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Popular Electronics

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE NOVEMBER 1975/75c

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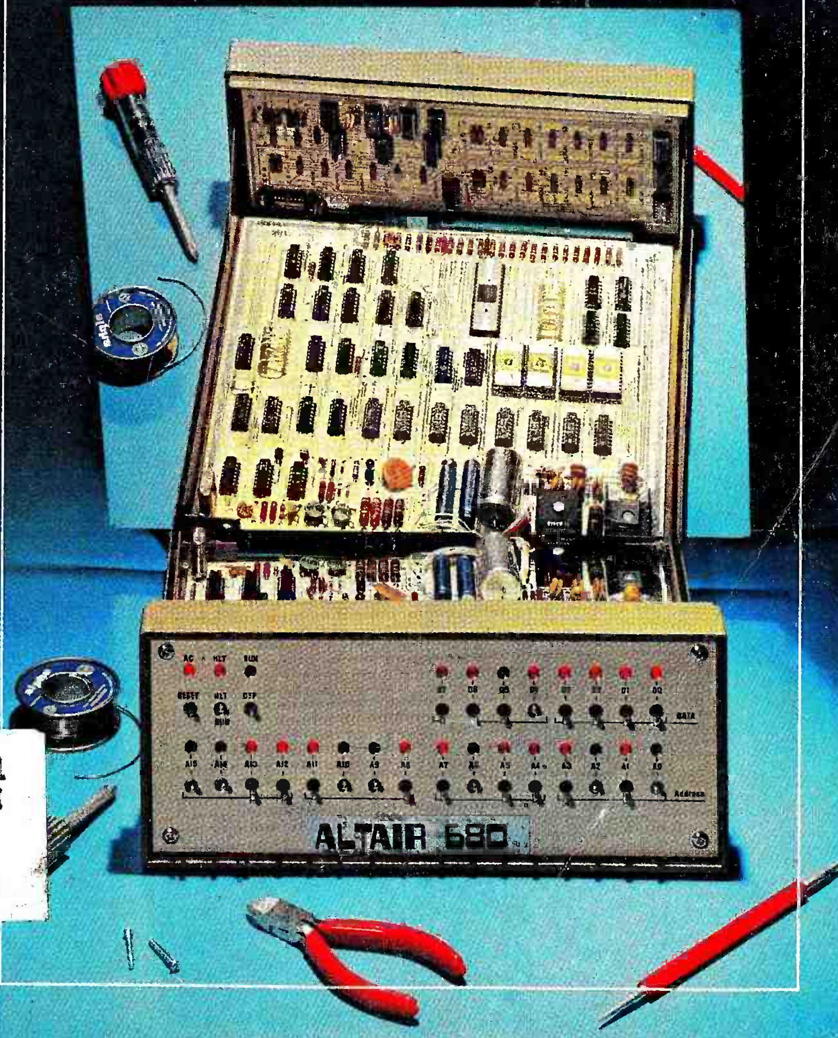

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Editorial

THE METRICATION WAITING GAME

Although Congress has not as yet passed a bill dealing with adoption of the metric system in the U.S., the changeover from our present English system is inevitable. After all, about 90% of the world's population with 75% of world trade uses the metric system. And with good reason! It's simpler and faster to deal with multiples and subdivisions of 10 than it is with units of 12.

Of course, the U.S. has been "going metric" for many years, although the use of the system has been more of an incursion than an adoption. For example, we employ the metric system for radio wavelengths, electrical measurements, medical prescriptions, and in photography. We even use it for hi-fi pickup tracking force—2 grams, 1 gram, etc.

Comparing the values of one standard with that of another is always awkward. For instance, 1 gram would translate to 1/28 ounce. In a turnabout, 7½ inches per second, a common U.S. tape recorder speed, is equivalent to 19.05 centimeters per second. Clearly, the nice even numbers occur with the standard that is dominant. The equivalent is generally complicated. For international trade purposes, however, many manufacturers "design" metric. That's why you see many cabinets and enclosures that measure fractionally, such as 14 3/16 inches instead of a nice round 14½ inches. The former measures 36 centimeters on the button!

There are many conversion tables around to compare a value in English to that of metric, and vice-versa. Metric conversion calculators are abundant, too. Moreover, there are factors to simplify conversion that are as easy as π to use (2.54 cm = 1 in.; 1 kg = 2.2 lb.). But when you get right down to it, one must eventually choose a system to the exclusion of all others so that even numbers predominate. Most countries employed a changeover period from English to metric, with highway signs reading both miles and kilometers, as an example.

The first country to go metric, France, had a 25-year dual system program starting in 1812 before metric became compulsory in 1837. Our defeated U.S. Metrication Bill had a 10-year changeover period.

Interestingly, Thomas Jefferson, when Secretary of State, recommended in 1790 that Congress introduce a decimal system; President John Quincy Adams advocated adoption of the metric system in 1821; Congress passed a law in 1866 making the metric system legal for those wishing to use it. Nearly 110 years later, however, the U.S. is the only major industrial nation in the world that uses the outmoded English system of weights and measures!

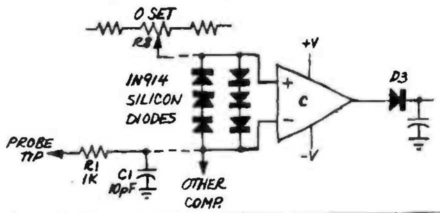
For a country that is a major participant in world trade, the delay in converting to metric is abhorrent. It means that a product cannot be made for universal distribution. Equally distressing, there is no serious move in our schools to teach upcoming generations the system of weights and measures that must ultimately be adopted.

Art Salsberg

Letters

USING DIODES WITH LOGIC PROBE

In "Build a Universal Logic Probe" (February 1975), it is doubtful that the probe will perform well at frequencies near 10 MHz. The diodes used to protect the inputs of the comparator IC are the bad guys. The capacitance of a typical zener diode is many times that of a typical switching diode. With the 1000-ohm value of *R1* and approximately 560-pF capacitance of *D1* and *D2*, there will be very little 10-MHz square-wave signal amplitude available at the comparator's inputs.



Far better results can be obtained if the zener diodes are each replaced with two or three switching diodes connected across the comparator's inputs as shown in my schematic.—*W.E. Parker, Columbus, Ohio*

NOTES ON PROGRAMMING PROCEDURE

The 8223 PROM specifications sheet recommends a 390-ohm burn resistor, as opposed to the 39-ohm value specified in "How To Program Read-Only Memories" (July 1975). The exact magnitude difference between the two values makes me suspicious of the article's procedure. —*Mark Coffman, Cincinnati, Ohio*

I have a question on one of the steps for programming a PROM (page 30). The note in step 1 states: "NEVER operate *S1* when *S2* is set to BURN." If this is correct, there is no way to blow the fuses.—*David Peterson, Edmonton, Alberta, Canada*

It has been our experience that most PROM's need a great deal more burn current than is possible to obtain using a 390-ohm resistor. We experimented with a number of PROM's and found that 39 ohms is the optimum burn resistor value. The 390-ohm value failed to give the desired results. (Perhaps the PROM's we had, from several sources, were manufacturer fallouts; if so, most of the PROM's our readers will be able to obtain are in this category.)

As for the note in step one of the programming procedure, it should read: "NEVER operate S1 when S2 is set to TEST."

RIPPLE CURRENT IN FILTER CAPACITORS

In "How to Design Your Own Power Supplies" (June 1975), no mention is made of the importance of not exceeding the ripple current rating of the capacitor. This factor cannot be ignored, particularly in low-voltage, high-current power supplies. Failure to consider the ripple current and its heating effect in the capacitor will severely shorten its life.—*S.A. Romano, Brooklyn, N.Y.*

The author replies that this is a good point to keep in mind if one finds heating in the filter capacitor. The ripple current may be what is causing it. Under normal loads and with full-wave and bridge systems, however, the typical capacitors available to experimenter should not present any problems.

Out of Tune

In "Build a Direct-Reading Logic Probe" (September 1975), in the Parts List, *DIS1* should be a common-anode unit, not common-cathode.

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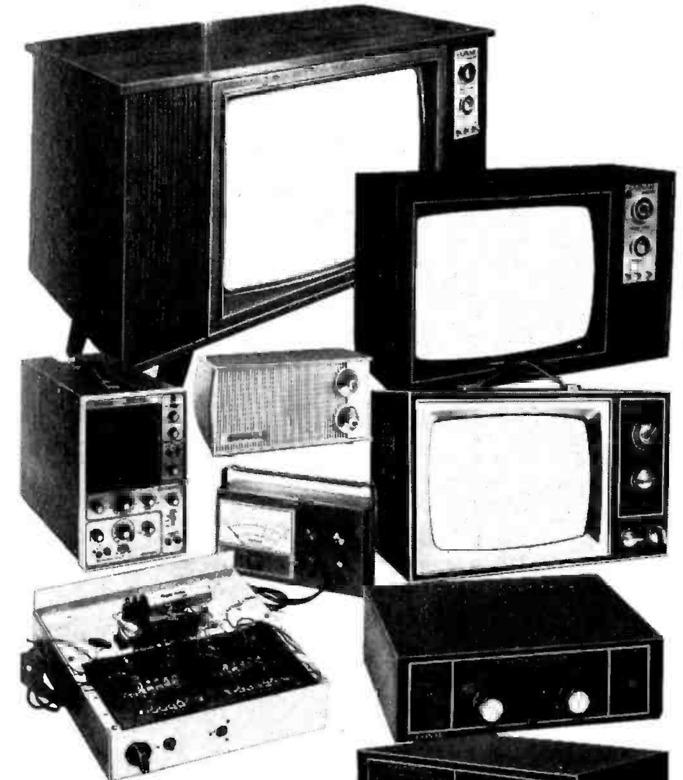

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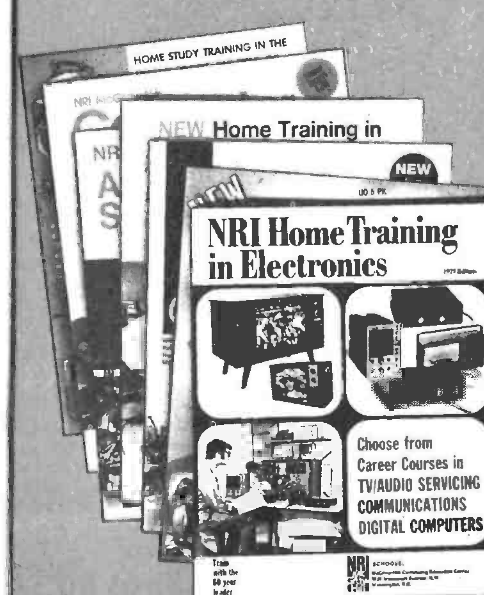

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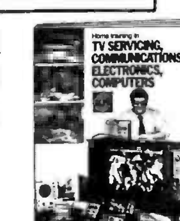

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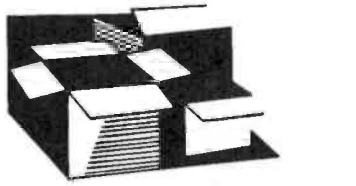

New Products

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.

ROTEL AM/FM STEREO TUNER

The Model RT-824 AM/FM Stereo Tuner by Rotel has a dual-gate MOSFET front end, an IHF sensitivity of 1.6 µV, a tuned r-f AM section, and a phase-locked-loop multiplex detector. A wide linear-scale dial and flywheel tuning are included for easy operation. A muting switch selects thresholds of 30 or 50 µV, or deactivates the muting

circuit. Two tuning meters facilitate proper tuning. The tuner also includes an FM stereo indicator lamp and an amplifier for headphone listening. An FM detector output jack can provide a composite signal for a four-channel decoder. $359.95.

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B.X. & L. AMPLIFIER DELAY SWITCH

The AMP-LAY-SWITCH[tm] amplifier delay switch by B.X. & L. Industries is a solid-state switching device that automatically turns off an amplifier at a preset time after an automatic turntable has played its last record. Time delays from 0 seconds to two hours are possible. Since both the amplifier and turntable are plugged into the AMP-LAY-SWITCH, the unit can serve as a master switch for the entire system. A manual/delay switch in included. $79.95. Address: B. X. & L. Industries, Inc., 17905 Sky Park Blvd., Irvine, CA 92707.

ADC "NEW MILFORD I" SPEAKER SYSTEM

The New Milford I is part of a series of loudspeakers developed by Audio Dynamics Corp. According to ADC, the speakers have been engineered with emphasis on "uniform energy response," which considers the listening room as an important speaker parameter. ADC claims that such speakers produce a uniformly flat energy output/frequency bandwidth characteristic, minimizing problems of critical speaker or listener location within the room. The New Milford I is a 3-way acoustic suspension system employing a 10-inch (25.4-cm), long excursion damped woofer which crosses over at 1500 Hz to a 2½-inch (6.4-cm) damped tweeter. Claimed energy response is 45 to 20,000 Hz ± 3 dB. A contour control adjusts the half-power (3-dB) tweeter rolloff frequency. Minimum recommended amplifier power is 5 W rms. Measures 22½"H × 13"W × 11"D (57.2 cm × 33 cm × 27.9 cm). Weighs 35 lb (15.9 kg). Simulated walnut grained, non-resonant wood products cabinet. $99.95.

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RCA DUAL-TRACE SCOPE ADAPTER

RCA's new Model WM-541A Dual Trace Adapter converts any triggered or recurrent-sweep oscilloscope to dual-trace operation for servicing audio, digital, and television circuits. The unit can provide additional traces for existing dual-trace scopes. Claimed frequency response is dc to 10 MHz, and display modes are channel A only, channel B only, or both A and B simultaneously (chopped or alternate). Ac and dc coupling are provided for both channels, as well as compensated 6-step (1, 2, 5 ratio) attenuators, separate variable sync-level control with polarity reversing switch, input and output BNC connectors, and vinyl-clad shielded case. COS/MOS integrated circuitry is said to yield a noise level of less than 10 mV, and a maximum signal output of 1 V (p-p). Maximum ac signal input is 50 V (p-p). Input impedance is 1 megohm shunted by 55 pF. The Model WG-400A direct/low capacitance probe is an option. The adapter measures 8¼" × 5¼" × 3¼" (21 cm × 13.3 cm × 8.3 cm) and weighs 3 lb (1.6 kg). $108.00. Probe, $15.00.

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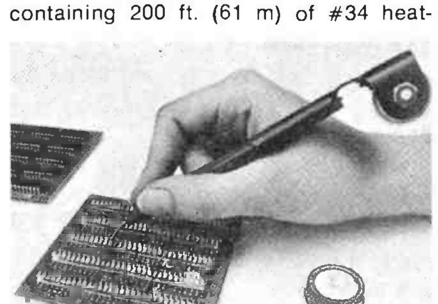
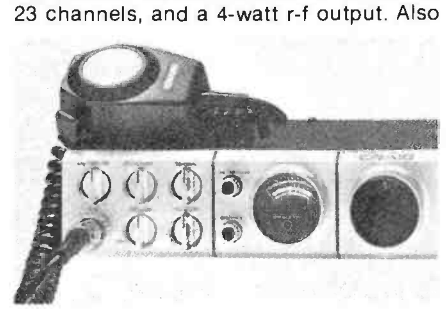


strippable wire, a circuit board with 15 IC positions and 10 insulating channels, and illustrated instructions. $11.95. Address: Applied Mfg. of Texas, One Main Place, Box 50273, Dallas, TX 75250.

CRAIG CB MOBILE TRANSCEIVER

Craig's new Model 4103 mobile transceiver features a quick-release, anti-theft mounting system, crystal synthesizer providing 23 channels, and a 4-watt r-f output. Also



provided are an r-f gain control, delta tune, ceramic filter, voice compression circuitry, adjustable squelch, anl, and short-circuit protection for output transistors. A three-position ANL/NB/PA switch, a backlighted S/r-f/SWR, and illuminated channel selector facilitate operations. A LED indicates that normal modulation is being achieved. The unit's detachable PTT dynamic mike comes with hanger and hardware. $199.95.

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TELEX CB HEADSET WITH BOOM MIKE

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HEATHKIT STEREO MIKE MIXER

Heath's new Model TM-1626 stereo mixer is a low-cost console with stereo outputs, four high/low impedance mike inputs (one with pan control), two auxiliary inputs, and slide controls. Switches above each input level control assign that input to the left or right channel or switch it off. A pan control adjusts the apparent location of the fourth mike anywhere between extreme left and extreme right. A mixer bus allows paralleling of any number of TM-1626 units. A pair of lighted VU meters continuously monitor the outputs over two switch-selected ranges—+4 or 10 dB. Peaks are caught by

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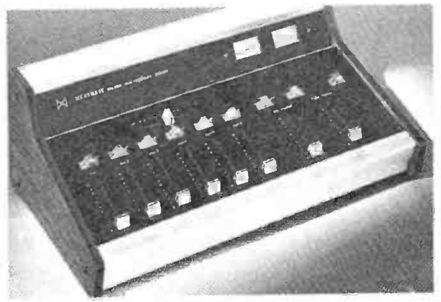

two LED's with adjustable thresholds. Claimed frequency response is 40-20,000 Hz ± 1 dB with less than 0.5% THD up to 6.5 V output. Overload-resistant inputs are rated at 3.0 V (AUX), 900 mV (HI-Z MIKE) and 60 mV (LO-Z MIKE). $129.95.

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A digital multimeter from Non-Linear Systems, the Model LM-3, offers three-digit readout and can be operated from either battery or line power (NiCd batteries and charger included). Small enough to be held in one hand, it has four ranges of ac and dc volts, and five resistance ranges from 1 kilohm to 1 megohm full-scale. Other features are automatic polarity and automatic zero, 10-megohm input impedance on all ranges, and a 0.33-inch (8.4-mm) LED display. Dimensions are 4" x 2.7" x 1.9" (10.2 x 6.9 x 4.8 cm). $125.00.

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TDK HIGH-PERFORMANCE CASSETTE

A new high-fidelity cassette tape, called Super Avilyn, is being introduced by TDK. Avilyn is a patented mix of cobalt, ferric oxide and other proprietary elements. The new tape is said to combine advantages of ferric and chromium tapes, but overcomes inherent problems in both the straight and hybrid formulas currently available. Headwear is said to be the same as that from FeO_3 tapes (much lower than that of CrO_2 formulas). According to TDK, the Avilyn tape has better low- and middle-range response while equaling the high-frequency response of chromium tapes. Its S/N is 0.5 to 1 dB better than CrO_2, and can be used with the standard chromium playback equalization time constant of 70 μs. The tape will retail for $3.95 in C-60 format. A C-90 package will be introduced later.

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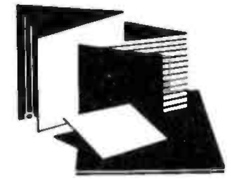

New Literature

JAMES MILLEN SHIELD DESIGN TIP

"Helpful Hints in the Design of a Magnetic Shield" is a 2-page engineering design tip describing how to shield sensitive devices from interference as well as how to shield devices that cause interference. Thickness and types of shielding materials are discussed, and degaussing procedures are given. Address: James Millen Manufacturing Co., Inc., 150 Exchange St., Malden, MA 02148.

ALTEC ENCLOSURE DESIGN MANUAL

"Loudspeaker Enclosures—Their Design and Use" is a 32-page manual containing data for use in designing and constructing enclosures for Altec loudspeakers. It discusses the function of the enclosure, speaker design theory, various types of enclosures, and how to tune a bass reflex port. Price is $2.00. Address: Altec Corp., 1515 S. Manchester, Anaheim, CA 92803.

NATIONAL CAMERA TOOL CATALOG

The "NC Flasher" (80 pages) includes hard-to-find tools, technicians' supplies, laboratory and workshop equipment, etc. Among new items listed are a low-cost circuit tester, accessories for the "Grabber" test-lead system, and tools and instruments for the photo equipment repair technician. Address: Dept. ORR, National Camera, 2000 W. Union Ave., Englewood, CO 80110.

PROJECTOR-RECORDER BELT CATALOG

A catalog and reference chart from Projector-Recorder Belt Corp. lists over 650 types of belts, wheels, and rubber parts for over 2000 models of audio and video tape players and audio/visual projectors. The company also specializes in servicing belts and other drive parts. Address: Projector-Recorder Belt Corp., 147 Whitewater St., Whitewater, WI 53190.

WOODCRAFTING CATALOG

A 22-page catalog from Garrett Wade Co. describes their line of hardwood workbenches and tools for all types of woodworking projects, including building speaker and hi-fi equipment enclosures and record cabinets. Tools include those for carving, clamping, mitering, and measuring. Workbenches come in a variety of sizes and styles. Address: Garrett Wade Co., Dept. 16, 302 Fifth Ave., New York, NY 10001.

