BM	1.20	1.05	.95
SG55453BT	2.95	2.30	2.00
SG75453BT	1.40	1.25	1.05
SG75453BM	1.20	1.05	.95
SG55460J	2.85	2.15	1.90
SG75460J	1.60	1.40	1.20
SG75460N	1.20	1.05	.95
SG55461T	2.85	2.15	1.90
SG75461T	1.60	1.40	1.20
SG75461M	1.40	1.25	1.05
SG55462T	2.85	2.15	1.90
SG75462T	1.60	1.40	1.20
SG75462M	1.40	1.25	1.05
SG55463T	2.85	2.15	1.90
SG75463T	1.60	1.40	1.20
SG75463M	1.40	1.25	1.05
SG55464T	2.85	2.15	1.90
SG75464T	1.60	1.40	1.20
SG75464M	1.40	1.25	1.05
MEMORY DRIVERS			
SG55325J	7.80	6.20	5.25
SG75325J	6.65	5.25	4.40
BUS TRANSCEIVER			
SG55138J	5.95	4.70	3.95
SG75138J	4.70	3.75	3.15

TRANSISTOR ARRAYS

Part	1-24	25up	100up
SG3045J	4.50	3.65	3.00
SG3046N	1.30	1.05	.86
SG3146J	4.60	3.65	3.05
SG3146N	1.60	1.25	1.05
SG3821N	1.80	1.40	1.20
SG3821J	2.70	2.15	1.80
SG3822T	1.60	1.30	1.00
SG3822N	1.60	1.30	1.00
SG3822J	2.70	2.15	1.80
SG3823N	1.75	1.40	1.20
SG3823J	2.20	1.75	1.47
SG3081N	1.70	1.50	1.50
SG3081J	2.00	2.00	1.63
SG3082N	1.50	1.50	1.50
SG3082J	2.00	2.00	1.63
SG3083J	2.80	2.25	1.85
SG3083N	2.25	1.80	1.50
SG3183EN	1.60	1.40	1.35
SG3183AEJ	2.55	2.25	1.95
SG2001J	5.00	3.95	3.35
SG2002J	5.00	3.95	3.35
SG2003J	5.00	3.95	3.35
SG3851J	8.75	6.95	5.85
SG3852J	8.75	6.95	5.85
SG3853J	8.75	6.95	5.85

OTHER LINEARS

Part	1-24	25up	100up
WIDEBAND AMPLIFIERS			
SG733T	7.45	5.95	4.95
SG733J	8.25	6.60	5.50
SG733CJ	2.20	1.75	1.45
SG733CN	2.00	1.60	1.35
SG733CT	2.10	1.70	1.40
SG1401T	4.00	3.20	2.65
SG1401J	4.45	3.60	3.00
SG2401T	3.25	2.60	2.15
SG3401T	2.65	2.10	1.75
SG3401N	2.55	2.05	1.70
SG1402T	7.45	5.95	4.95
SG1402J	8.25	6.60	5.52
SG2402T	5.00	4.15	3.45
SG2402N	5.00	4.15	3.45
SG3402T	3.15	2.55	2.10
SG3402N	3.10	2.45	2.05
MULTIPLIERS			
SG1595J	8.20	7.00	6.15
SG1495J	5.05	3.45	2.55
SG1495N	2.25	1.90	1.55
MODULATORS			
SG1496J	1.60	1.25	1.05
SG1496T	1.60	1.25	1.05
SG1496N	1.60	1.25	1.05
SG1596T	4.05	3.25	2.70
ZERO VOLTAGE SWITCH			
SG3058J	5.80	5.00	4.20
SG3059N	3.20	2.95	2.35
SG3079N	1.65	1.45	1.20
TIMERS			
SG555T	13.00	10.48	8.70
SG555Y	15.00	12.00	10.00
SG555CT	1.30	1.05	.87
SG555CM	1.00	.70	.65
SG555CY	2.80	2.25	1.87
SG556J	10.50	8.35	7.00
SG556CJ	2.50	1.98	1.68
SG556CN	1.60	1.45	1.05

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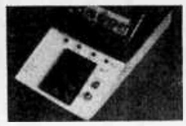

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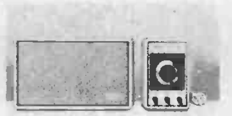

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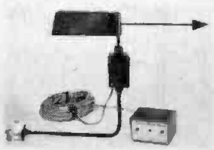

Glance at our Weather Wizard and know what to expect for the next 8-18 hrs. Be up to 80-85% accurate (better than most pro's)! Based on wind—no charts, dials—no computations! Program WW for *your* location once, then forecasting is automatic. Roofmounted windvane sends pulses to indoor control unit programmed w/75 yrs. data; interprets on 3 panel lights (Unsettled; Fair; Change). Who needs TV! Incls vane, support, 60 ft. of cable, 5 × 4½ × 3½" control unit, instruc.

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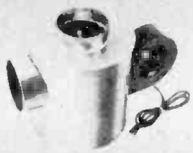

Save your 40% wasted heat to warm a basement, garage or rec room at no extra cost! Instead of going "up the chimney" it goes where you want it. Remove part of furnace exhaust pipe, slip Heat Exchanger in. At 125° fan automat. forces clean air through unit which heats to over 200°F., can be ducted to 20 ft. from unit. 110v AC. Inst.