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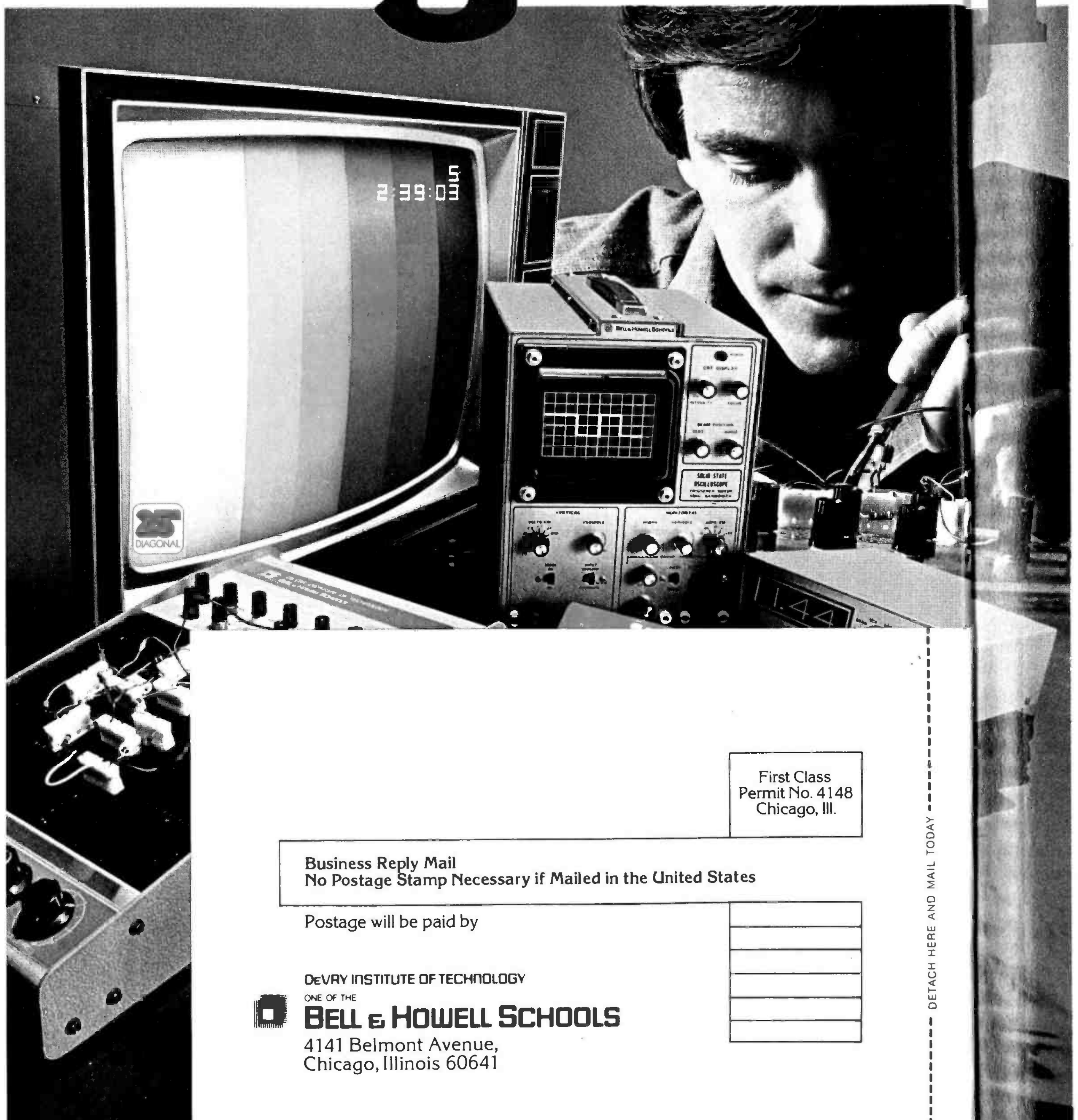

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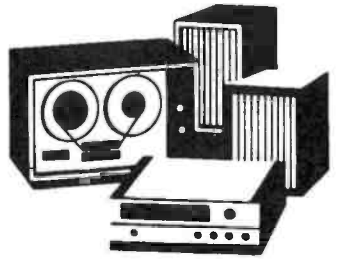


Stereo Scene

By Ralph Hodges

CLEARING UP SOME ODDS AND ENDS

THIS month's column will consist mainly of a few curiosities and conundrums that have kept my mind occupied for the past several weeks, but about which I don't expect to learn much more in the near future. Therefore, it's time to be out with them.

The Omni Question. A long-standing controversy surrounds the use of wide-dispersion or omnidirectional ("omni") loudspeakers in stereo installations. The stereo image provided by omni's, say their detractors, is vague, wandering, diffuse, and sometimes grossly distorted (as when a single instrument, which should have a small, sharply localized apparent source, grows to fill much of the space between the speakers). This is usually attributed to the wealth of reflected sound that omni's provide, creating an incalculable number of secondary sound sources in the vicinity of the speakers where the sound bounces off the walls or ceiling.

Reputedly, the true test of a loudspeaker's stereo capability—and it's certainly a theoretically logical one—is whether a pair of them, reproducing an in-phase mono signal, can develop a "stereo" image that is exactly front-and-center and rock solid, with no lateral spread whatever. This is not an easy test for many speaker systems, as it turns out.

Over the years I've come to share some of these misgivings, although not without reservations. For one thing, the anti-omni faction has handed down a blanket indictment of all such speakers, which instinct and experience tell me is unjust. Omni's differ. There is the Walsh-Ohm sort of device that should behave very much like a vertical line radiator and is inherently omnidirectional in the lateral plane. Then there is the distributed-source configuration in which drivers may be studded on all available surfaces of the cabinet. To a real-time spectrum analyzer integrating over short time increments, these would appear to be very different types of reproducers. To the ear itself, it's hard to predict what distinctions would be apparent.

But my major quibble with the omni detractors is on theoretical grounds. Oh, I know there's often something interesting going on—whether detrimental or not—when omni's are listened to, but I can't make the pat reflected-sound explanation jibe with what I understand to be the workings of the human ear. To enlarge: in the opinion of such august bodies as the Acoustical Society of America, the localization of a transient sound is likely to depend very much on the difference in arrival times of its very first onset at the two ears. If the left ear hears it a fraction of a millisecond before the right ear, then we're led to conclude that the source is somewhere to the left. In the case of sustained sounds for which onset time differences have not done the trick, we seem to depend on interaural *phase* differences for whatever localization is possible, provided the sound is below about 2,000 Hz. Above 2,000 Hz, which (interestingly) is the point where the wavelengths approach the distance between our ears, amplitude differences between the two ears appear to be dominant.

Now then, stereo is a contrived illusion that is typically achieved in complex ways, but it is certainly safe to say that, in terms of interaural onset-time differences (before any sound reflections have had a chance to reach us), omni's and more conventional speakers start out on an equal footing, and should "image" equally well.

It is true that a later-arriving reflection that is significantly stronger than the onset sound (not an impossibility if a speaker's free-field frequency response varies much at different angles) can overthrow the original localization, but such difficulties are not inherent in the omni approach. And when we consider phase and intensity differences, the situation is much the same. Properly worked-out omni's should be equivalent in integrity to conventional designs. But there remains another aspect of speaker behavior having to do with "togetherness" that might have some meaning here.

Time Smear. Because of the design of most crossover networks, and the nature of the drivers themselves, the separate elements of a multi-way speaker system tend not to respond to an input with equal alacrity. Usually the larger drivers are late, so that an input signal with a steep wavefront, like a square wave, would come out with its frequency components broken down according to which driver was handling them, and spread out over an appreciable time base. Not long ago someone dubbed this phenomenon "time smear"—definitely my favorite jargon phrase of the year—and it became a serious consideration in some speaker-evaluation schemes. The point is that a number of omni speakers, most especially the ones with multiple tweeters arranged so that you hear direct radiations from several of them, are going to exhibit more time smear than the usual case, because some tweeters will inevitably be nearer or farther than others. And, of course, the reflected sound they engender will be correspondingly smeared.

Probably it would be better if speakers didn't have any such anomaly, but since the overwhelming number of available products do, it's appropriate to wonder what audible bad effects it has. That is a subject on which it's hard to find agreement. On a signal (a drum beat, perhaps) that involves together the woofer, midrange, and tweeter(s) in what should be a unison response, we're likely to find some frequencies lagging considerably behind, which will sound not so good or perfectly all right, depending on whether you're talking to one "authority" or another.

One predictable effect of omni's documented long ago by Haas, is an increase in perceived loudness. The graph (page 24), which I think has implications for many audible phenomena, indicates that the ear integrates over a time "window" of about 100 milliseconds, so that any sound of about that duration will sound louder the longer it lasts. The delayed arrivals of sound that are an omni specialty—whether caused by reflections or the layout of the drivers—should bring about an extension of the time the sound lasts at the listener's position. It is to this that I'd attribute some of the bright, open quality (particularly in the high frequencies) that we tend to associate with wide dispersion.

As for time smear over several frequency bands, there is no logical reason for an omni's being at all inferior to a conventional speaker. There is some evidence—all of it quite subjective—for such temporal dislocations' causing a subtle change in perceived tonal balance. For example, some experienced listeners have reported noting tonal changes when they moved off the axis of a conventional speaker so that they were slightly closer to some drivers than others. (Of course, the reports state that all other likely causes of this were eliminated.) Also, several speaker designs, some in existence and others still aborning, take the whole matter very seriously.

Assuming there's substance in any of this, it's interesting to speculate on what portions of the signal would dominate; the leading or the lagging ones? As it happens, few omni designs take these considerations into account, and most would be hard pressed to do so. Ultimately this might prove to be a limitation. As things stand now, however, there might very well be something going on.

A New Phase. On a completely different subject, in a conversation with Chuck Wood of Audionics not long ago, I learned of a unique new product that that company is considering. It is an all-pass network that varies the phase of one channel of a phono cartridge, the idea being to get the two channels phase-synchronized as closely as possible and thereby enable your four-channel matrix decoder to work at its optimum. Harumph, I thought at first, but subsequent investigations have shown a number of cartridges I've checked out to have some phase shift between the two channels. Whether it's enough to be ruinous to matrix-decoder operation I can't say, but my impression is that these boxes need all the help they can get.

More Demo Records. My remarks of some months ago on demonstration records have lured a few more contestants out into the open.

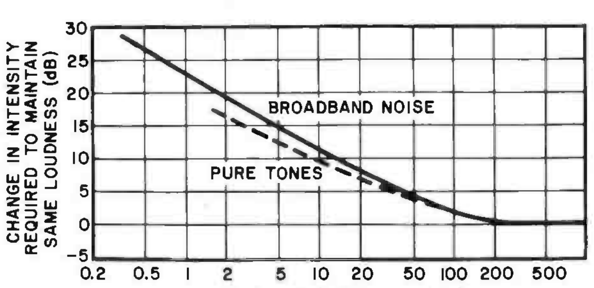
Fulton Electronics, among whose products is the FMI Model 80 (considered by many to be in the top rank of under-$100 speaker systems), also has a small recording operation at its Minneapolis base. Bob Fulton makes records the way I would if I knew how. Of the five Ark (his label) albums I've sampled, none is less than remarkable. One—*Organ Music from Westminster* (a Minneapolis church, not the British institution)—is unique in my listening experience. No light-voiced Baroque instrument this, but one of the high-pressure roarers that has you checking the ceiling overhead for rickety chandeliers. In fact, the specification shows the swell organ to be the largest section of the instrument, which smacks of nineteenth-century excess. Fortunately, the tone of the organ is not hard or piercing, but is almost dominated by the tremendous low-frequency resources—six 16-foot stops and one 32-foot Bourdon. Fulton has gone after these sounds in a way that all but opens the heavens. The bass is as substantial as a brick wall, and it just rolls over you without remission. Yet the rest remains in focus. I recommend the delightful Mozart selection for openers. I also recommend sturdy woofers.

I could be more enthusiastic about Ark's *Organ Sounds from Mount Olivet* if I hadn't heard the *Westminster* first. The *Olivet* recording is more than adquate in the bass, but of greater interest to me is the upper register, which is very strong yet freer of modulation effects and plain distortion than I'm used to. I should note that, as in the *Westminster*, some of the repertoire is of less than poignant interest, and unfortunately the organist's manner with J.S. Bach, of which there is nearly a full side, tends to be overmethodical.

It is unusual to find a large-scale work such as Bloch's *Sacred Service* as an original recording effort by a small label, but it is available from Ark, paired with Francis Poulenc's *Gloria*, as performed by orchestral and choral forces of the University of Minnesota. Being a two-microphone pickup (fundamental in Mr. Fulton's recording philosophy, I'm told; also, no Dolby processing—I suspect he doesn't believe in it—so all these records hiss), the recording assigns all soloists to the left channel. And, of course, there are no touch-up mikes to highlight orchestral details, if you've become used to that artifact of multi-track recording. The sound that results is extremely attractive and full-bodied, with a "sweetness" (the only word that comes to mind) of the high frequencies that seems characteristic of all the Ark releases (which wears very well for protracted listening). By great good luck, the Minnesota string section seems to have that rarest of talents among nonprofessional groups: the ability to play together and in tune most of the time. All in all, I don't know which large recording outfit you could turn to for so satisfactory a rendition of this music, or any choral-orchestral work.

The repertoire of the *Armstrong High School Choirs* ranges from Renaissance to late-Romantic sentimentality and the inevitable spiritual; but it has taste, and the Armstrong teenagers do crack ensemble with effortless range and dynamics. The recording is close-up and superlative; it should make you feel warm all over, as well as enabling you to hear the words of almost every voice in the group. *Anoka High School Concert Band (1974)* is just as good technically, but it is a high school band—a healthy cut above the troupes that march on New York's Fifth Avenue on St. Patricks Day, but distinctly troubled at times by the difficulty of the material selected (a transcription of the Berlioz *Roman Festival Overture*, for example). Catalog and prices available from Fulton Electronics, 4428 Zane Ave N., Minneapolis, MN 55422.

Old-time Dixieland is becoming a



Below 100 ms, short sounds must be more intense to seem as loud as longer sounds. (Courtesy Hewlett-Packard Journal) specialty of Burwen Laboratories, which incidentally manufactures a compander recording system and a dynamic noise filter for playback-only purposes. Burwen's first record (there have been a couple since, I believe) demonstrates the compander with stunning success. The disc, *Perfectly Clear,* presents the East Bay City Jazz Band and vocalist Jane Campedelli in what is said to be a close approach to traditional New Orleans music making. The record is a real wonder. There is not a sound on it that has not been captured with absolute, crystalline precision, and it's fascinating to follow the sharply etched outlines of the brass timbre into the sinuosity of a virtuoso clarinet. The banjo is a bit remote (it "rustles," as the song says), and the drums are really too far away from the mikes, getting soaked up by the extremely dead acoustic of the recording site. But the recording overall has, of course, no tape noise, and no trace of side effects that I could hear from the operation of the compander system. Nor is there any print-through of groove echo. Recorded levels are on the moderate side to accommodate the extreme peaks (which Burwen claims are there and my scope confirms), but the pressing is the flattest piece of vinyl I've seen in years, and exceptionally quiet. If your system will tolerate high gain settings you can blow yourself into chopped liver with this recording and never hear more than a whisper of noise. The Burwen record is $10.50 from: Burwen Labs, 209 Middlesex Tpke., Burlington, MA 0183.

As promised, Ambiphon provided a new copy of the Natalie Ryshna piano recording that I found too noisy and otherwise unimpressive in my last report. The new pressing is a great improvement—much superior to the earlier one in terms of discrete noises, and perhaps a bit better in hiss level. Listening to it has set my mind working again on the extremely detrimental effects of noise in any listening situation. At first hearing, the dynamic range of the new pressing seemed much better, but in a later direct comparison with the older version it came out about equal. A tricky business this.

Ambiphon also sent a newer recording by the Tequila Mocking Bird Chamber Ensemble. From the name you'd not expect that the group plays Handel, Vivaldi, and Pachelbel straight, but that appears to be the case. However, they attack this material with violin, tuba, and vibraphone. I question whether the vibes achieve a successful blend with the violin, but the tuba generally works well. God knows the bass line is always audible. The recording is very good. The only thing that keeps it from being exceptional is the lack of a big, spacy acoustic and/or spectacular dynamic range. Ambiphon's address is: P.O. Box 341, Kingsbridge Station, Bronx, NY 10463.

In closing, let me announce that CBS Laboratories, now reorganized as CBS Technology Center, is again offering its full range of test records, many of them remastered with newer equipment. The CBS series is especially valuable to the hobbyist because voice-identified spot frequencies are provided along with the more usual sweep tones that require a chart recorder. Thus a good voltmeter will suffice for reasonably accurate frequency-response measurements. For a catalog and price list write: CBS Technology Center, High Ridge Rd., Stamford, CT 06905. ◈

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Popular Electronics
NOVEMBER, 1975

The First Motorola/AMI '6800' MPU Computer Project

PE TESTED

Features compact size, simplified construction, built-in TTY interface, and low cost.

BY H. EDWARD ROBERTS & PAUL VAN BAALEN

LARGE-SCALE integration (LSI) has provided many useful IC chips for the hobbyist. One of the latest LSI devices is the microprocessor unit (MPU), which has made it possible to build microcomputers that are fairly easy to assemble at moderate cost. The most popular MPU's are the 8008 and 8080 due to their reasonable cost and wide availability in computer kits.

However, many knowledgeable hobbyists have been looking for a microcomputer built around one of a number of other MPU's available (just as some people would like to try a diesel or steam engine to replace the gasoline motor). Most of these readers have told us they were interested in the Motorola M6800 MPU (for one reason or another). Many also felt that the price of a microcomputer was still too high. POPULAR ELECTRONICS is therefore pleased to introduce the first microcomputer using the 6800 MPU in a design that substantially reduces cost.

THE Altair 680 is a complete microcomputer built around the 6800 MPU available from Motorola and American Micro-Systems, Inc. Measuring a very compact 11 1/16"W × 11 1/16"D × 4 11/16"H (28.1 × 28.1 × 11.9 cm), the 680 is less than one-third the size of the Altair 8800. Although both computers have MPU's with the same memory capacity, the 680's smaller enclosure makes internal expandability significantly less. However, it is more than adequate for most applications. More importantly, the 680 costs less than half the price of the 8800 when the two machines are configured similarly in a minimum system.

Other attributes of the new computer include ease of assembly (only one large pc board), built-in TTY interface, and high speed (4-μs minimum cycle time). The last is some 10 to 50 times faster than earlier small computers built around the 8008 MPU but half the speed of the 8800.

Another meaningful consideration in a 6800-MPU computer design is the raft of instructional material readily available from Motorola Semiconductor Products, Inc., including the "M6800 Microprocessor Programming Manual." Too, the 6800 is TTL compatible and uses just one 5-volt power supply.

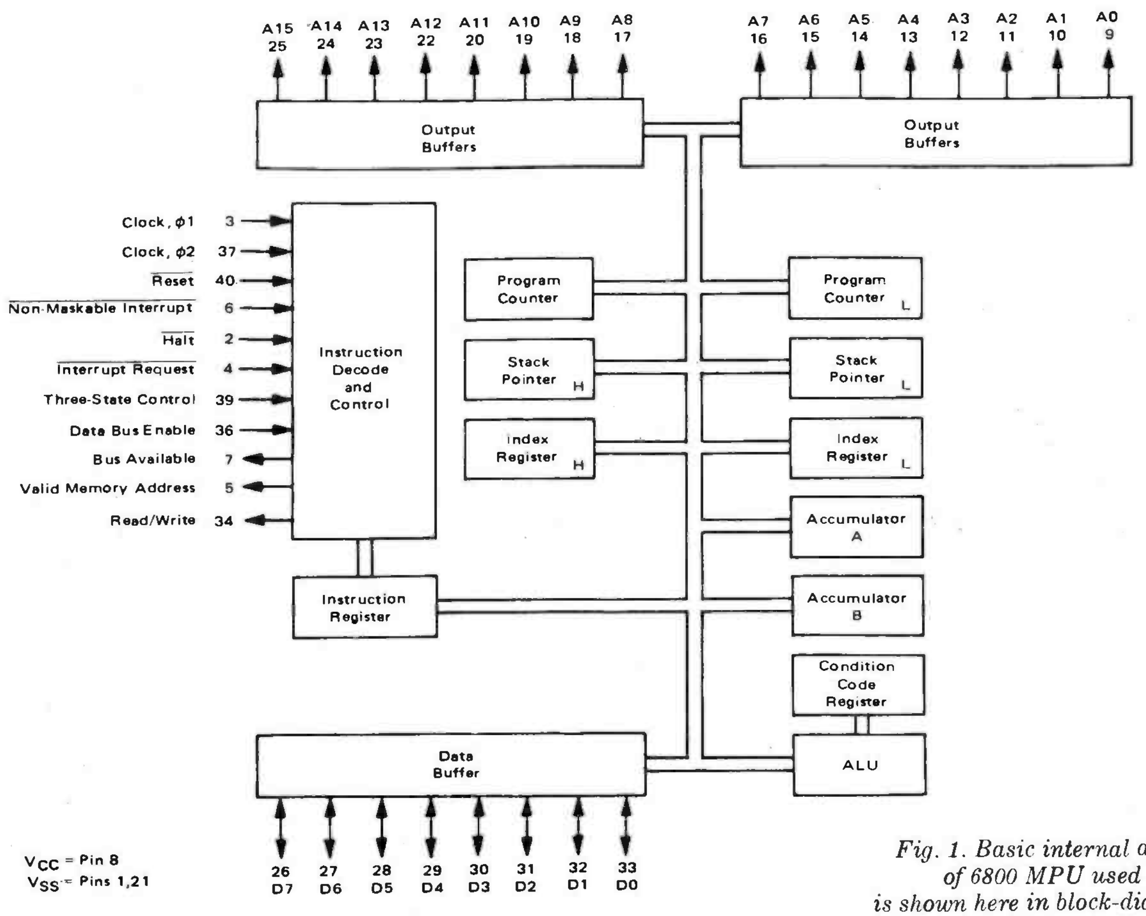


Fig. 1. Basic internal arrangement of 6800 MPU used in computer is shown here in block-diagram form.

Basic System Philosophy. The basic MPU, memory, I/O (input/output), and power-supply circuits in the Altair 680 are located on a single printed circuit board. The addition of a compact power transformer makes this assembly a complete computer system. (Front-panel switch programming can be used, but in the absence of this assembly, PROM's or ROM's must be installed for programming.)

The front-panel assembly contains all the logic needed to reset, halt, or start the processor. Also, any memory cell can be read or written into from the front panel via 16 ADDRESS and eight DATA switches. Mounted on the front-panel circuit board is a 100-contact edge connector that permits the main MPU board to plug directly into the front panel, thus eliminating the need for a wiring harness. (In systems that do not use the front-panel assembly, the MPU board automatically starts running at an address specified by either a PROM or a hard-wired patch.) The front panel contains 27 LED's that indicate the state of each switch. As a safety measure, the POWER switch is located on the back of the cabinet to obviate the possibility of its being accidentally operated during programming.

The basic computer contains 1024 bytes of memory and has provisions for an additional 1024 bytes of PROM or ROM memory. An I/O channel and interface are also included in the basic system. The I/O channel can be configured to interface RS-232 or a 20-mA or 60-mA TTY loop. This means that anyone who can obtain an old five-level Baudot-type Teletype—such as the MOD-15, MOD-19, etc.—can use it as a computer terminal. (Many such Teletypes are available for less than $100 and frequently for as little as $25 nationwide.)

The Altair 680 can be built with either a full-programmability or a "turn-key" front panel. The latter eliminates all controls except restarting the processor. There are a number of applications where this is desirable to eliminate the possibility of having an operator affect the contents of the memory or the computing cycle. An example might be in a sophisticated intruder-detection system where the only control provided for the operator is essentially on/off.

Software. The software associated with the 6800 MPU includes an editor, PROM monitor, and assembler, as contrasted to the editor, assembler, monitor and basic for the Altair 8800 computer.

System Details. The Altair 680 computer is composed of five sections: MPU and clock, memory, control and indication, I/O port, and power supply.

MPU and Clock. As mentioned earlier, the MPU and clock are the new 6800 LSI chip. Its basic internal arrangement is shown in Fig. 1. The main elements are instruction decode and control, instruction register, data and address registers and buffers, 16-bit index register, 16-bit program counter, 16-bit stack pointer, two 8-bit accumulators, condition code register, and ALU (arithmetic logic unit).

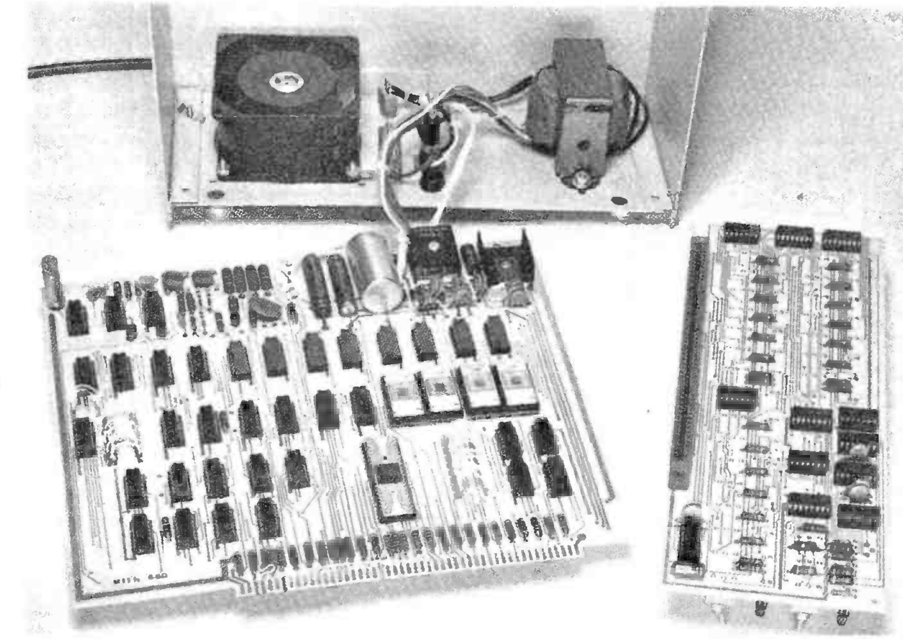
The timing and control inputs and outputs for the 6800 chip are:

Phase 1 and phase 2 clock (φ1,φ2)—a nonoverlapping 500-kHz clock at V_{cc}.

Address bus A0 through A15—16 high active outputs that determine address or I/O sections to use.

DISPLAY PARTS LIST

C1,C4—0.33-μF, 12-V disc ceramic capacitor
C2,C3—0.47-μF, 12-V disc ceramic capacitor
DA00 to DA15, DD00 to DD07, and DS1 to DS3—RL21 light-emitting diode
ICA,ICB,ICC,ICD,ICI—74LS05
ICE,ICF,ICG,ICH—4449
ICJ—74L00
ICK,ICL—26L123
Following resistors are ½-watt, 5%:
R1 to R16,R20 to R27—1500 ohms
R17 to R19—20,000 ohms
R28 to R30,R33 to R37—4700 ohms
R31 to R38—1000 ohms
R39,R40—10,000 ohms
SC1 to SC12—0.1-μF, 12-V disc ceramic capacitor
SA00 to SA15,SD00 to SD07,S24—Spdt toggle switch
S26,S27—Spdt momentary toggle switch
Misc.—100-contact edge connector



Almost entire computer is assembled on a single large pc board (left). Board at right is for front panel. Boards plug together.

Data bus D0 through D7—eight high active bidirectional lines for transfer to and from memory and peripherals.

Halt signal ($\overline{HLT}$)—low active input that ceases activity in the computer.

Read/write signal (R/$\overline{W}$)—in the high state, signals the memory and peripherals that the MPU is in the read condition; in the low state, signals that the MPU is in the write condition.

Valid memory address (VMA)—signals external devices (memory and I/O) that the MPU has a valid address on the memory bus.

Data bus enable (DBE)—enables the bus drivers.

Bus available (BA)—indicates machine has stopped and address bus is available.

Reset ($\overline{RES}$)—resets and starts the MPU from a power-off condition. A positive-going edge on this input tells the MPU to begin the restart sequence.

Interrupt request ($\overline{IRQ}$)—when low, tells the MPU to start an interrupt sequence (save the registers on the stack, set interrupt mask bit high so no other interrupts can occur, and vector to the interrupt address). This type of interrupt can only occur if the interrupt mask bit in the condition code register is low.

Nonmaskable interrupt ($\overline{NMI}$)—essentially the same as the $\overline{IRQ}$, except it is not dependent on the condition code register.

The clock is a 2-MHz crystal-controlled oscillator that uses a pair of inverters that drive flip-flops to form a 500-kHz, two-phase clock that is distributed to the MPU, memory, and I/O sections in the computer via inverters and buffers.

Memory. The memory system consists of 1024 words of 8-bit-wide RAM, using 2102-type 1024 × 1-bit devices, and up to 1024 words of PROM, using ultraviolet-erasable 1702 devices. The basic arrangement is shown in Fig. 2. The low-order address bits are fed to both the RAM's and PROM's.

Front Panel. The front panel assembly contains the RUN/HALT switch, with a LED for each switch position; a reset switch with no LED indicator; and the ac power ON LED indicator (Fig. 3). The 16 ADDRESS switches and eight DATA switches each have their own LED indicator.

The DEPOSIT, RESET, DATA, and ADDRESS switches are enabled only when the RUN/HALT switch is in the HALT position, at which time, a retriggerable one-shot multivibrator drives the halt input of the MPU low. This, in turn, drives the bus-available (BA) signal high and also conditions the other switches. To view the data in any memory location, the RUN/HALT switch must be placed in the HALT position and the ADDRESS switches set to the required address. The data at that

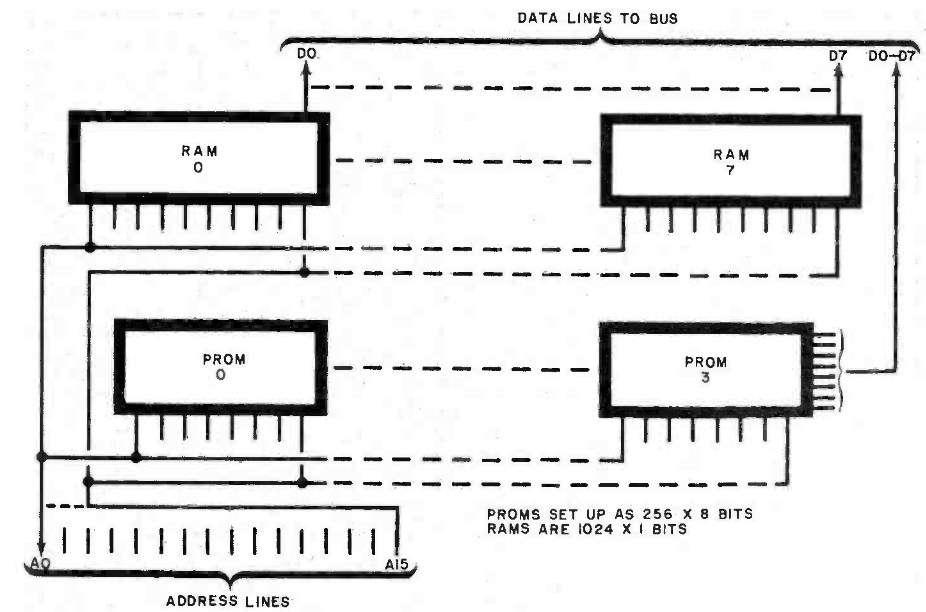


Fig. 2. There are eight RAM's (RAM 0 through RAM 7) and four PROM's (PROM 0 through PROM 3) in the computer's memory system.

ALTAIR COMPUTER COMPARISON CHART

Features	Altair 680	Altair 8800
Maximum word size	24 bits (byte oriented)	24 bits (byte oriented)
Arithmetic unit	8-bit parallel	8-bit parallel
Minimum cycle time	4 µs	2 µs
Program instructions	72	78
Maximum memory size	65k bytes	65k bytes
Internal expandability	5 interface cards	250 interface cards
Interrupt	3 levels	8 levels
MPU	6800 (Motorola, AMI)	8080 (Intel, TI)
Approximate system cost (lk memory, I/O, case, P/S)	$300	$600
Miscellaneous	Fewer parts 2 printed circuit boards Smaller size Built-in TTY interface	Minimum of 4 pc boards

MAIN BOARD PARTS LIST

BD1—Bridge rectifier (VJ048)
C1—3300-µF, 50-V electrolytic capacitor
C2,C3—100-µF, 50-V electrolytic capacitor
C4 to C9—0.33-µF, 50-V disc ceramic capacitor
C10,C13—0.1-µF, 16-V disc capacitor
C11,C12—0.33-µF, 16-V disc capacitor
C14—0.01-µF, 16-V disc capacitor
C15—1-µF, 50-V electrolytic capacitor
D1,D2,D7 to D12—1N4004 diode
D3 to D6—1N4739A, 9.1-V zener diode
F1—1-A, 250-V ac, 3-AG fuse
ICA—7404
ICB—7473
ICC,ICUU—7408
ICD,ICE,ICS—4449
ICF,ICG—74LS01
ICH,ICJ,ICK,ICL,ICM,ICN,ICP, ICR—2102
ICT,ICU,ICGG,ICHH,ICPP, ICRR—74L30
ICV—74L00
ICW—74L74
ICX,ICY,ICTT—4050
ICZ,ICAA,ICBB,ICCC—1702
ICDD,ICFF—74L04
ICEE,ICMM—74L10
ICJJ—6800
ICKK,ICLL,ICSS—74LS05
ICNN—74LS27
Q1,Q3,Q4—TIS98
Q2—EN3907
Except where noted, following resistors are ½-watt, 5%:
R1,R2—33 ohms, 2-watt, 5%
R3,R4,R5,R7—100 ohms
R6—130 ohms, 1-watt, 5%
R8,R11—800 ohms
R9—220 ohms, 1-watt, 5%
R10,R28 to R51—7500 ohms
R12,R15,R16,R17—1000 ohms
R13—470 ohms
R14,R20,R21—390 ohms
R18,R19—330 ohms
R22—33,000 ohms
R23,R24,R25,R60—10,000 ohms
R26,R27,R56,R57,R58,R59—not used
R52 to R55—3000 ohms
SP1—Spdt toggle switch
T1—5-volt, 1.2-A transformer
VR1—7805 regulator
XTAL—2-MHz crystal
Misc.—Fuse holder (Buss HKP-CC, line cord, fan (IMC 3⅜"), I/O socket (DB-255), sockets (14-pin, 22; 16-pin, 20; 24-pin, 4; 40-pin, 1), case optional).
Note—The following are available from MITS, 6328 Linn, N.E., Albuquerque, NM 87108: complete kit (all parts) #680F at $293; complete kit except for front panel board #680T at $240; kit #680MPU, including pc board, 6800 MPU, lk memory, and all main board components except power supply at $180; front panel and MPU pc boards #680PC at $48; I/O socket kit at $29; fan kit at $16; 256 x 8-bit PROM kit at $42; construction information package is free, with self-addressed stamped 9" x 12" envelope.

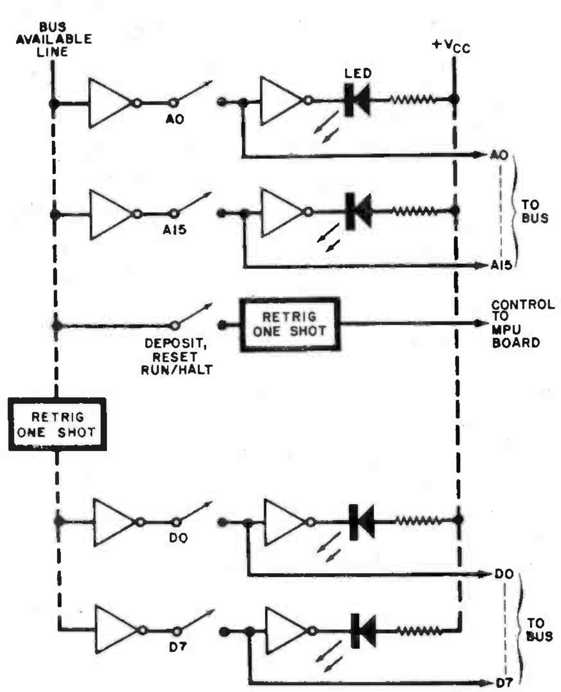


Fig. 3. Front panel contains address and data switches A0 through A15 and D0 through D7, reset switch, and LED indicators.

memory address location will then appear as lighted and unlighted LED's in the DATA display.

To change data in a location, the desired data is written via the DATA switches and entered by operating the DEPOSIT switch. This triggers a one-shot multivibrator, enabling the data information to the data bus and causing the R/W̄ signal to go low. Since the address bus is already connected to the switches by being in the halt state, the write pulse causes the data to be written into the selected RAM address.

When the RESET switch is operated, the CPU resets. This, in turn, initiates a restart sequence. That is, the address bus is pulled to the high state and causes the hard-wired data in the board jumpers to be used as the restart address.

Access to the I/O port is gained by addressing location 17577 (in octal). A sequence of events then occurs that

causes an output to the built-in TTY output jack and at the Teletype itself.

Power Supply. The main 5-volt line is generated within the computer by a conventional bridge rectifier, filter capacitor, and IC regulator circuit. A 32-volt winding on the transformer is used to generate the unregulated ±16 volts required for the TTY interface system, while a −16-volt line is fed to four zener-diode-regulated outputs to provide four 9-volt lines for the PROM's.

Construction. The actual-size etching and drilling guides for the computer boards are larger than our page size. Rather than reducing or cutting them up to fit our pages, a free construction package is available. If you wish to obtain a construction information package, simply send a self-addressed stamped 9" × 12" envelope to the address given at the end of the Parts List.

The construction package contains full-size schematics, full-size etching and drilling guides, component-placement diagrams, and front-panel layout. ◈

CRAMER ELECTRONICS ENTERS OEM COMPUTER KIT MARKET

THE major reason for the tremendous success of the various computer kits on the market is that they save considerable time. One doesn't have to hunt down the MPU's, memories, etc., that must be accumulated before embarking on a home computer project. It appears that OEM engineers are also spending considerable time in hunting down computer parts. Cramer Electronics, one of the leading U.S. electronic parts distributors, has decided to enter the computer kit business, with emphasis on the OEM market.

Cramer is starting with three kits, separately based on the Intel 8080, Motorola 6800, and Texas Instruments TMS8080 MPU's. Each of the kits shares a common $495 price tag.

You get a lot for $495: complete color-coded schematic diagram; RAM with 1024 (8-bit) bytes, expandable to 65 k bytes; erasable PROM with 1024 (8-bit) bytes; support circuitry, including clock, complete buffering, control and synchronization logic, interrupts, DMA controls; etc. The PROM gives you a program to run at the outset. There are at least four 8-bit-wide input and output ports, with expandability to 512 ports, decoding for 16 of which is included.

The PROM contains a system monitor to permit the computer to be used as soon as it is assembled. Programs can be entered, modified, examined, and executed under switch control or by typed-in commands. A cassette program, included with the kit, can be used to debug the computer. Finally, a complete user manual gives hints on programming and how to expand the computer.

All together, there are about 190 parts in each kit, adding up to a total catalog value of some $700. Software is included in the kits to help in programming via front-panel switches and LED's, cassette tape, Teletypewriter, or any RS-232-compatible terminal. Not supplied are printed circuit boards, power supply, and cabinet.

For more information about the new computer kits, write to: Cramer Electronics, Inc., 65 Wells Ave., Newton, MA 02159. ◈

At bottom right in photo is RCA's VideoDisc player. Engineer is holding typical 12" VideoDisc.

HERE COME THE HOME VIDEO DISCS

How the three leading video disc systems produce sight and sound from a disc resembling the familiar LP record

BY KEN WINSLOW

AFTER several false starts with magnetic tape and optical film and expensive equipment, a practical home-entertainment video playback system that can be used with any TV receiver is on the horizon. RCA, AEG Telefunken, British Decca, Zenith Radio, N.V. Philips, MCA, Thomson CSF, and others have developed video disc systems, that resemble and can be played like an audio disc. More important, the decks and program material are relatively inexpensive compared to tape and optical film systems.

If the developers have their way, we will no longer be tied to network and local station programming. Soon, we'll be able to make our own choices of prerecorded video disc color TV programs. In fact, West Germans can *now* buy a video disc player from a local retailer. They can also choose from an initial selection of 200 video disc programs.

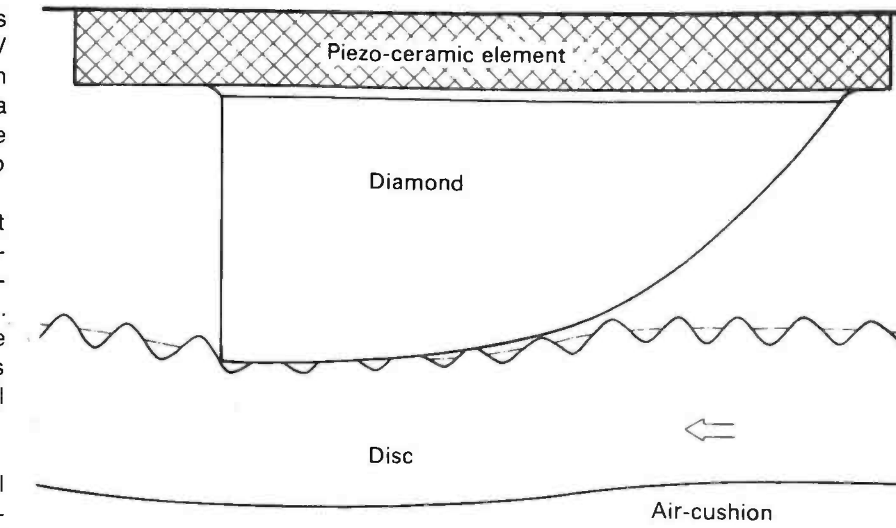
By the end of 1976, it appears that there will be two incompatible systems (produced by RCA and Philips/MCA) in competition for the U.S. consumer dollar. There is also the possibility that other systems, such as West Germany's Teldec system, will join the battle.

The Video Discs. Similar in physical appearance to and played in essentially the same manner as the 12" LP audio record, the video disc will offer just about every form of entertainment imaginable—from motion pictures to plays to opera and even informational and educational programs. Some manufacturers are busily trying to obtain the rights to current-run motion pictures. One manufacturer (Philips/MCA) plans to provide text—illustrations and print—materials that permit the user to scan or read single pages forward, backward, or at random simply by pressing a pushbutton switch.

Although a video disc might look like an audio disc, the similarity is only superficial. By modern high-fidelity audio recording standards, the transient flow of information bits dealt with is calculated to be 300,000 bits/second. Consequently, LP records have the ability to accommodate a density of about 5,000 bits/square millimeter. The result is that a 33⅓ rpm LP disc can easily accommodate 30 to 45 minutes of audio program signal.

The transient information flow required to present a TV picture today is about 100 times more intense than that of sound transmission. A storage medium with the information-density capacity of a video disc would have to offer 100 times more capacity in the same or enlarged surface area for recording the same length (in time) program in video as it does in audio.

An ever-widening variety of dense storage and retrieval techniques and technologies for use with a reasonably sized disc have been demonstrated since 1970. Three leading methods—from RCA, Teldec (Telefunken/Decca), and Philips/MCA—have emerged as of this writing. Because it is the only system currently available, we will take a detailed look at Teldec's pioneering work as an example of the problems faced and as a means for comparing the different solutions to the problems. (Teldec's "TeD" system, a cooperative effort between AEG-Telefunken and British Decca, first demonstrated its solution to dense storage technology with a working monochrome system in June 1970.)



Elastic deformation of Teldec video disc with pressure pickup.

The standard LP audio disc contains 250 to 350 grooves/radial inch, with information recovery dependent upon a side-to-side (lateral) stylus excursion. Teldec discovered that, by adopting a frequency-modulation carrier oscillation technique, a single cutting amplitude could be employed during disc mastering to handle the full required frequency range of the video and audio signals within a constant track width. This also permitted the use of an up-and-down (vertical) stylus excursion method for signal information recovery. Teldec was able to almost eliminate the guard space allowance between the tracks, with the result of raising the number of tracks to 3500/radial inch. This gave the needed 100-fold increase in storage capacity from the same surface area used in audio discs, and it made possible a 12" disc.

The problems of TV's high-frequency range and dense information storage encountered in making the recorded video disc are similarly overcome in retrieving the information from the disc. The stylus for an LP can easily respond as mechanical movement at audio frequencies. However, the mass of the stylus of an audio cartridge is too great to permit such response at the much higher TV frequencies. Needless to say, the various companies have solved the problem in their own special ways.

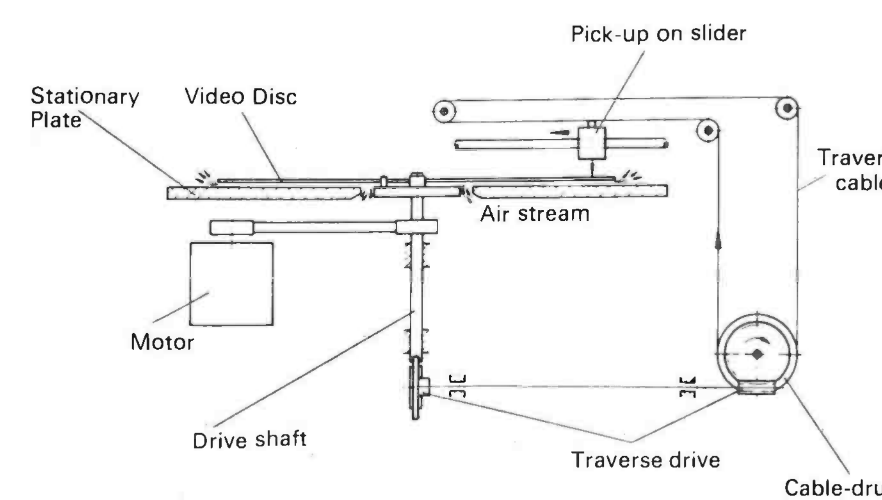


Diagram shows mechanical details of Teldec's disc drive and signal pickup system.