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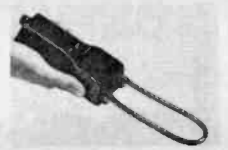

Not only ideal for searching out treasure, metal or mineral (its pitch tells you which), this *hand-held* (8 oz.; 12¼" long) high quality 2 oscillator BFO unit is great on security searches! And a real bloodhound at locating hidden pipes, other metal at home or work. Self-contained! 6" oval search coil and compact size let you get where ordinary detectors won't; has extension handle. It may make you rich, can save lives (concealed weapons, letter bombs) and work!

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CIRCLE NO. 56 ON FREE INFORMATION CARD

The new Dual CS 721 represents everything Dual has learned about turntables.

The new Dual CS721 is the ultimate expression of the principles that determine the performance of tonearms and drive systems. Its straight-line, tubular tonearm pivots horizontally and vertically within a true four-point gimbal, thus maintaining dynamic balance in all planes.

Another Dual innovation—Vertical Tonearm Control—contributes in yet another way to fine tracking performance. A vernier height adjustment over an 8mm range parallels the tonearm to the record with any cartridge. This eliminates the added mass of cartridge spacers otherwise needed to achieve precise vertical tracking angle. In all, there are seven tonearm settings and adjustments — from stylus overhang to cueing height and descent speed—all serving to optimize tracking performance with any cartridge.

The direct-drive system of the CS721 is of comparable precision. The electronically-controlled, DC, brushless motor is the smoothest and quietest ever made. A major contribution to this end result is an exclusive Dual feature: two stacked coil layers, each consisting of eight coreless bifilar-wound coils, that overlap to achieve a gapless rotating magnetic field. This eliminates the successive magnetic pulses typical of all other motor designs.

Although the CS721 is Dual's most expensive model, it is hardly the most expensive turntable available today. When you make comparisons, as we believe you should, you may well consider the CS721 considerably underpriced.

Dual

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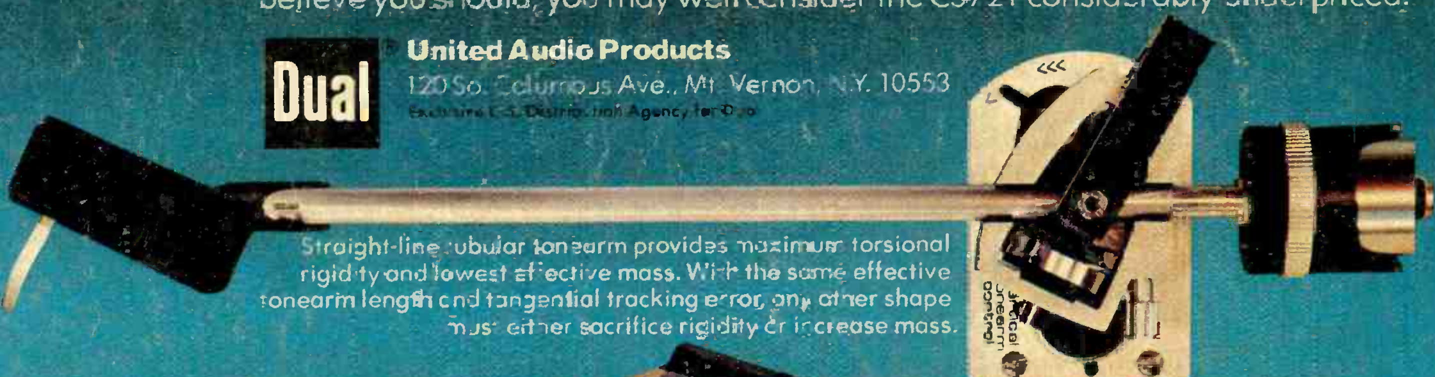
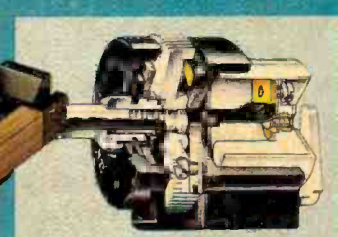


Straight-line tubular tonearm provides maximum torsional rigidity and lowest effective mass. With the same effective tonearm length and tangential tracking error, any other shape must either sacrifice rigidity or increase mass.

The Dual CS721. Single-play direct-drive turntable with fully automatic start and stop plus continuous repeat. Features include: 10% electronic pitch control, illuminated strobe, dynamically-balanced 12" platter, anti-skating separately calibrated for conical, elliptical and "long-contact" styli. Less than $400, including base and cover.
Dual CS704. Similar, except semi-automatic. Mechanical sensor locates lead-in groove of 12" and 7" records; tonearm lifts and motor shuts off at end of play. Less than $310, including base and cover.



Counterbalance contains two mechanical filters, tuned to absorb energy in resonance-frequency ranges of tonearm/cartridge system and chassis to avoid feedback.

Other Dual turntables: Fully automatic, single-play/multi-play: 1225, less than $140; 1226, less than $170; 1228, less than $200; 1249, less than $280. Semi-automatic, single-play Duals: 502, less than $160; 510, less than $200.

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