Teldec's "Stylus" Player. In the Teldec system, the information is recorded as deformations in the groove track over which a diamond rides and is sensed as changes in pressure. The stylus tip is in the shape of a sled runner with a gradual radius on the leading edge (relative to disc rotation) and a sharp trailing edge. During playback, the leading edge glides smoothly along the groove over the deformations without damaging them. As the deformations move under the stylus, they become compressed. The sharp trailing edge of the stylus runner passes over the compressed deformations, causing them to spring back to their original shape. In doing so, the signal on the stylus is registered as a constantly varying pressure. The diamond stylus is rigidly fixed to a piezoceramic element that converts pressure variations into electrical picture and sound signals. The sound, recorded in the same fashion as the video, is recovered as pulses that appear during the blanking interval between horizontal line scans.

Consisting of 30 frames/second (equivalent U.S. standards), Teldec's color TV picture is recorded on the disc with each frame occupying one full rotation of the disc. The disc must rotate at 1800 rpm, which is readily accomplished in synchronization with the power line frequency. Rather than riding on a conventional turntable, the disc is center-positioned on a spindle and is supported on a cushion of air above a stationary platter. Instead of being freely guided by the groove, as with an LP, the video disc's stylus assembly traverses the disc's surface by a simple drum, cable, and pulley arrangement run by the same motor that turns the disc spindle. (The easily scratched disc is not handled by the user. An automatic mechanism extracts it from the protective envelope and returns it after play when the envelope is inserted into the machine by the operator.)

The entire player, with its electrical circuits, is about the size of a large briefcase. It is independent of the TV receiver, providing a modulated r-f sound-and-picture signal on an unused channel through the receiver's antenna terminals.

As the system is currently designed, Teldec's video disc has a playing time of 10 minutes.

P/M's Laser Player. Philips/MCA and RCA have taken the video disc considerably further than Teldec has to date in terms of playing time. Both companies pack greater numbers of grooves to each inch on their disc. Also, both have developed their own unique information recovery transducer sytems that are said to be less expensive per hour of use, cause less wear on the disc, and have longer operating lives. Their discs are also designed to be more rugged and easier to handle than are Teldec's.

N.V. Philips and MCA initially pursued separate development of laser/optical systems but have recently combined their efforts. In March of this year, an impressive demonstration of the joint venture was given. Magnavox, now a subsidiary of North American Philips, is said to be planning to manufacture a U.S. P/M video disc player by the fourth quarter of 1976. The large entertainment conglomerate of MCA will be handling programming and disc mastering and replication for the U.S. market.

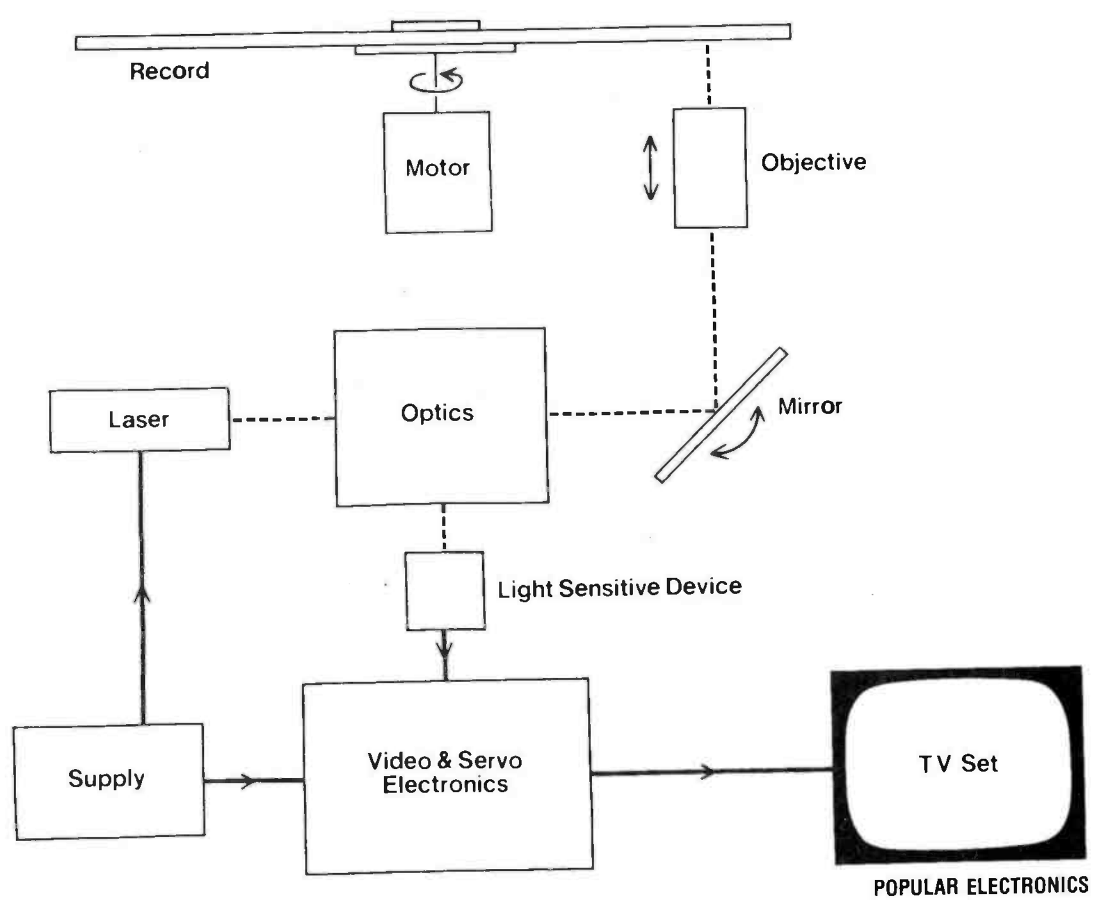
The P/M system employs a very precisely controlled laser beam to record information on and recover it from the video disc. In recording, a laser is used to cut minute oblong depressions that represent sound, color, and brightness information. About 0.7-micron wide, the depressions vary by 0.8 to 2.5 microns in length and follow a continuous spiral path. Because of this extremely small size and the fact that the tracks can be spaced less than 2 microns apart, P/M is able to achieve about 12,500 tracks per radial inch. This is almost three times more than is possible with the Teldec approach.

The P/M disc consists of three parts: protective layer, information layer, and highly reflective layer of aluminum.

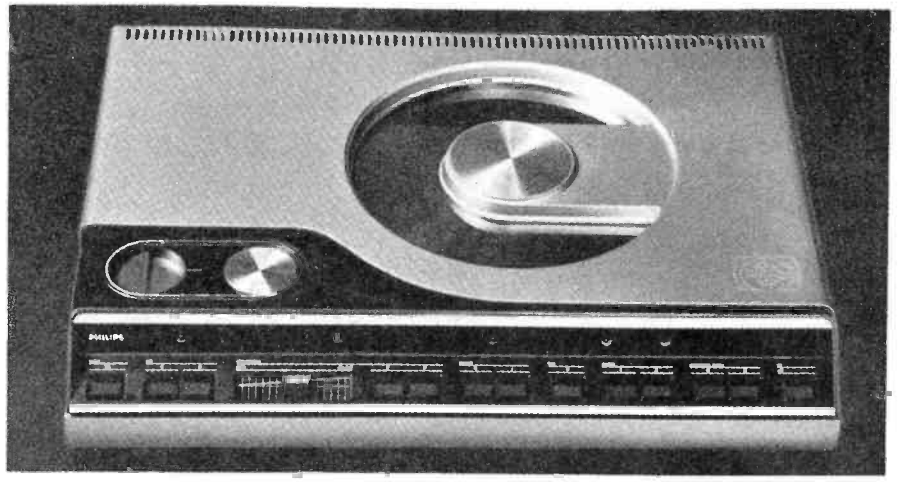
A laser beam in the player is used as a non-contact optical "reader" to recover audio and video information from the disc. Light from a 1-mW helium-neon laser is focused onto the video disc as a spot 1 micron in diameter. This is reflected back from the aluminum layer through a recovery lens that focuses it on a photo detector. The detector converts the beam into an electronic sound-and-picture signal. The spot of light follows the rotating track and intercepts the depressions that contain the video information. As the light rides over each track depression, the amount of light reflected back is modulated by the length/depth characteristics of the depressions.

A number of different control and servo systems perform various functions: to select and preserve accurate spot tracking and focus; to maintain time-base stability in case of unevenness of the disc surface due to irregularities or warping and center-hole location eccentricities; and to ignore the accumulation of surface dirt and scratches on the protective transparent coating. Since there is no stylus or physical contact with the disc, the P/M player is a "no-wear" system, and the video disc should theoretically last forever.

VIDEODISC PLAYER



Complete Philips/ MCA optical laser player system is shown here in block diagram form.



Philips/MCA player has controls located on front panel. To left of center is slide-type slow-motion control. Remaining controls on panel are pushbuttons.

VIDEO DISC SYSTEM COMPARISON CHART

	TELDEC	PHILIPS/MCA	RCA
DISC:			
Composition	PVC	Mylar/reflective aluminum	vinyl/metal dielectric/oil
Diameter	8"-10"	8", 12"	12"
Playing time	10 min.	30 min.	60 min. (2 sides)
Speed	1800 rpm	1800 rpm	450 rpm
Tracks/inch	3500	12,500	5555
Information scheme	groove deformations	long longitudinal pits	transverse slots in grooves
Average life	100 plays (min.)	indefinite	100 plays (min.)
Estimated cost	$4-$10/disc	$2-$10/program	$10/disc
PLAYER:			
System type/ transducer	mechanical contact/pressure	no-contact/ optical laser	mechanical contact/capacitive
Estimated price	$500	$500	$400
PICKUP:			
Type	diamond stylus	laser	sapphire stylus
Estimated life	70-100 hours	NA	200 hours (min.)
Replacement price	NA	NA	less than $10 for stylus/cartridge assembly

NA = Information not available at this writing.

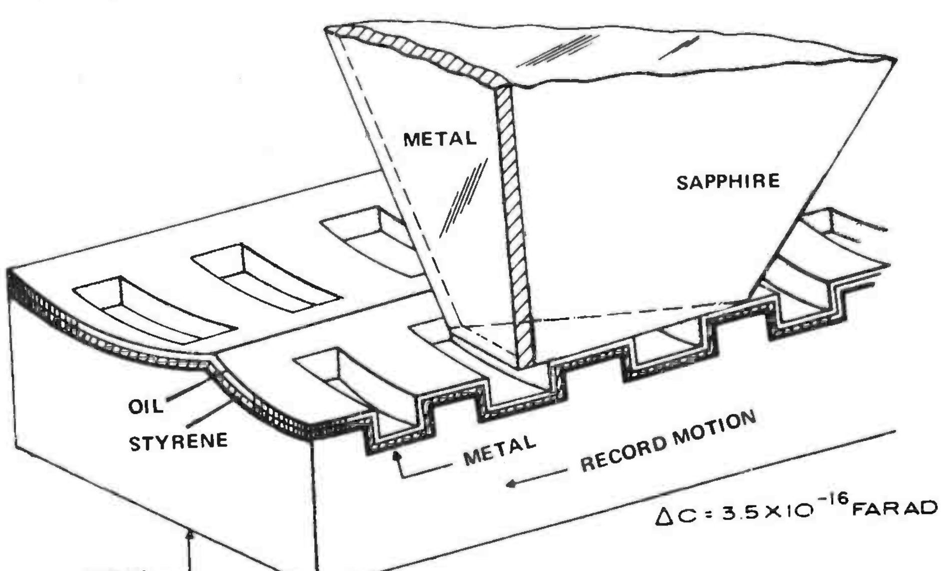
The disc rotates at 1800 rpm. As a consequence of the 30-frame/second U.S. NTSC TV sytem, the disc makes one revolution of 360° for each frame. A radial deflection mirror forms part of the laser beam control system. P/M says that the radial deflecting mirror can easily be made to control the beam during the vertical interval to repeat the same track, jump back one or more tracks, or jump forward one or more tracks. Since this occurs during the vertical blanking period of the frame, and provided that not too big a jump is made during this limited time, all manner of still, fixed, and variable slow forward and reverse motion, and random-access effects can be obtained by "playing" the controls. A digital index counter is used to help pinpoint the location of a specific selection or frame.

The disc will be single-sided and will contain up to 30 minutes of program material. Company spokesmen say that they will be able to meet the announced price of $500 for the player and still be able to offer the stop/slow/variable-frame display system that the player seems so uniquely able to provide.

As announced, the P/M player will offer modulated r-f picture and sound signals through the antenna input of any conventional TV receiver. Two separate 15,000-Hz audio output channels will also be provided for feeding into a stereo audio system.

RCA's "Capacitive" Player. In a number of respects, RCA's capacitive-mechanical video disc system falls between the Teldec and P/M systems in terms of storage-density and playing capability. RCA spokesmen say that a calculated choice was made to design a system that offers a player/disc component system that keeps the difficult parts in the factory and the noncritical parts in the home. By using a stylus tracking system, a capacitive-sensing signal-detection technique, and a 450-rpm disc speed, RCA believes it has struck the best possible balance in manufacturing, reliability, operational simplicity, low purchase/operating cost, and duration of available playing time. Except for the stylus assembly, the company states that the electrical and mechanical assemblies for the player are largely off-the-shelf items.

Similar to Teldec and unlike P/M, RCA uses a grooved disc that mechanically guides the stylus over the signal track. The grooves are spaced 4.57 microns apart (center to center). There are 5555 grooves per radial inch. The disc itself consists of five layers of material sandwiched together. The vinyl core contains the information slots that vary in length between 0.23 and 1.23 microns. (The slots are cut in the master by a high-resolution electron beam in a vacuum chamber.) Metallic and styrene coatings are then applied to both sides of the disc. Finally, a layer of oil that increases the life expectancy of both the



Detail view of RCA's stylus tip and cutaway view of VideoDisc surface. Metal layers on disc and sapphire stylus form two plates of capacitive element.

disc and the stylus is applied to both sides of the disc.

The signal is recovered from the disc by capacitively sensing the information elements pressed as transverse slots in the groove. A plow-shaped sapphire stylus, when in contact with the groove, extends about 3 to 10 microns along the groove. A thin coating of metal on the flat trailing edge of the stylus serves as one plate of a capacitor, while the metallic layer in the disc represents the other plate. The styrene coating on the disc serves as the capacitor's dielectric.

As the stylus travels along the groove over the information slots, the capacitive voltage relationship between the insulated plates fluctuates by amounts that depend on whether or not the area immediately beneath the stylus is or is not a slot cavity. The changing capacitance is sensed by a tuned circuit, of which the stylus "plate" is one element, thereby providing the signal information for amplification and processing into a standard video/audio signal.

Variations in disc speed caused by power-line frequency fluctuations, as well as disc imperfections caused by warping and centering problems, must be corrected to insure a steady, fault-free picture. While P/M uses various compensating servo loops, RCA says it has made a special design effort to keep such complexity, with corresponding chances for misadjustment and malfunction, to a minimum. RCA has designed a single servo stylus "arm stretcher" arrangement that consists of a small electromechanical transducer similar to the moving coil in a speaker that continuously drives the stylus arm back and forth along its long dimension according to the variations.

The arm stretcher is housed in a cage driven by a toothed belt to follow the basic groove spiral pitch of the disc. The entire arm sweeps across the disc's surface in a manner similar to that used by Teldec. RCA says that this combination of a belt-driven arm cage and the mechanically tracking stylus, guided by the actual groove spiral, preclude the necessity of holding to difficult mechanical manufacturing tolerances. The player has a built-in one-line horizontal delay for substitution of a preceding picture when a noise or similar defect occurs in an upcoming picture line.

Teldec and P/M have chosen an 1800-rpm playback speed that equates to one frame every 360° of disc rotation, making it potentially easy to use the disc for still/slow/single-frame viewing. RCA's choice of 450 rpm, equating to four frames per 360° revolution (one frame every 90°), while not precluding these framing effects, makes providing for such features more complex and expensive. The company says that its choice of a 90° frame is critical to greater utility.

RCA is able to design an overall system that can currently offer a combination of the longest playing time with high picture quality. A two-sided disc that will give up to a 60-minute per disc program playing time will be offered with the RCA system.

The slower speed of the RCA player contributes to its ability to offer a less expensive system. The use of a simple stylus arm stretcher is also said to be less expensive than the means adopted by P/M to stabilize signal timing. RCA's lower-speed player enables its more complex stylus assembly to handle the expected amount of disc unbalance, eccentricity, and warp during playback.

While not yet committed to a market entry date, RCA says it could begin to provide players and discs in small retail quantities in the third or fourth quarter of 1976. Prices for the player and individual disc have been tentatively set at $400 and $10, respectively. The disc will give some 100 (minimum) plays in normal use, and the operating life of the stylus will be a minimum of 200 hours. A user-replaceable stylus/cartridge assembly is expected to sell for less than $10. The player's modulated r-f output is set to an unused channel of any TV receiver, and separate outputs to drive a stereo system will be provided.

Conclusion. In this article, we have placed the emphasis on three systems that are almost certain to be available by the end of 1976. However, a host of other systems are under development. These include magnetic card (Sony) and magnetic disc (Bogen) systems that can record and erase and an optical disc system (i/o Metrics) that can record but not erase.

One thing is certain: separately or together, these home video systems will herald a new era in home entertainment. The prices will be right. And if all goes as expected, the programming will be on a par with the best live and film entertainment available anywhere today. ◈

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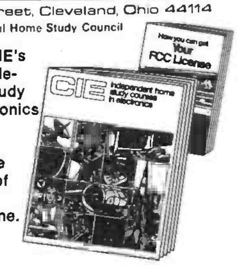

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A New Industry Standard for FM Tuner Measurement

PART ONE

BY LEN FELDMAN

AFTER an undisturbed 16-year reign, the old "IHFM Standard Methods of Measurement for Tuners" (IHFM-T-100) has been succeeded by the new "Standard Methods of Testing Frequency Modulation Broadcast Receivers." This new Standard (IHF-T-200 and IEEE Std 185-1975), was produced under the auspices of the IEEE, the IHF, and the EIA. It focuses on some key areas of tuner performance—including stereo—that were inadequately covered by the old Standard. (The old one was developed before stereo FM programming was authorized.) Also, it establishes new reference levels for sensitivity, selectivity, and distortion measurements, among others.

Hopefully, this new set of guidelines will enable manufacturers to relate their products' performances more meaningfully, and allow the consumer to make a well-informed decision when he goes to the marketplace.

The Femtowatt. One of the Standard's more important provisions deals with the basic reference level of signal strength. Previously, the microvolt (10^{-6} V) was used, but now the femtowatt (10^{-15} W) supplants it. Thus, instead of considering the amount of signal voltage developed across the tuner's antenna input, many measurements will be based on the amount of *power* delivered to the tuner. By definition, an available signal power level of one femtowatt is the reference 0 dBf—*not* to be confused with its cousin, dB, which expresses something completely different.

But why power? The previous standard was ambiguous about the true amount of signal delivered to the tuner. For example, most signal sources can deliver a higher voltage across an open circuit than across a resistive one, so "open-circuit" microvolts would produce a different result than "terminated" microvolts. Furthermore, tuner inputs are commonly either 75 or 300 ohms, and a standard based on voltage led to a 6-dB hedge due to loading effects.

Copies of the new "Standard Methods of Testing Frequency Modulation Broadcast Receivers," IEEE Std 185-1975 and IHF-T-200, 1975, are available from the Institute of High Fidelity, 489 Fifth Ave., New York, NY 10017 and from the Institute of Electrical and Electronics Engineers, 345 E. 45th St., New York, NY 10017. 35 pages (8½" x 11), $6.00 soft cover.

What really determines signal strength is the amount of power that's available, which is related to the voltage by the equation $P = E^2/R$. For example, 10 μV across a 300-ohm input develops 333×10^{-15} W, but the same voltage across 75 ohms produces 1333×10^{-15} W—an increase of about 4 times, or 6 dB! Some manufacturers might quote the 75-ohm figure, which would apparently give them hotter receivers than those whose sensitivity was rated at 300 ohms. Now that everyone is expected to use the new power rating, specification differences based on type of termination will no longer be exaggerated.

Naturally, it will take time for people to get used to the dBf idea, so the IHF suggests that manufacturers publish the "new" figures alongside the old microvolt ones. This should make the transition smoother. The relationship between available power in dBf and open-circuit voltage across a 300-ohm impedance is shown in the nomograph of Fig. 1. Here we see that 0 dBf is equivalent to 1.1 "open-circuit" μV. Since the units increase exponentially, we'll now be reading sensitivity ratings such as 5 dBf or 1.96 μV.

Signal generators that are used in FM tuner measurements usually have an output impedance of 50 ohms (unbalanced). To match this to the common 75- or 300-ohm balanced or unbalanced tuner inputs, the Standard suggests eight dummy antenna configurations (Fig. 2). For each network, E_G is the terminated generator output voltage, usually indicated on a calibrated attenuator. (This works out to be half the open-circuit generator output voltage.) The open-circuit voltage at the receiver input terminals is designated as E_O. Power available to the receiver is P_A, and the power loss incurred by the dummy antenna (in dB) is P_L. Equations relating these variables are given in each case.

For example, suppose we're measuring the sensitivity of a tuner using the dummy antenna in Fig. 2A. With the "old" IHF procedure, we reached the IHF sensitivity when the generator's attenuator read 4.0 μV. The reading would then be divided by 2, since half the voltage was "dropped" across the resistive network. Thus, the "old" IHF sensitivity would be 2.0 μV.

In terms of the new Standard, the 4.0 μV reading is E_O, the "open-circuit" voltage. Accordingly, no division is

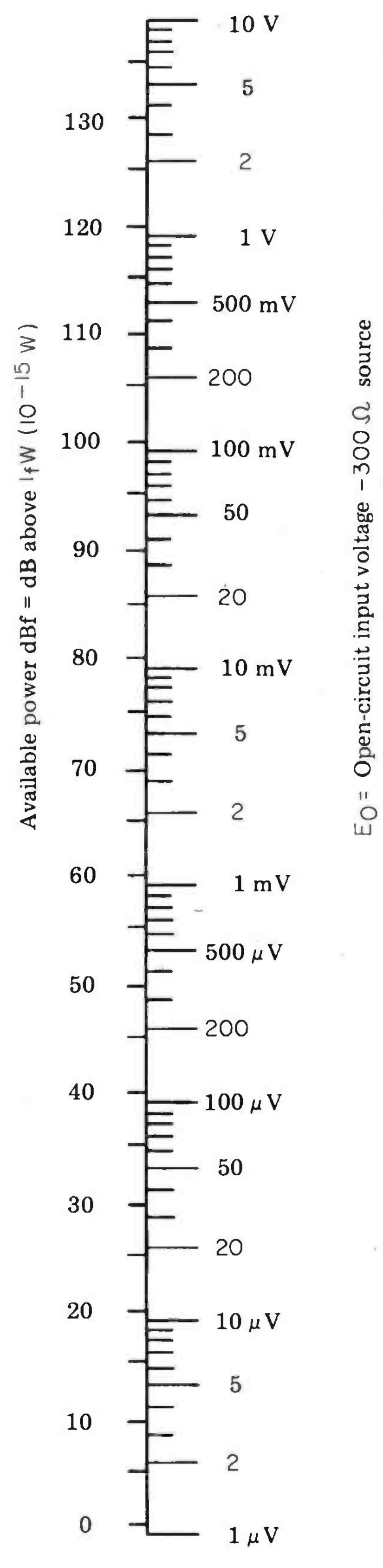


Fig. 1. Voltage/power nomograph relates available power in dBf (left scale) to open-circuit microvolts (right scale).

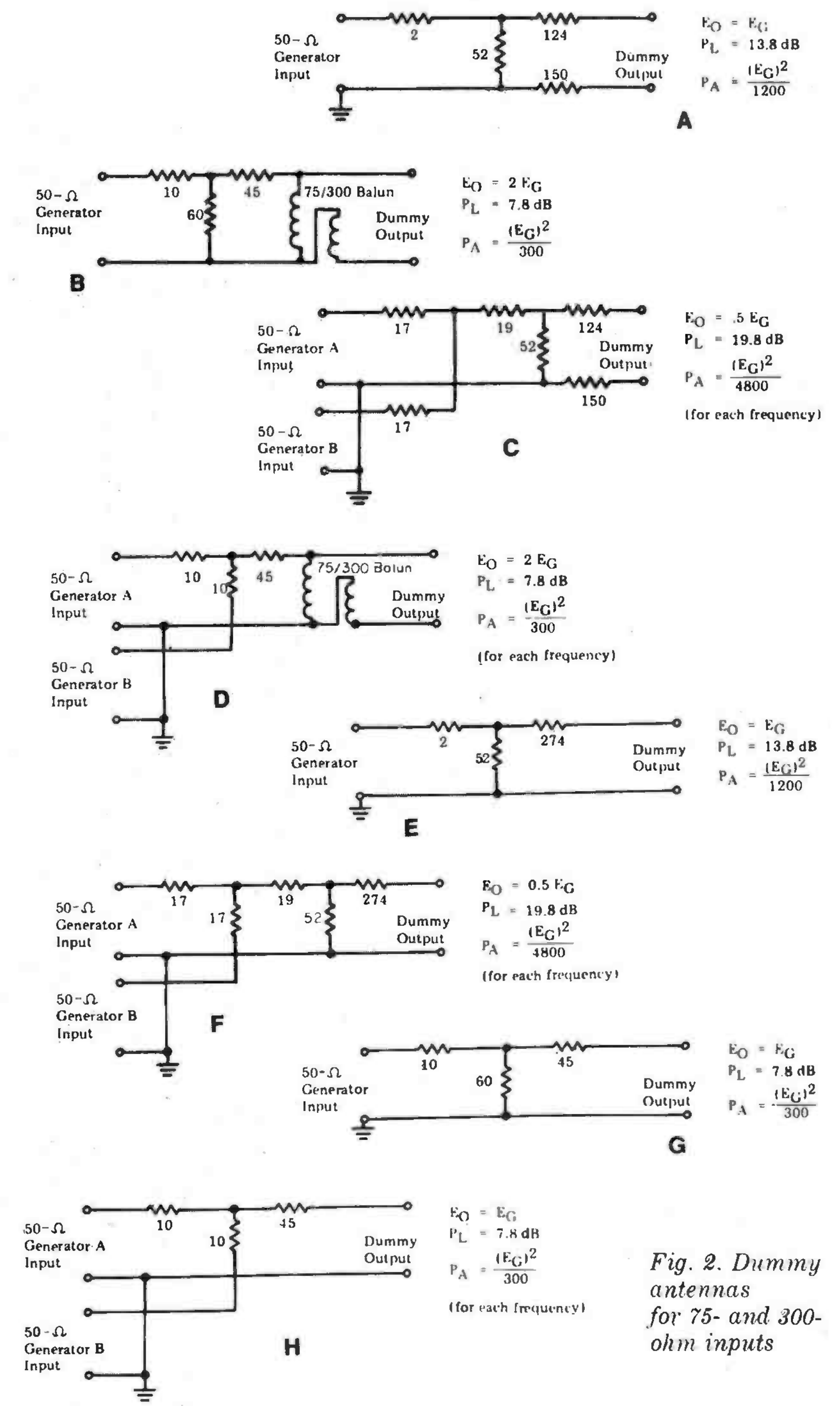


Fig. 2. Dummy antennas for 75- and 300-ohm inputs

required since $E_O = E_G$ for this network. A glance at Fig. 1 shows us that the "new" sensitivity is about 11 dBf. If greater accuracy is desired, you can calculate the dBf figure using the formula: dBf = 20 log (E_O/1.1), where E_O is expressed in μV. For this particular case, E_O is 4.0 μV, so the sensitivity in dBf is 20 log (4.0/1.1) or 11.213 dBf. A chart of dBf values versus generator output in μV is shown as Table I, and includes conversion formulae.

New Mono Specifications. It has become obvious that IHF sensitivity alone does little to point out significant differences between two modern tuners or receivers. Of far greater importance is the nature of the "quieting slope," and more specifically, the point where a S/N ratio of 50 dB is obtained. For this reason, the new Standard requires disclosure of the "50-dB Quieting Sensitivity," expressed in dBf. The familiar "Usable Sensitivity" spec—the level of signal resulting in a combined noise and distortion content of 3% (−30 dB)—will also be included in dBf, because the public is familiar with it, and it takes into account both noise and distortion.

Although only residual noise is measured by the "50-dB Quieting Sensitivity" test (the modulating signal is turned off), it is of great interest

Table I. Available Power From Dummy Antennas in Terms of Terminated 50 ohm Generator Output E_G

Impedance Dummy	300 ohms (B),(D)	300 ohms (A),(E)	300 ohms (C),(F)
Impedance Dummy	75 ohms (G),(H)		
dBf			
0	0.55 µV	1.1 µV	2.2 µV
5	0.97 µV	1.9 µV	3.9 µV
10	1.7 µV	3.5 µV	6.9 µV
15	3.1 µV	6.2 µV	12 µV
20	5.5 µV	11 µV	22 µV
25	9.7 µV	19 µV	39 µV
30	17 µV	35 µV	69 µV
35	31 µV	62 µV	120 µV
40	55 µV	110 µV	220 µV
45	97 µV	190 µV	390 µV
50	170 µV	350 µV	690 µV
55	310 µV	620 µV	1.2 mV
60	550 µV	1.1 mV	2.2 mV
65	970 µV	1.9 mV	3.9 mV
70	1.7 mV	3.5 mV	6.9 mV
75	3.1 mV	6.2 mV	12 mV
80	5.5 mV	11 mV	22 mV
85	9.7 mV	19 mV	39 mV
90	17 mV	35 mV	69 mV
95	31 mV	62 mV	0.12 V
100	55 mV	0.11 V	0.22 V
105	97 mV	0.19 V	0.39V
110	0.17 V	0.35 V	0.69 V
115	0.31 V	0. 62 V	1.2 V
120	0.55 V	1.1 V	2.2 V

E_O = open-circuit voltage

$= \sqrt{4 \times 10^{-15} R \times 10^{dBf/10}}$

R = impedance level

dBf = available power for a 1 fW reference level

$= 10 \log (E_o^2/4R \times 10^{-15})$.

Note: Letters in parentheses refer to dummy antenna configurations shown in Fig. 2.

to determine how much harmonic distortion exists at this point. Therefore, a "Distortion at 50-dB Quieting" spec has been established. The distortion readings for this test and those at higher signal levels must be quoted for three frequencies—100, 1000, and 6000 Hz. Previously, THD was most often quoted at 1000 Hz, but it's well-known that most audio products exhibit lowest THD content in the mid-range. Hence, the additional measurements will give a more realistic picture of overall performance.

The Committees that collaborated on the Standard felt that 6000 Hz was the highest practical frequency to conduct this test. Harmonics of higher-frequency fundamentals are not only beyond the range of human hearing, but also extend past the upper limit of FM broadcast audio (15,000 Hz).

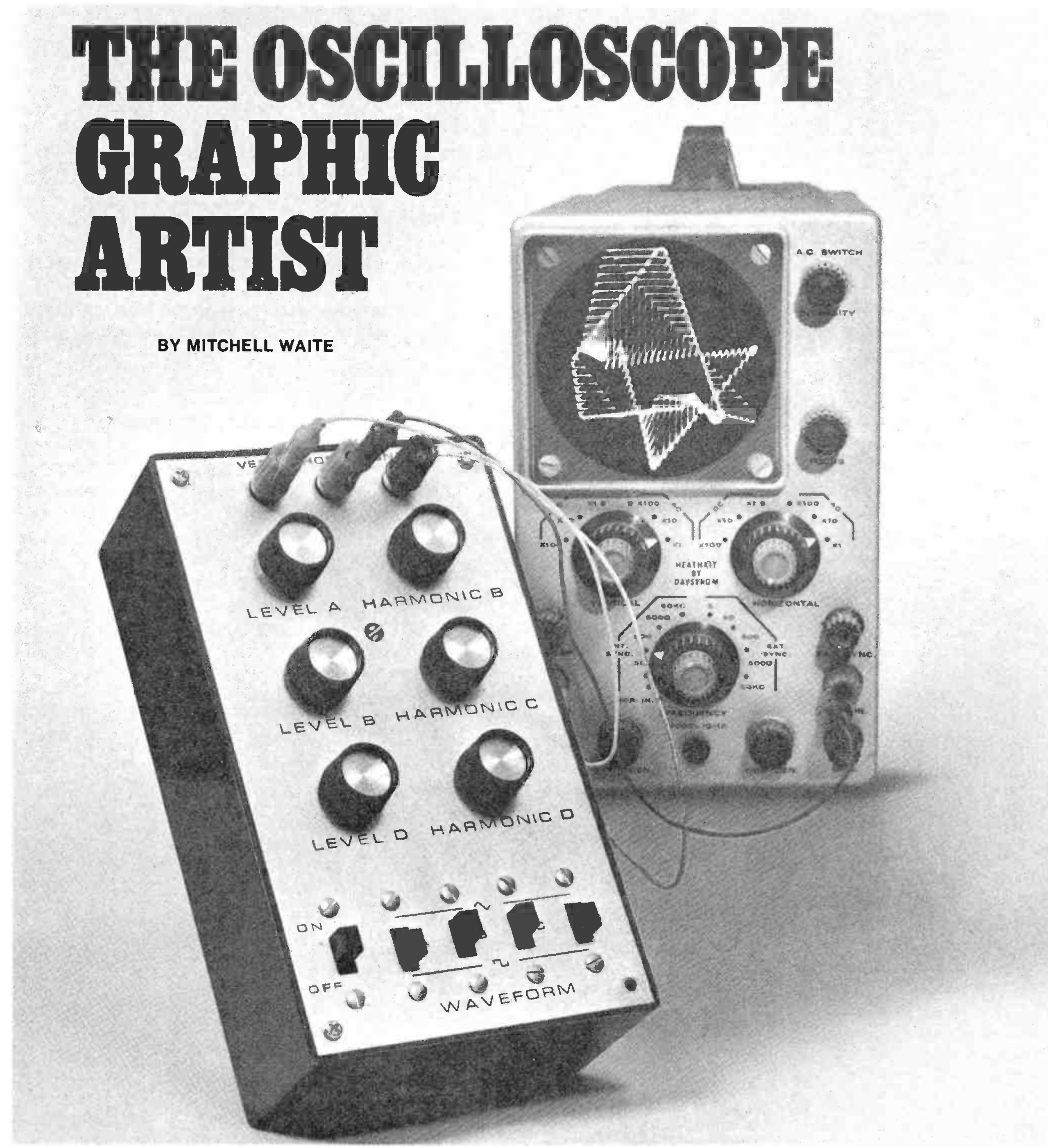
Strong Signal Measurements. Tests formerly conducted at high (1000 "terminated" μV) signal levels, such as "Ultimate S/N," "Ultimate THD," and "Stereo Separation" will now be performed at 65 dBf. That's roughly 1,970 "open-circuit" μV, or 970 "old IHF" (300-ohm) μV—almost the same signal level previously used. Capture ratio is measured in much the same way as before, but the readings must be taken at signal levels of 45 dBf and 65 dBf. The poorer of the two figures must be published as the "rated" capture ratio in dB.

Two Selectivity Specs. "Alternate Channel Selectivity," which spells out the degree of interference from an FM station 400 kHz away from the desired one, will now be measured at 45 dBf (desired signal input), or about 97 "old IHF" μV.

Now, we have another selectivity spec that must also be published—"Adjacent Channel Selectivity." The "numbers" are not going to look too good, of course. Obviously, it's much tougher to suppress signals 200 kHz away than those 400 kHz removed—at least it is when you're trying to maintain sufficient bandwidth for low distortion and good phase linearity. But as the public gets used to seeing "Adjacent Channel" figures in the 20-to-30-dB range, this "embarassment" should fade away. (This concludes Part One. Next month, we'll examine new methods of curve plotting, and look at the new Stereophonic Specifications.) ◈

THE OSCILLOSCOPE GRAPHIC ARTIST

BY MITCHELL WAITE



Create exciting, computer-generated, three-dimensional drawings on your oscilloscope

A DIM light traces a delicate pattern of geometrical lines on the screen of an oscilloscope. The lines form a rectangle that suddenly tilts back and transforms into a revolving ring of diamonds. You can produce these, plus many more, effects by operating the controls on the Graphic Artist project described here. You can easily make an image rotate in three dimensions, compress and expand, break up into other shapes, or slowly oscillate.

The Graphic Artist is a visual pattern generator that is designed to use the CRT screen of an oscilloscope as a "canvas" and its electron beam as a high-speed "brush." The real-time three-dimensional display on the CRT screen has all the delicate geometric beauty and detail of the computer-generated three-dimensional drawings with which we are all familiar.

The beam in an oscilloscope is forced to follow two complex, harmonically related signals in producing the geometeric patterns. Phase-shift networks, working in concert with a simple modulator, in the Graphic Artist add a signal that produces a depth and volume cue for the scope image.

If you're into electronic music, you might try feeding the output signal of the Graphic Artist into a stereo amplifying system to hear the tones associated with the on-screen images. Even more interesting, you can feed harmonics from a music source into the Artist's circuit in place of the oscillator signals. This allows you to view the patterns created by harmonically related musical notes.

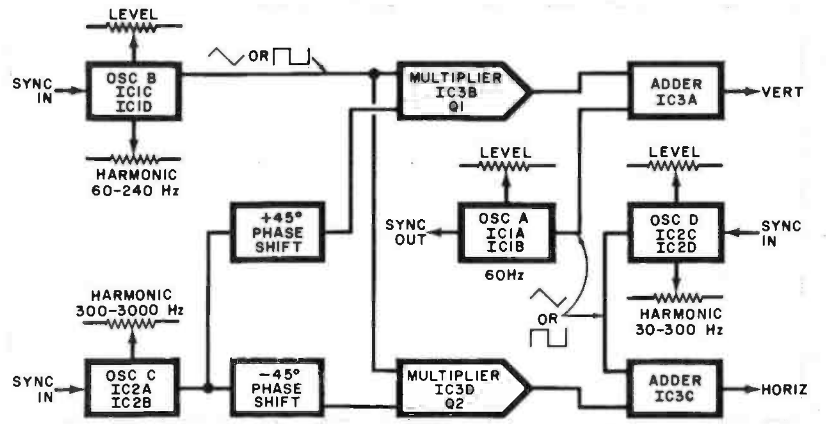


Fig. 1. Block diagram of Graphic Artist.

About the Circuit. As shown in the block diagram in Fig. 1, two almost identical signal channels in the Artist are connected to the vertical and horizontal inputs of an oscilloscope. This hookup results in a CRT trace that is known as a Lissajous figure—a circular-like trace that is proportional to the vertical and horizontal displacement of the scope's electron beam.

Each channel in the Artist consists of two oscillators (A and D) that generate square and triangular waveforms. Added to the signals produced by these oscillators is a common modulated signal derived from oscillators B and C. The overall shape of the Lissajous pattern is set by the signals from oscillators A and D. (For example, a simple rectangle results when triangular waveforms make up these signals.)

The modulation component is comprised of a variable high-frequency carrier from oscillator C and a variable medium-frequency envelope from oscillator B. The carrier is shifted in phase by ±45°. The +45° component is modulated by waveform B in the multiplier and summed with the waveform from oscillator A in an adder. Likewise, the −45° carrier is modulated by waveform B but is summed with the waveform from oscillator D. When the phase-shifted components interact in the scope, they form another Lissajous pattern that is perpendicular to the major rectangle pattern, creating the three-dimensional illusion of volume.

Each oscillator can be switched to generate square waves. Depending on which oscillator is switched to square waves, the pattern will either break up into multiple images or change the character of its surface composition. There are three level controls, which tilt or expand the image and change the relative sizes of the modulating components. The harmonic controls are frequency setting potentiometers that are used to adjust the ratio between the various harmonic signals. The ratios of the signals in turn control the "family" of images you see.

To prevent the patterns from revolving on the screen (this occurs whenever the patterns are derived from uncorrelated oscillators), one of the four oscillators is fixed in frequency. The output from this "master" oscillator is used to synchronize

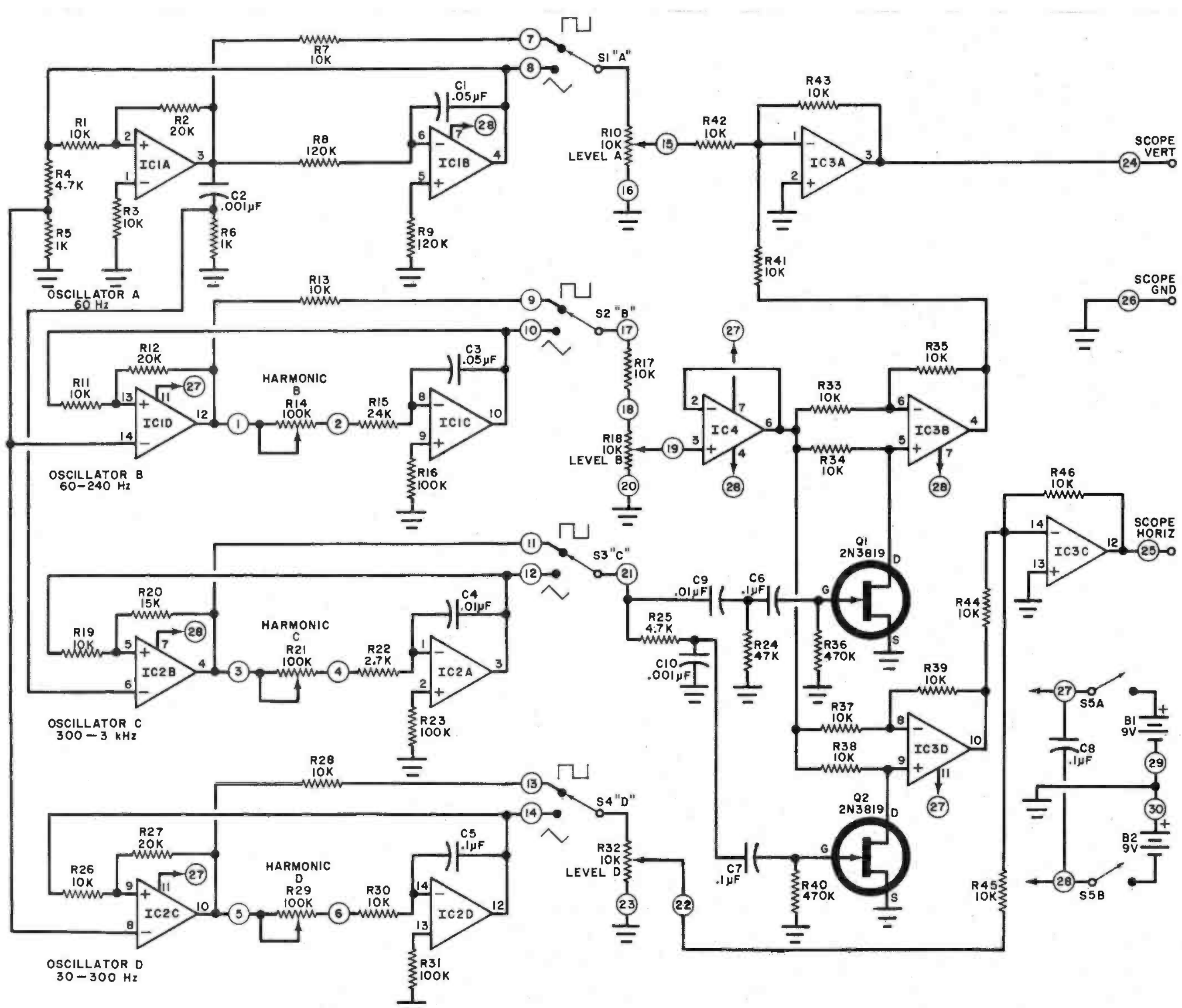
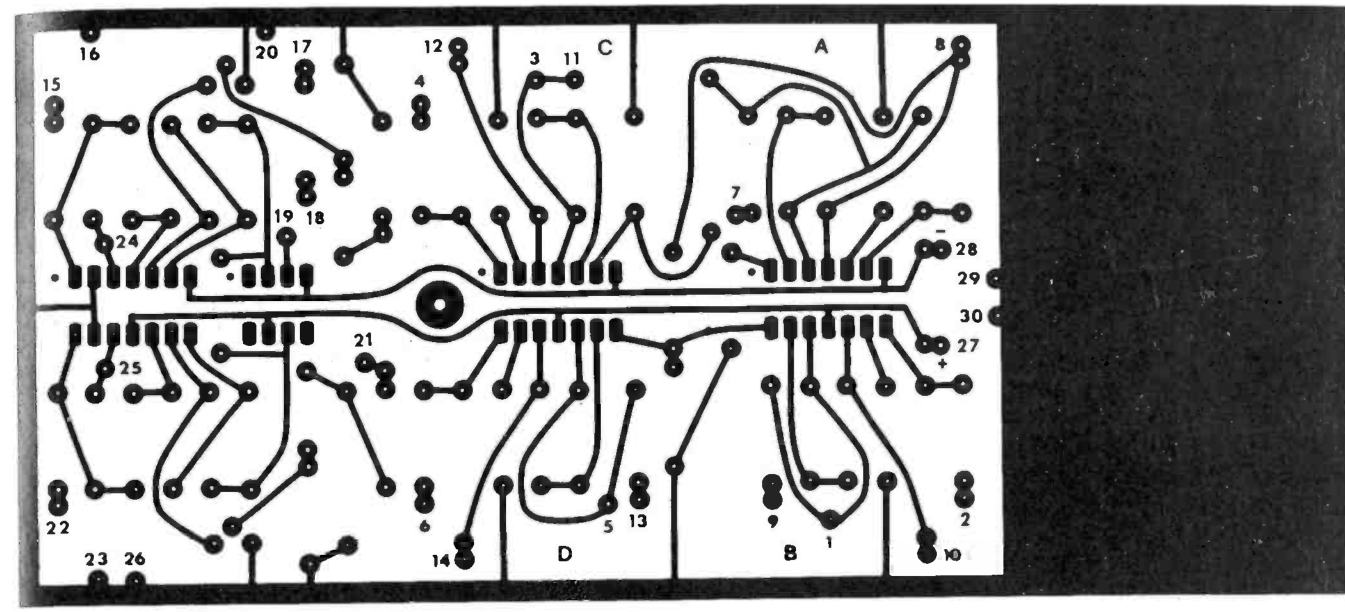


Fig. 2. Oscillators are identical except for frequency-determining elements.



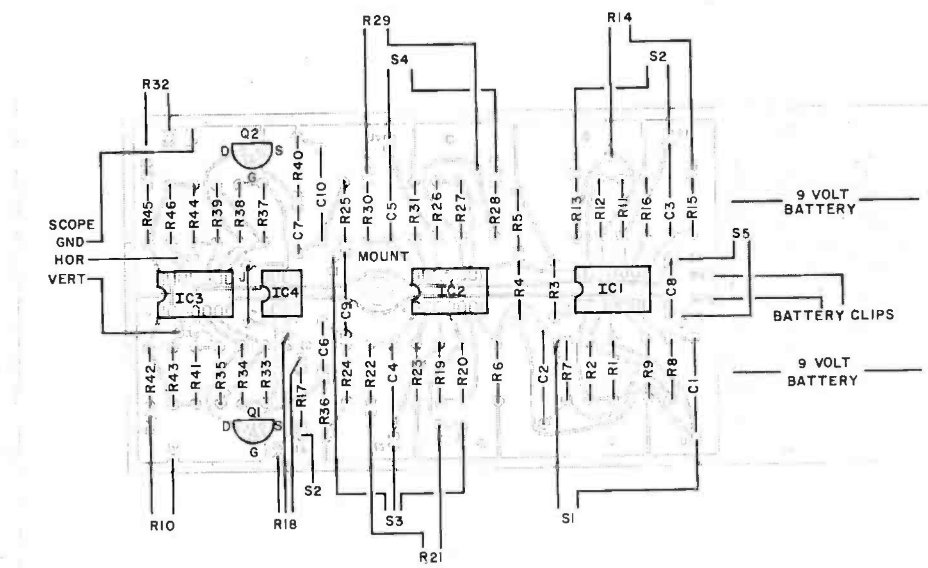


Fig. 3. Etching and drilling (above) and component (right) guides.

PARTS LIST

B1,B2—9-volt battery
C1,C3—0.05-µF Mylar capacitor
C2,C10—0.001-µF Mylar capacitor
C4,C9—0.01-µF Mylar capacitor
C5,C6,C7,C8—0.1-µF 100-volt Mylar capacitor
IC1, IC2,IC3—Quad 741 operational amplifier integrated circuit (Raytheon RC4136DB)
IC4—741 operational amplifier integrated circuit
J1, J2, J3—Five-way binding post
Q1,Q2—2N3819 junction field-effect transistor
The following resistors are ¼-watt 10% tolerance:
R1,R3,R7,R11,R13,R17,R19,R26,R28, R30,R33,R34,R35,R37,R38,R39,R41, R42,R43,R44,R45,R46—10,000 ohms
R2,R12,R27—20,000 ohms
R4,R25—4700 ohms
R5,R6—1000 ohms
R8,R9—120,000 ohms
R15—24,000 ohms
R16,R23,R31—100,000 ohms
R20—15,000 ohms
R22—2700 ohms
R24—47,000 ohms
R36,R40—470,000 ohms
R10,R18,R32—10,000-ohm linear taper potentiometer
R14,R21,R29—100,000-ohm linear-taper potentiometer
S1 thru S4—Spdt slide or toggle switch
S5—Dpdt slide or toggle switch
Misc.—Printed circuit or perforated board; 7½"L × 4¼"W × 2"D (19 × 11 × 5.1 cm) case; knobs (6); battery clips (2); lettering kit; hookup wire; machine hardware; solder; etc.

Note: The following are available from CalKit, P.O. Box 38, San Rafael, CA 94901: Complete kit #GA-1 (includes components, board, case, but not battery) at $55; p.c. board #GA-3 at $7.50. All orders postpaid. California residents, add 6% sales tax.

the remaining oscillators, forcing them to run at an exact multiple of the syncing frequency.

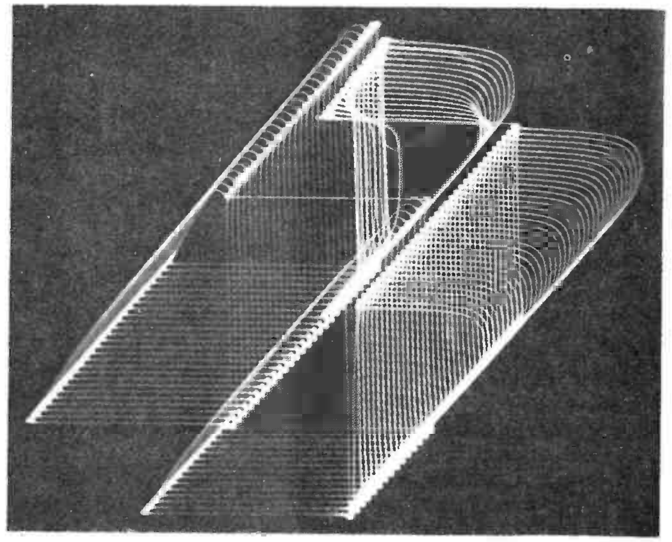
In addition to using the controls on the project, you can also use the vertical- and horizontal-gain controls on the scope to adjust the width and height of the images.

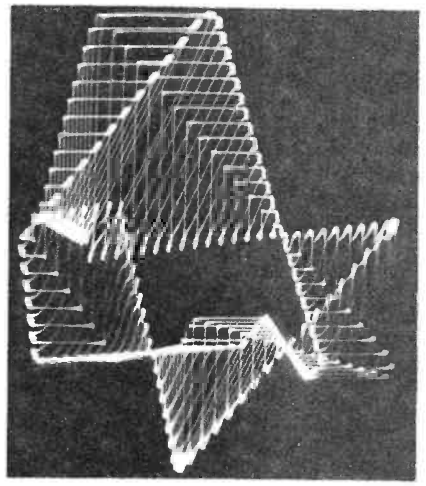
Circuit Details. As shown in Fig. 2, the four oscillators are identical except for their frequency-determining elements. Oscillator A is fixed at approximately 60 Hz by *R8* and *C1;* oscillator B is variable from 60 to 240 Hz; oscillator C is variable from 300 to 3000 Hz; and oscillator D is variable from 30 to 300 Hz. The oscillators are arranged in a classical comparator-integrator configuration.

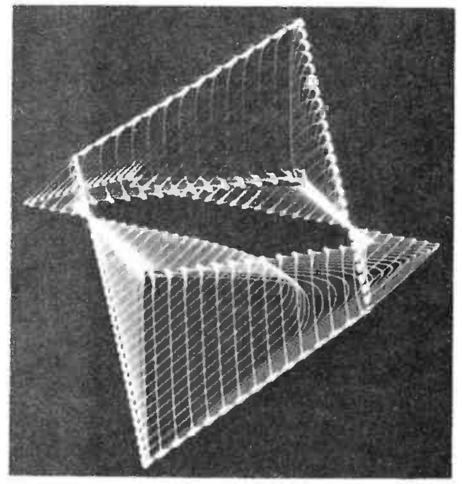
Taking oscillator A as an example, *IC1A* uses *R1* and *R2* to set the trip point at about $\pm V_{cc}/2$. The output of this comparator connects to integrator *IC1B*, which in turn, connects back to *IC1A's* input. When *IC1A's* output is at −9 volts, *IC1B* linearly charges *C1* through *R8*. Hence, the output of *IC1B* is a positive-going ramp. As soon as the ramp reaches $V_{cc}/2$, *IC1A* changes to the positive state and *IC1B* linearly discharges *C1* to initiate a negative-going ramp. When this ramp reaches $-V_{cc}/2$, *IC1A* trips to the negative state and the cycle repeats itself.

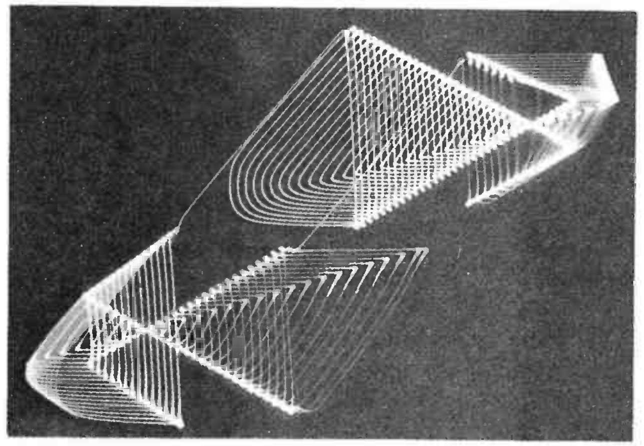
Potentiometers are used to set the frequencies in the three variable-frequency oscillators by varying the charging currents. The outputs from the comparators (*IC1D, IC2B,* and *IC2C*) are symmetrical square waves, while the outputs from the integrators (*IC1C, IC2A,* and *IC2D*) are triangle waves. Resistor *R10* in fixed-frequency oscillator *IC1A*/*IC1B* sets the amplitude of the two waveforms. Level controls are provided for all but oscillator C. Oscillator C has no level control because only one signal need be variable if both signals go to the inputs of a multiplier to cause the output of the multiplier to vary.

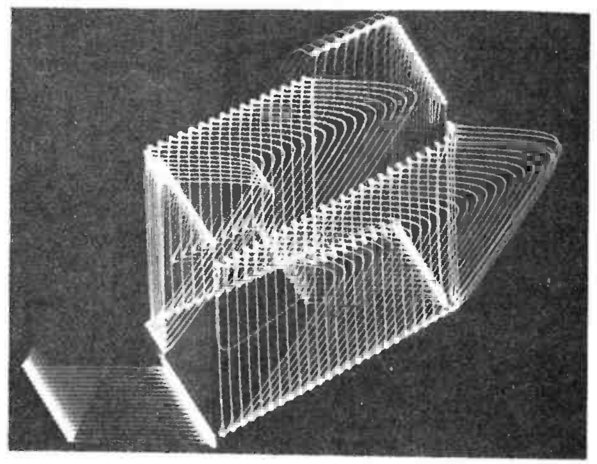
The square-wave output from oscillator A is differentiated by *C2* and *R6* to create a sync pulse. This pulse is fed to the inverting (−) input of *IC2B* to force oscillator C's operating frequency to be an exact multiple of the operating frequency of oscillator A. To sync the remaining oscillators, the triangle-wave output from oscillator A is attenuated by *R4* and *R5* and fed to the inverting inputs of *IC1D* in oscillator B and *IC2C* in oscillator D. The 60-Hz triangle wave forces oscillators B and D into exact sync. Resistor *R7* in oscillator A makes the square and triangle waves in this oscillator equal in amplitude. Switches *S1* through *S4* provide means for selecting the desired waveforms.











Photos illustrate only five of the countless varieties of waveform displays possible.

Integrated circuit *IC4* is an op amp follower, used here to reduce the source impedance to chopper-type multipliers *IC3B* and *IC3D*. In this type of multiplier, a bipolar transistor or JFET is used to switch the op amp between a noninverting (+) and an inverting (−) unity-gain buffer. Transistor *Q1* serves this purpose in this circuit.

When the signal in oscillator C goes positive, *Q1* conducts and *IC3B* reverts to an inverting amplifier. When oscillator C goes negative, *Q1* starts to cut off, and *IC3B* becomes a noninverting amplifier with unity gain. This switching action results in suppression of the carrier, and the output of *IC3B* is a balanced four-quadrant signal.

The signal from oscillator C is shifted in-phase by +45° in network *C9-R24* and by −45° by network *C10-R25*. So, the waveform to each JFET (*Q1* and *Q2*) is out-of-phase, resulting in a modulated output from the multiplier also being out-of-phase. Networks *C6-R36* and *C7-R40* provide dc restoration for *Q1* and *Q2*.

The output from multiplier *IC3B* is summed with the signal from oscillator A in adder *IC3A*. The output from multiplier *IC3D* is summed with the signal from oscillator D in adder *IC3C*. Finally, the outputs from the two adders are fed to the oscilloscope to form the complex Lissajous patterns.

Power is supplied to the Artist by two standard 9-volt batteries (*B1* and *B2*). Capacitor C8 aids in reducing instability in the IC op amps.

Construction. The project can be built on either printed circuit or perforated board. The actual-size etching and drilling guide and components-placement diagram are shown in Fig. 3. After preparing or buying a ready-to-use pc board (see Parts List for supplier), mount the components on it as shown in the placement diagram, paying particular attention to the orientations of the IC's and transistors. Place *B1* and *B2* on the blank end of the board, terminals pointing away

Set time LEVEL B control fully counterclockwise (off). Because oscillator B connects to both multipliers, making LEVEL B zero eliminates the modulated component on the screen. You should now see a simple rectangular or square Lissajous pattern. Adjust the horizontal- and vertical-gain controls on the scope so that, when LEVEL A and LEVEL D controls are set to midrange, the image just fills most of the screen.

Slowly turn up LEVEL B. This adds the modulated waveform to the existing pattern. Readjust LEVEL A and LEVEL D for a pleasant balance and to keep the image from drifting off-screen. Adjust HARMONIC B to sync the modulated envelope with the image. In essence, this control sets the number of "lobes" riding on the primary Lissajous pattern.

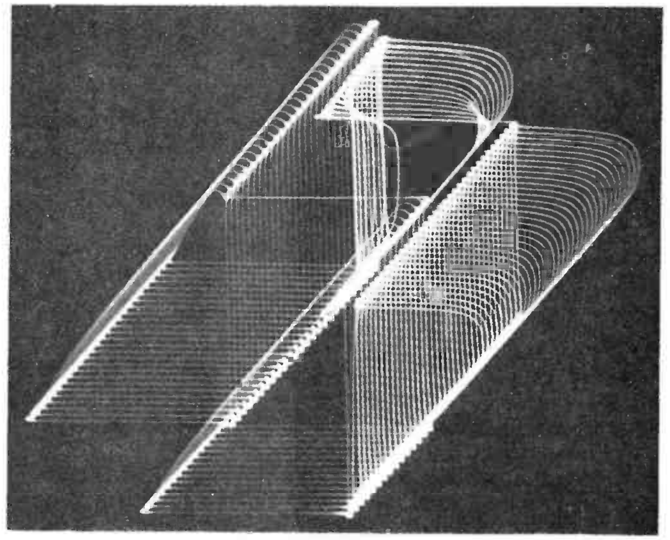
Next, adjust HARMONIC C so that the high-frequency carrier is in sync with the image. You should now have a display similar to those shown in the photos. The next thing we can do is alter the Lissajous "family" by using combinations of the waveform switches. For example, switching WAVEFORM A to the square-wave position and setting WAVEFORM D to the triangle-wave position causes the

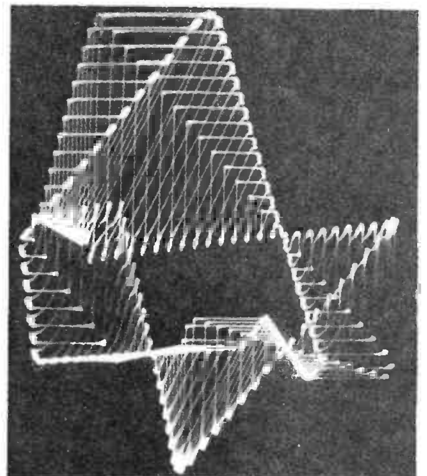
the remaining oscillators, forcing them to run at an exact multiple of the syncing frequency.

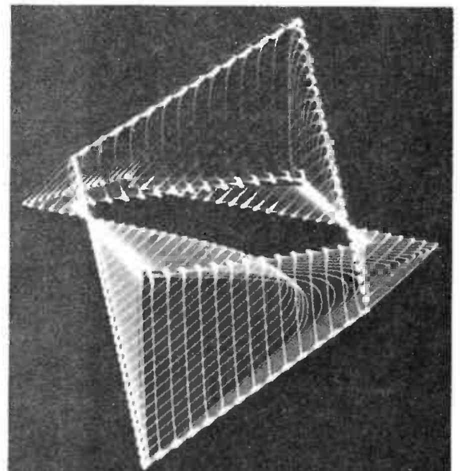
In addition to using the controls on the project, you can also use the vertical- and horizontal-gain controls on the scope to adjust the width and height of the images.

Circuit Details. As shown in Fig. 2, the four oscillators are identical except for their frequency-determining elements. Oscillator A is fixed at approximately 60 Hz by *R8* and *C1*; oscillator B is variable from 60 to 240 Hz; oscillator C is variable from 300 to 3000 Hz; and oscillator D is variable from 30 to 300 Hz. The oscillators are arranged in a classical comparator-integrator configuration.

Taking oscillator A as an example, *IC1A* uses *R1* and *R2* to set the trip point at about $\pm V_{cc}/2$. The output of this comparator connects to integrator *IC1B*, which in turn, connects back to *IC1A's* input. When *IC1A's* output is at −9 volts, *IC1B* linearly charges *C1* through *R8*. Hence, the output of *IC1B* is a positive-going ramp. As soon as the ramp reaches $V_{cc}/2$, *IC1A* changes to the positive state and *IC1B* linearly discharges *C1* to initiate a negative-going ramp.







triangle wave forces oscillators B and D into exact sync. Resistor *R7* in oscillator A makes the square and triangle waves in this oscillator equal in amplitude. Switches *S1* through *S4* provide means for selecting the desired waveforms.

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The signal from oscillator C is shifted in-phase by +45° in network *C9-R24* and by −45° by network *C10-R25*. So, the waveform to each JFET (*Q1* and *Q2*) is out-of-phase, resulting in a modulated output from the multiplier also being out-of-phase. Networks *C6-R36* and *C7-R40* provide dc restoration for *Q1* and *Q2*.

The output from multiplier *IC3B* is summed with the signal from oscillator A in adder *IC3A*. The output from multiplier *IC3D* is summed with the signal from oscillator D in adder *IC3C*. Finally, the outputs from the two adders are fed to the oscilloscope to form the complex Lissajous patterns.

Power is supplied to the Artist by two standard 9-volt batteries (*B1* and *B2*). Capacitor *C8* aids in reducing instability in the IC op amps.

Construction. The project can be built on either printed circuit or perforated board. The actual-size etching and drilling guide and components-placement diagram are shown in Fig. 3. After preparing or buying a ready-to-use pc board (see Parts List for supplier), mount the components on it as shown in the placement diagram, paying particular attention to the orientations of the IC's and transistors. Place *B1* and *B2* on the blank end of the board, terminals pointing away from the components, and fasten them in place with loops of wire passed between the batteries. Temporarily set aside the board assembly.

Next, machine the front panel for the six potentiometers, five switches, three binding posts, and a No. 6 machine screw. The last hole should line up exactly with the large hole in the pc board assembly. Mount the pots, switches, and binding posts in their respective locations (see Fig. 4). Pass a 6-32 × 2" machine screw (to support the circuit board assembly) through the remaining hole, slip over its threads a length of plastic spacer, and follow with a No. 6 machine nut. The spacer should be just long enough that, when the nut is in place, about ¼" of screw thread is still visible. Label the controls, switches, and binding posts.

Referring back to Fig. 2 and Fig. 3, finish wiring the project.

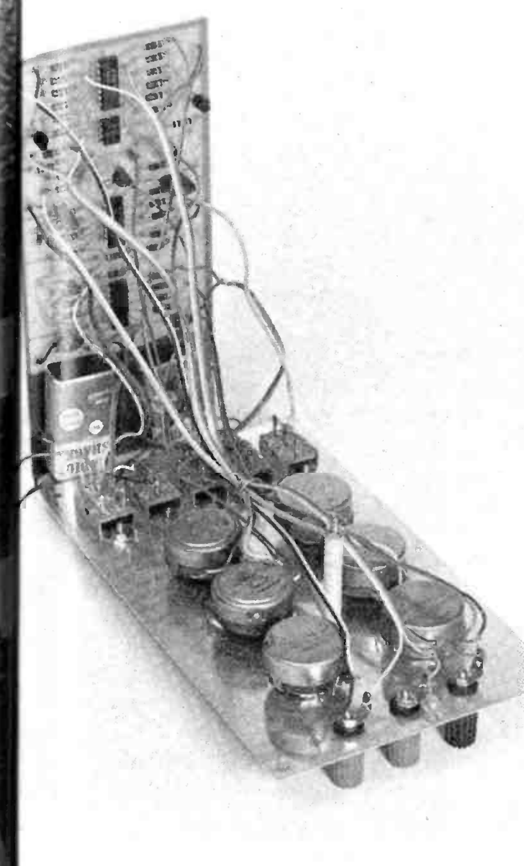

Fig. 4. Construction details.

Operation. The oscilloscope used with the Graphic Artist must have an external horizontal input. Connect test-lead cables from the output binding posts on the Artist to the appropriate inputs on the scope. Set all waveform switches to triangle. Switch on the project and scope.

Set time LEVEL B control fully counterclockwise (off). Because oscillator B connects to both multipliers, making LEVEL B zero eliminates the modulated component on the screen. You should now see a simple rectangular or square Lissajous pattern. Adjust the horizontal- and vertical-gain controls on the scope so that, when LEVEL A and LEVEL D controls are set to midrange, the image just fills most of the screen.

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Next, adjust HARMONIC C so that the high-frequency carrier is in sync with the image. You should now have a display similar to those shown in the photos. The next thing we can do is alter the Lissajous "family" by using combinations of the waveform switches. For example, switching WAVEFORM A to the square-wave position and setting WAVEFORM D to the triangle-wave position causes the image to break up into separate shapes. There are 16 combinations for the four waveform switches. Add to this the effects of the six HARMONIC and LEVEL controls, and chances are you will never see the same pattern twice.

After you've familiarized yourself with the operation of the controls (it does take some skill), you might try connecting a pair of stereo headphones to the two output channels. The sounds of the four oscillators mixing and adding produces beat notes that are fascinating in themselves. You can even "play" the sounds by twisting the various controls.

Some very different and interesting effects can be produced by running the Graphic Artist in reverse. Take a signal from an external source, such as an electronic organ, and connect it in place of one of the oscillators. You can do this by disconnecting one waveform switch input and connecting your signal in its place. Choose your notes to be exact even or odd harmonics of oscillator A, which operates at approximately 60 Hz. The images will appear to stop their motion and their actual shape will depend on the particular waveform of the note being played. ◈

BY G.R. BAUMGRAS

BUILD A PREREGULATED POWER SUPPLY

Super-stable, multi-purpose supply for the experimenter's workbench

ANYONE who works with modern electronic circuits, whether he is a professional or an amateur, will eventually require a closely regulated variable power supply. While most power supplies are regulated directly from the basic rectified and filtered dc line, tighter regulation can be obtained by using a preregulated approach in the supply's design.

The preregulated power supply described here can be built for about $15 more than you would have to pay for a conventionally regulated low-current supply. It employs two inexpensive 723 voltage regulator IC's in a circuit that can deliver 3 to 35 volts dc at load currents up to 3 amperes. The design eliminates the need for massive heat sinks and cooling fans.

How It Works. The power supply's circuit shown in Fig. 1 can be functionally diagrammed as an ac source, rectifier bridge, and two voltage regulators in series. The preregulator, by means of *SCR1*, continuously controls the potential at *C1* so that the potential across *Q1* remains constant. The output regulator (*IC2*) is a high-performance circuit that is capable of providing 0.1% regulation.

Synchronized to the 120-Hz rectified ac input, preregulator integrated circuit *IC1* is connected as a time-delayed pulse generator that controls the gate of *SCR1* to trigger conduction at the exact point required during each half cycle. The bias voltage applied to the inverting input (pin 2) of *IC1* is adjustable via potentiometer *R9*; it determines the reference level for the supply.

The zener-regulated source at pin 4 of *IC1* also supplies current through *R14*, *R15*, and *R18* to *C4* and pin 3 (noninverting input). The current continues to flow until the reference voltage is exceeded. At this point, *IC1* turns on. The resulting square-wave pulse from pin 6 of the IC is limited to 9 volts by current-sensing resistors *R12* and *R13*, which is sufficient, at the gate of *SCR1*, to trigger the SCR into conduction.

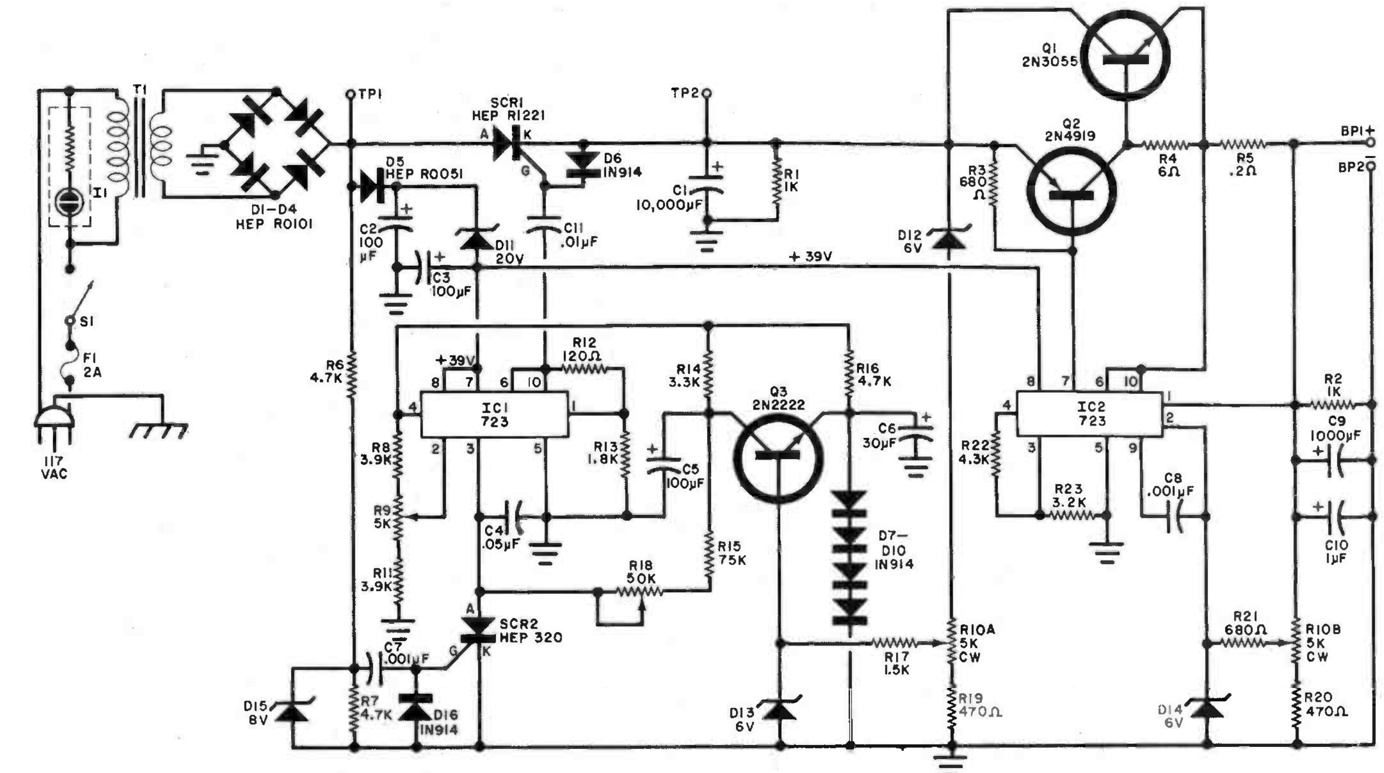
The RC time constants in the circuit are controlled by the amount of current flowing through *Q3*, which, in turn, depends on the error voltage present at the wiper of *R10A*. A voltage divider consisting of *R16* and diodes *D7* through *D10* applies a relatively constant 2.4 volts to the emitter of *Q3* so that when the transistor's base goes above 3 volts there will be a voltage drop across *R14* and a corresponding change in the RC time constant. Capacitors *C5* and *C6* stabilize the operation of *Q3* to prevent *SCR1* from firing erratically. When *R10* is rotated counterclockwise, *R17* and *D13* protect *Q3* and *D12* from damage.

The method of synchronizing *IC1* to the rectified input is graphically shown in Fig. 2. Triggered into conduction by the positive-going voltage, *SCR1* cuts off when the gate signal ceases and *C4* discharges sufficiently to reduce to a minimum the holding current to the SCR. The diagram also reveals why the secondary voltage from *T1* must be greater than would be normal in a conventionally regulated power supply. The SCR cannot conduct until its anode is more positive than its cathode. Simultaneously, a minimum latching current must flow. Also, *SCR1* must remain conducting until the energy drawn from *C1* by the output load is replaced.

Since the potential across *C1* will be 41 volts at maximum output, the 18-volt difference allows the time interval necessary for maximum current. This also means that *SCR1* fires only near the peak or on the negative-going side of the waveform. Resistors *R1* and *R2* are bleeders that carry the minimum holding current required by *SCR1*.

Dual potentiometer *R10* establishes feedback to both voltage-regulator IC's. (A wire-wound potentiometer is best used here so that the sections will be more evenly matched. So, if an identical voltage were present across each section of the pot, the wiper voltages would be very nearly the same at any setting.) Potentiometer section *R10B* samples the output voltage and drives *IC2* in the proper direction to maintain 3 volts between wiper and ground. The A section of the pot samples the voltage across *C1* and controls the firing of *SCR1*, also maintaining 3 volts between wiper and ground.

Since the potential at the counterclockwise ends of *R10A* and *R10B* must be the same, the potential across



PARTS LIST

BP1, BP2—Five-way binding post (one black, one red)
C1—10,000-µF, 50-volt electrolytic capacitor
C2, C3—100-µF, 65-volt electrolytic capacitor
C4—0.05-µF disc capacitor
C5—100-µF, 10-volt electrolytic capacitor
C6—30-µF, 10-volt electrolytic capacitor
C7, C8—0.001-µF disc capacitor
C9—1000-µF, 50-volt electrolytic capacitor
C10—1-µF, 50-volt tantalum electrolytic capacitor
C11—0.01-µF disc capacitor
D1 thru D4—100-PIV, 3-ampere rectifier (Motorola HEP R0101 or similar)
D5—100-PIV, 1-ampere rectifier (Motorola HEP R0051 or similar)
D6, D7 thru D10, D16—1N914 diode
D11—20-volt, 1-watt zener diode (Motorola HEP Z0421 or similar)
D12—6-volt zener diode (1N429 or similar)
D13, D14—6-volt zener diode (1N1509 or similar)
D15—8-volt zener diode (Motorola HEP Z0217 or similar)
F1—2-ampere slow-blow fuse
I1—Neon panel lamp with resistor
IC1, IC2—723 voltage regulator integrated circuit (in TO-5 can)
Q1—HEP 704 (Motorola) or 2N3055 transistor
Q2—HEP 246 (Motorola) or 2N4919 transistor
Q3—HEP 736 (Motorola) or 2N2222 transistor
R1, R2—1000-ohm, 2-watt, 10% resistor
R3, R21—680-ohm, ½-watt, 5% resistor
R4—6-ohm, 1-watt, 5% resistor
R5—0.2-ohm, 2-watt, 5% resistor
R6—4700-ohm, 1-watt, 5% resistor
R7,R16—4700-ohm, ½-watt, 5% resistor
R8,R11—3900-ohm, ¼-watt, 5% resistor
R9—5000-ohm miniature pc potentiometer
R10—5000-ohm dual wire-wound potentiometer
R12—120-ohm, ¼-watt, 5% resistor
R13—1800-ohm, ¼-watt, 5% resistor
R14—3300-ohm, ¼-watt, 5% resistor
R15—75,000-ohm, ¼-watt, 5% resistor
R17—1500-ohm, ¼-watt, 5% resistor
R18—50,000-ohm, miniature pc potentiometer
R19,R20—470-ohm, ½-watt, 5% resistor
R22—4300-ohm, 1% resistor
R23—3200-ohm, 1% resistor
SCR1—HEPR 1221
SCR2—HEP 320
S1—Spst switch
T1—Transformer, 42V, 3A Secondary
Misc.—Printed circuit or perforated board; suitable cabinet; heat sink; fuse holder; sockets for IC's (2); etc.

Fig. 1. Power supply employs two voltage-regulator IC's for super stability.

C1 will be 6 volts greater than the output because of the action of *D12*. Any change in the output voltage and/or current will affect the firing-pulse timing at the gate of *SCR1*, maintaining a constant potential across *Q1*.

Construction. The easiest way to assemble the power supply is by using a printed circuit board. (See Fig. 3 for actual-size etching and drilling and component placement guides.) Alternatively, you can assemble the circuit on perforated board using solder clips and sockets. Whichever method you use, refer to the table in Fig. 3 for instructions on how to interconnect the circuit board assembly and the com-

SEQUENCE OF EVENTS

A. *SCR2* fires as *C7* charges; *C4* then discharges and *IC1* cuts off.
B. *D15* limits voltage on *C7*; *SCR2* cuts off and *C4* begins to charge.
C. *C4* has charged above reference level at pin 2 of *IC1*, causing the IC to conduct; a trigger pulse at pin 6 turns on *SCR1* through *C11*.
D. *SCR1* current decreases as *C1* voltage increases. When voltage across *SCR1* is insufficient to maintain about 10 mA current, *SCR1* turns off.

Note: *SCR1* turns on and off at approximately C and D on the curve, when the output load is drawing 3 amperes at 35 volts. With no external load, events C and D occur near the end of the wave as indicated by the unmarked dots.

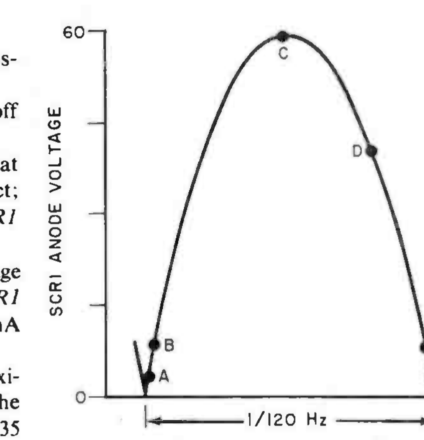
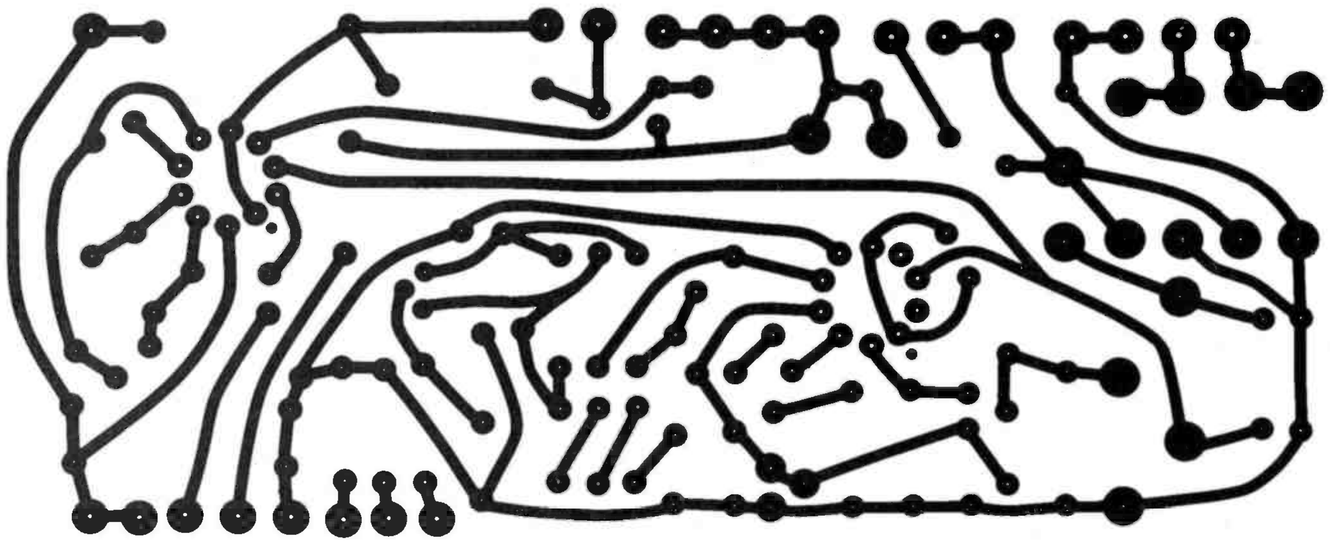
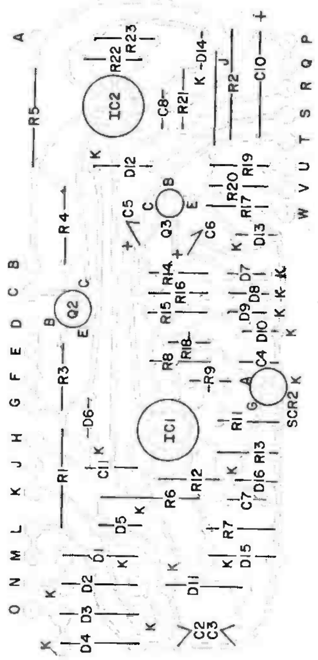


Fig. 2. Events above left are keyed to points on curve.





Note: Components shown from foil side of board.

Fig. 3. Actual-size etching and drilling guide is shown above; component-placement diagram is at left; table at right details hookups between board and off-the-board components.

CONNECT

FROM:	TO:	FROM:	TO
A	C9 +	M	C1 −
B	Q1 E	N, O	T1 S
C	Q1 B	P	BP1
D	Q1 C	Q	R10B CCW
E	TP2	R	R10B WIP
F	C1 +	S	R10A CCW
G	SCR1 K	T	BP2
H	SCR1 G	U	R10A CW
J	SCR1 A	V	R10B CW
K	TP1	W	R10A WIP
L	C9 −		

ponents located off the printed circuit board.

Select a cabinet for the supply that is large enough to accommodate all components without crowding. Machine the front panel for potentiometer *R10*, lamp/resistor assembly *I1*, and binding posts *BP1* and *BP2*. Mount the components in their respective holes.

Next, mount *Q1* and *SCR1* on a 4″ × 2½″ × 1″ (10.2 × 6.4 × 2.5-cm) finned heat sink. Drill mounting holes for this assembly, the line cord, and fuse holder through the rear panel of the cabinet. Mount the fuse holder and heat-sink assembly in place. Line the remaining hole with a rubber grommet for the line cord.

Mount the off-the-board components, followed by the circuit-board assembly inside the cabinet. Then refer to the table in Fig. 3 and Fig. 1 to complete wiring the system.

Test and Use. To balance out component tolerances, *IC1* must be initially aligned. To accomplish this, you will need an oscilloscope, high-impedance multimeter, and an improvised load. Rotate *R10* counterclockwise, set *R18* to maximum resistance and *R9* for maximum voltage gain at pin 2 of *IC1 before* applying power to the supply. Connect the scope from *TP1* to ground and the multimeter from *TP2* to ground. Turn on the power.

There should be a small voltage present at *TP2*, but the scope should indicate that *SCR1* is not conducting. Keeping the voltage reference as high as possible at pin 2 of *IC1*, adjust *R18* and *R9* until *SCR1* fires regularly and the meter indicates 9 volts at *TP2*. When *R10* is rotated fully clockwise, the meter should indicate 41 volts at *TP2*.

Temporarily short out *R5* and momentarily connect a 12-ohm, 120-watt resistor (or an equivalent combination) across the output via *BP1* and *BP2*. If the TP2 reading drops more than 0.2 volt or *SCR1* fires intermittently, adjust *R9* only enough to correct. Then, with no load connected to the output of the supply, rotate *R10* counterclockwise. The reading at *TP2* should slowly decrease to 9 volts. If it does not, adjust *R9* for a higher voltage at pin 2 of *IC1* until it does.

Rotate *R10* again and apply the load, compensating for the voltage drop by adjusting *R18*. There will be some combination of the two adjustments that will permit *Q3* to retain control over *IC1* throughout the specified voltage and current ranges. To do this, *Q3* must always be forward biased. If at any time *Q3* does not draw the proper current from *R14*, it has lost control.

Correct alignment will be achieved when the voltage at the wiper of *R10A* is the same at any output. As a further test, connect the meter across *Q1* and note the voltage change when *R10* is rotated clockwise. Any difference would correspond with *D12's* zener voltage characteristics at bias currents of from 1 to 7mA. ◈

BUILD AN AUTOMOBILE LOGIC ALARM

Simple circuit monitors five electrical points in the car and sounds an alarm when the wrong conditions occur.

BY ROBERT GRATER

MODERN cars have warning systems that monitor various conditions in the engine, lights, etc. One such system is the buzzer that sounds when the driver's door is opened with the key still in the ignition. There are other conditions that can also be monitored if you install the Logic Alarm described here. These include: leaving the headlights on when the ignition is turned off, leaving the ignition on when the oil pressure is low; and leaving the ignition on when the engine is overheated. (As options, the brake and seat-belt warning light circuits can be monitored.) An extra advantage of the Logic Alarm is that the raucous buzzing of most door warning systems can be replaced by a more pleasing audio tone.

Circuit Operation. As shown in Fig. 1, the Logic Alarm uses a single 74L86 low-power quad exclusive-OR gate that receives power from the car's 12-volt line (negative ground) regulated by a 5-volt zener diode. The IC has four separate gates, each producing an output if its two inputs are in opposite states. A gate will not deliver an output if both inputs are simultaneously high or low.

The 74L86 is used because it is a low-power device requiring only 3 mA. It is not a pin-for-pin replacement for the conventional TTL 7486, which requires more current. The 7486 could be used if the circuit is changed to suit the different pin arrangement, the value of *R9* is changed because of greater current flow, and a switch is added to turn off the 12-volt supply when not needed.

The outputs of the four gates pass through diode isolators to a solid-state alarm (another low-power device).

For the headlights-on/ignition-off circuits, the inputs of gate A are held high by the supply through *R1* and *R2*. With the headlights off, *D1* and *D2* conduct, maintaining the stable status of gate A. However, with the headlights on and the ignition off, *D3* conducts and input 2 to the gate drops, providing an output from the gate.

The oil-pressure (gate B) and temperature (gate C) circuits are identical. One side of each gate is coupled to the ignition through *D4* and *D6*, respectively so that they are in a high state when the ignition is on. The oil-pressure and temperature sensing signals should also be high when the engine is running. Thus there are no outputs from these gates. When the vehicle is first entered and the ignition is turned on (prior to starting the engine), the oil-pressure and temperature sensors will be "cold," and the alarm will sound. This serves as a system test. (If the car has instrument-panel lamps for these functions, the Logic Alarm will provide a warning even if one of the lamps fails.)

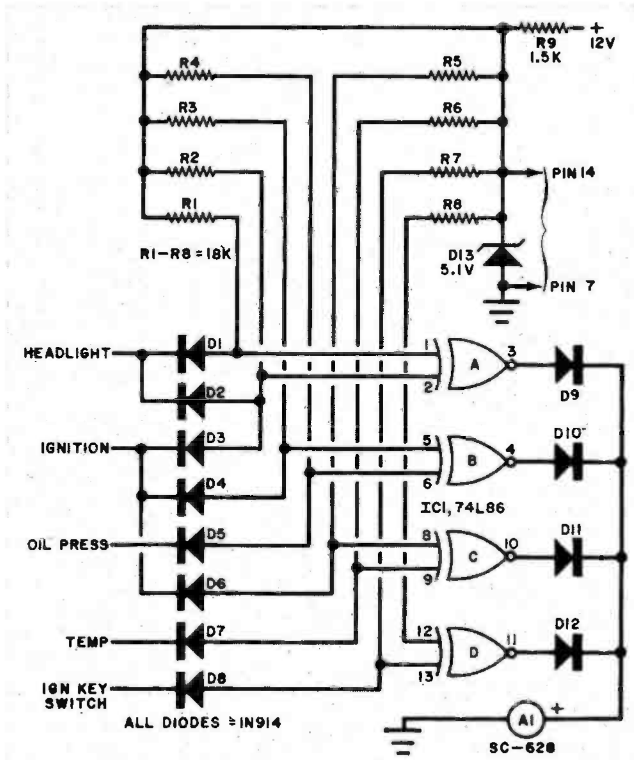


Fig. 1. Points to be monitored are connected to exclusive OR gates through diodes.

PARTS LIST

A1—Tone generator (Mallory Sonalert SC-628 or similar)
D1 to D12—Diode (1N914 or similar)
D13—5.1-V, ½-W zener diode (HEP ZO-212 or similar)
IC1—Quad exclusive OR gate (74L86)
R1 to R8—18,000-ohm, ¼-W resistor
R9—1500-ohm, ¼-W resistor
Misc.—14-pin DIP socket, pc or perforated board, wire for connections, mounting hardware, etc.
Note: The following are available from RGS Electronics, 3650 Charles St., Suite K, Santa Clara, CA 95050: kit of parts including pc board but not Sonalert at $6.35 including postage and handling; pc board alone at $2.50.

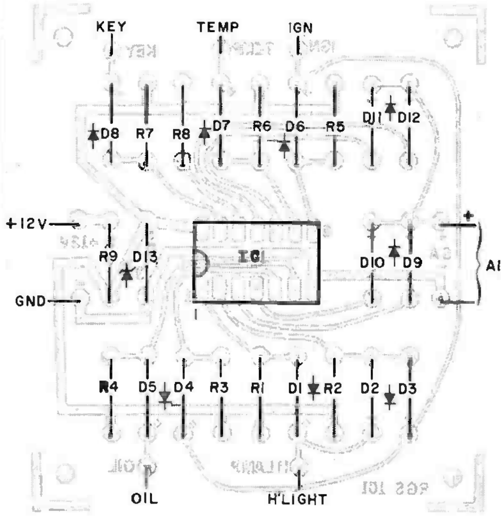
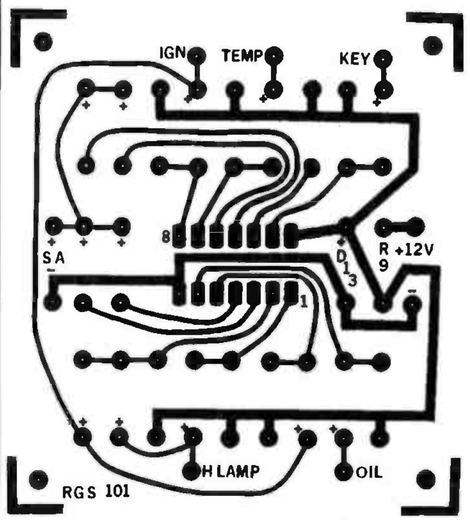


Fig. 2. Etching and drilling guide for pc board is shown below; component layout at left.



The "you left the key in the ignition" circuit uses gate D, with one input connected to the ignition switch through *D8*. Thus when the ignition key circuit goes to ground with the key in, one input is low, causing the alarm to sound.

Construction. The Logic Alarm can be assembled on a pc board (Fig. 2) or wired point-to-point on perforated board. The board assembly can be cemented directly to the back of the alarm. The alarm can then be mounted either in a hole cut in the dashboard or in a small enclosure mounted under the dashboard.

Wiring. The headlight sensing point can be picked up either at the fuseblock or the headlight switch—or on the headlight wire using an insulated connection. Use a dc voltmeter to make sure that this point is at 12 volts when the lights are on.

The best place to get at the ignition circuit is at the fuseblock. Use a dc voltmeter to locate a circuit that is at 12 volts when the ignition is on.

The +12 volts used to power the alarm can also be obtained from the fuseblock. The alarm can be wired permanently to the supply since the power consumption is so low. Using the fuseblock to pick off the various signals allows the application of conventional automotive snap-in connectors sold at most automotive supply stores.

The oil-pressure and temperature pickoff points can be made as shown in Fig. 3A, using an insulated connector.

The circuit from the ignition key must be located with the voltmeter and should be at 12 volts with the key in the switch. Fig. 3B shows the buzzer circuit used in most GM cars—others are similar. The buzzer is in the horn relay enclosure and ground is provided through the key switch and door switch. Remove the wire marked with an X in Fig. 3B and connect to it for the ignition key sensing. ◈

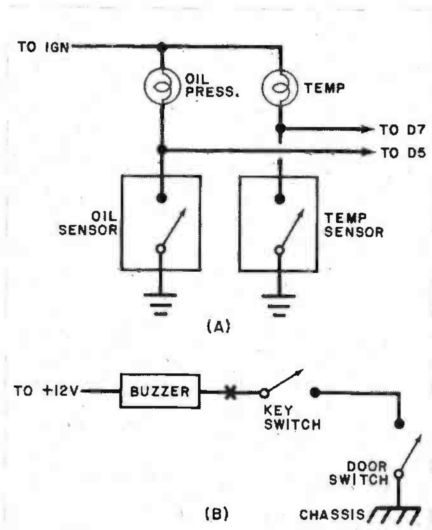


Fig. 3. Circuits for connecting to monitored points.

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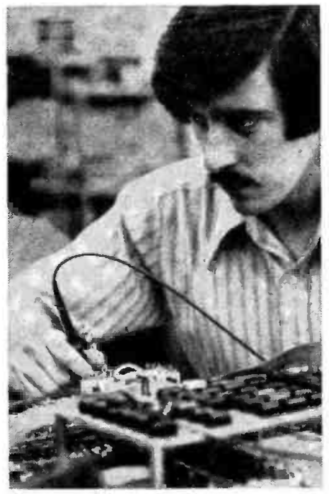

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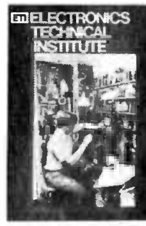

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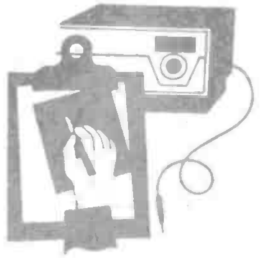


Product Test Reports

ABOUT THIS MONTH'S HI-FI REPORTS

International Audio Designs is an unfamiliar name in the hi-fi marketplace, but the company's Model B3A dynamic range expander should have a wide appeal for audiophiles who wish to restore some of the dynamics lost in their compressed tape and disc recordings and FM broadcasts. The expander can add up to 15 dB of dynamic range to the program. Its gain variations are absolutely undetectable while listening to a program.

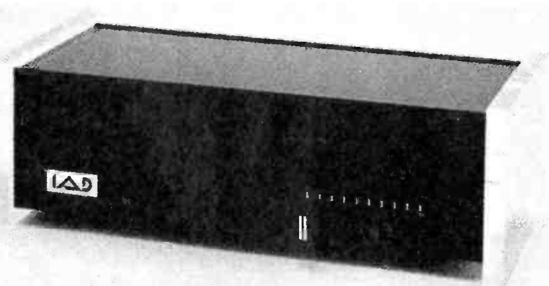
When Shure Brothers announces a new phono cartridge, you can be sure that it is designed to fill a definite need in the marketplace. The Model M95ED has the flat, uncolored sound of the highly respected Shure V-15 Type III at a price most critical audiophiles can afford.

Yamaha, a company well-known for its motorcycles, has only recently had its audio products achieve a telling fame on the hi-fi scene. The company's Model CR-800 stereo receiver does almost everything you could require of a deluxe receiver. It performs more like the most refined separate components than like a compact, reasonably priced receiver.

—Julian D. Hirsch

IAD MODEL B3A DYNAMIC RANGE EXPANDER

Restores dynamics to compressed recorded material.



HIRSCH-HOUCK LABS REPORT

International Audio Designs has recently introduced a novel dynamic range expander whose operating parameters (as we'll see) are radically different from those of other expanders we have used. The Model B3A, as with other expanders, is designed to restore some of the program dynamics that are inevitably lost in any compressor-processed recording or broadcast program.

The expander is housed in an attractive black plastic case with thick clear plastic end plates. The case measures 12"L × 5¼"D × 3¾"H (30.5 × 13.3 × 9.5 cm) and weighs 3½ pounds (1.6 kg). The manufacturer's warranty covers defects in material and labor for a period of three years from date of purchase. The retail price of the expander is $279.

Technical Details. The designer of an expander must choose appropriate attack and release time constants, as well as the slope of the expansion (such as 1.5 dB of output change for 1 dB of input signal change). The goal is usually to restore some measure of the compressed dynamics of the program without introducing audible side effects. Almost all expander designs have fallen short of the latter requirement.

If the expansion is accompanied by "pumping" sounds as the level changes or by transient "fuzz" or "swishes" of background noise, the expander is of little value to the user. By careful design and by limiting the degree of expansion to some extent, these effects can be minimized. It is difficult to eliminate them competely.

IAD has chosen an attack time of 100 ms for the Model B3A, which is relatively slow for some expanders but is fast enough to be effective. On the other hand, a very long release time on the order of 30 seconds renders the reduction in gain following an expansion completely inaudible. As we determined during our tests, the action of the IAD expander is somewhat more complex than this would indicate, but its extremely long release time certainly distinguishes the IAD approach from all others we have seen.

The expander provides a smoothly controllable expansion of as much as 15 dB or more. It can be inserted in the signal path between a preamplifier and a power amplifier or in the tape-monitoring system in an integrated amplifier. With no expansion, the gain of the expander is unity, with each channel's signal passing through an operational amplifier that uses some 80 dB of negative feedback. The input impedance is 47,000 ohms, while the output impedance is 600 ohms.

The maximum output signal level is 9 volts into a high-impedance load or 4 volts into 600 ohms. The maximum rated output is 7.5 volts. Hum and noise are rated to be at least 86 dB below the rated output, with distortion less than 0.05% at any level up to the rated output and 0.005% at outputs of less than 1 volt.

The only operating control on the expander is a slide-type potentiometer that is used to adjust the sensitivity of the expansion circuit. At its minimum setting, there is no expansion. As the pot is moved right toward maximum, increasing amounts of expansion are introduced, depending on the input signal level. Red LED indicators above the control come on at 2-dB intervals that correspond to 1.5 to 13.5 dB of expansion. (The circuits have a somewhat greater range than this.) Although the LED's are sequentially activated by an analog-to-digital converter, the expansion process is smooth and continuous.

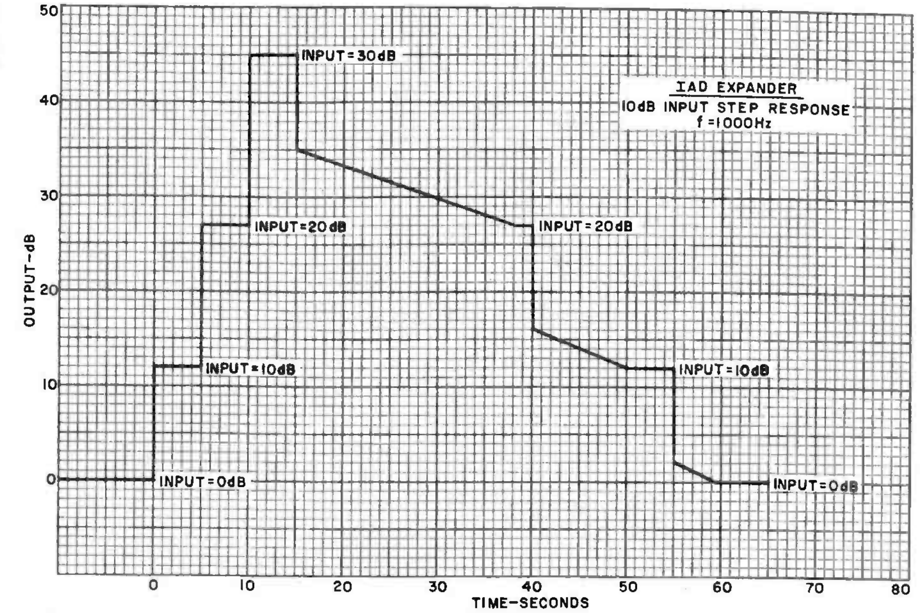
There is no power switch on the expander, which is designed to be powered and deactivated when it is plugged into a switched ac outlet of an amplifying system. With a 2-watt power consumption it is practical to leave the expander on at all times if this proves to be more convenient.

Laboratory Measurements. The output of the expander clipped at 9 volts into a high-impedance load, as rated. The 1000-Hz harmonic distortion was buried in the noise level below 2 volts output, where it measured 0.006% with no expansion being used. At 7 volts output, the THD measured 0.03% at 20 Hz, 0.014% at 1000 Hz, and 0.013% at 20,000 Hz. With full expansion, the THD was 0.04% at 20 and 20,000 Hz and 0.025% at 1000 Hz. The output noise with IEC "A" weighting measured 76 dB below 1 volt, or 91.5 dB below the rated 7.5-volt output.

With no expansion, the frequency response was as flat as our test instruments, measuring ±0.25 dB from 20 to 20,000 Hz. (IAD's rating is ±0.3 dB, 5 to 100,000 Hz.) When we applied full expansion, the response appeared to be reasonably flat through the midrange, being down 1 dB at 200 and 2500 Hz and rolling off to −11 dB at 20 Hz and −12 dB at 20,000 Hz. It was obvious from observing the LED indicators that they did not really represent the response of the expander's amplifiers. Instead, they represent the shaping of the response in its expansion-sensing circuits. Apparently, the expander responds most readily to midrange levels and is less influenced by very low and very high frequencies.

The expander's dynamic behavior was revealed quite clearly when we applied 10-dB increments of input signal level change and plotted the output on a graphic recorder. Starting from a low signal level (our 0-dB reference was below the threshold for the expansion circuit), the first 10-dB increase produced a 12-dB output increase that appeared to be well within the 100-ms rated attack time. The second 10-dB increase stepped the output up by 15.5 dB, while the third 10-dB input increase stepped the output 17.5 dB. Hence, a total increase of 30 dB at the input increased the output by 45 dB. On the time scale of the recorder chart, the increases appeared to be instantaneous.

When we dropped the input signal level from +30 to +20 dB, the output dropped 10 dB, following the input change. However, the gain of the expander then decreased smoothly by



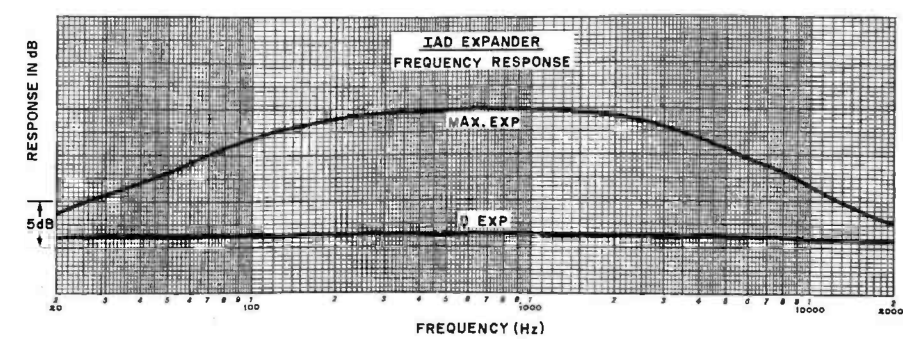
7.5 dB in the next 22.5 seconds. The next step downward, to +10 dB, also appeared at the output as a 10-dB drop, followed by a 5-dB reduction in the next 10 seconds. Finally, the last reduction, to 0 dB, dropped the output by 10 dB to a +2-dB level, with the output dropping to 0 dB (to equal the input level) in another 4.5 seconds.

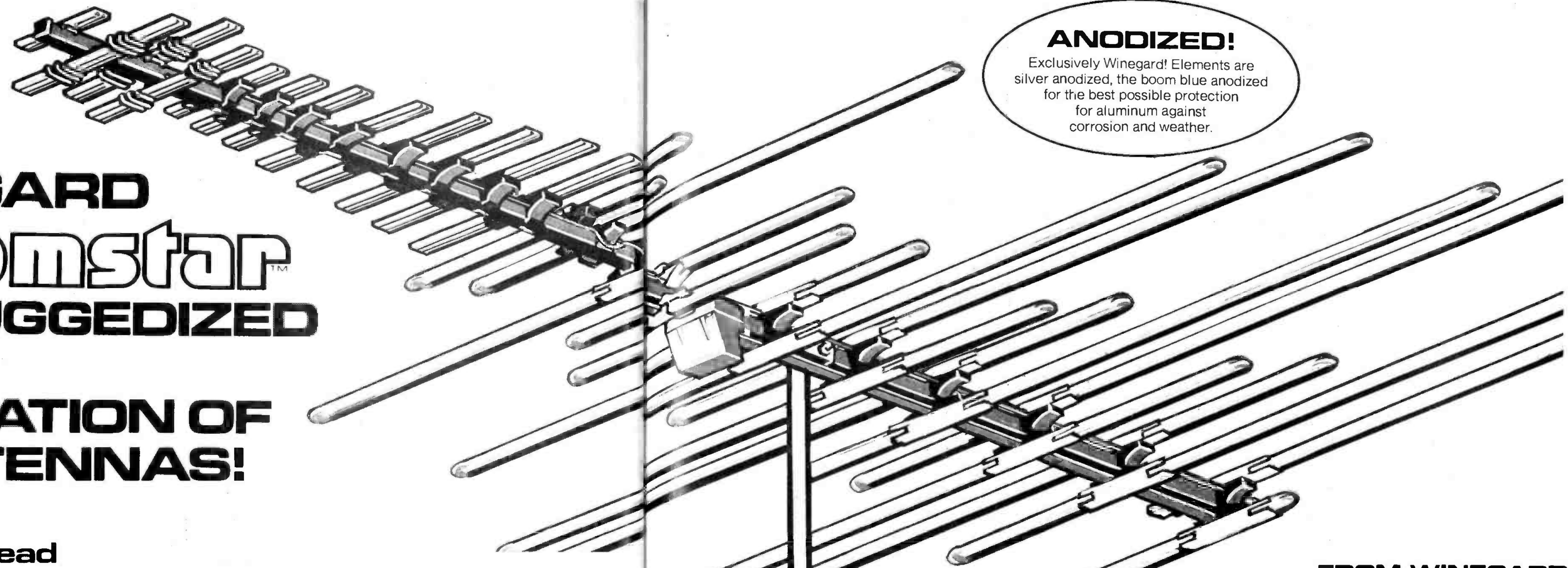
User Comment. Our measurements confirmed IAD's claims for the electrical performance of the Model B3A expander. However, the value of the expander can be assessed only by actually operating it in a music system. We connected the expander into several systems and found the tape-monitor connection to be the most practical. Not only does this make the expansion characteristic independent of the volume control setting, but it makes it possible to instantly switch the expander in and out of the system to demonstrate its subjective effect. This is very important if for no other reason than to determine whether or not the expander is really operating.

At no time—regardless of program material, control settings, or other considerations—were we able to detect the expander in the performance of its function. When none of its LED's were on, switching the expander in and out of the system made no change in the program level. On the other hand, if the LED's indicated considerable expansion, the drop in volume level was dramatic when the expander was bypassed.

The digital operation of the LED's gives the impression that the changes in gain of the amplifiers in the expander also occur in discrete steps. In reality, the changes are so continuous and smooth that one can never detect the expansion action by ear. Depending on where the sensitivity control is set, relative to the program level, one can use the Model B3A as an "upward expander," with the average program level receiving little or no expansion. If you do this, be sure that your amplifier and speaker systems are equal to the task, since 15 dB of expansion will increase the amp's output power by some 32 times compared to what it would be without the expander!

An alternate approach is to use a large portion of the expansion at nor-





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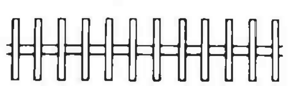
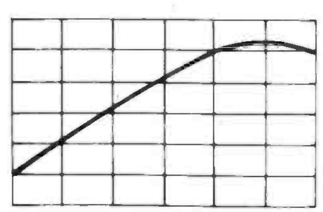


55"

Boom length required for 12 directors



Typical gain curve with ordinary UHF directors. Note low response on low end of band.

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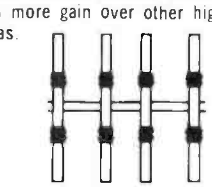
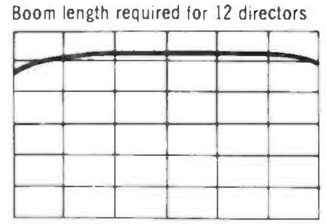


10"

Boom length required for 12 directors



Typical gain curve with Winegard Tri-Linear directors. Note high uniform gain across entire band.

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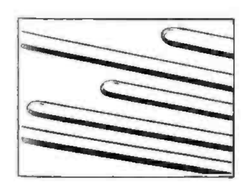
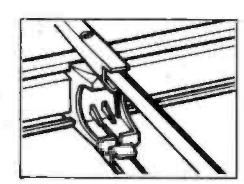
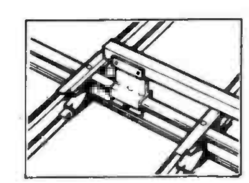


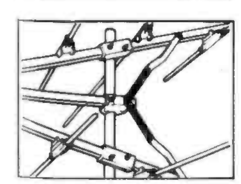
Exclusive ⅞" diameter aluminum tubing for 30% greater strength, better performance, longer life. Winegard is the first and only manufacturer to use this larger diameter.



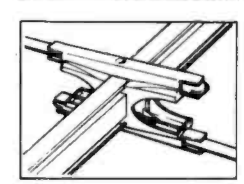
New truss-type phasing bars, top and bottom, with more conductive surface, give maximum transfer of signal. Truss-type "bridge" construction more than doubles boom strength.



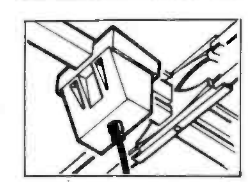
Double boom on longer flat line models for extra strength & rigidity.



New scissors-type struts between upper and lower booms and center boom on wedge models, for extra support, easier installation.



High-impact girder design support insulators are moulded of super-tough Noryl G-E plastic. Four positive locks give maximum support and permanent alignment.



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mal program levels (turning down the amp's volume control and raising the expander's sensitivity control to restore the lost volume). Then the Model B3A acts as a "downward expander" and in the process reduces noise and hum by as much as 15 dB. In this mode, soft passages may become nearly inaudible. For our purposes, the best mode was an intermediate stage, with the third or fourth LED on at average program levels. This provided a useful amount of expansion as well as some noise reduction.

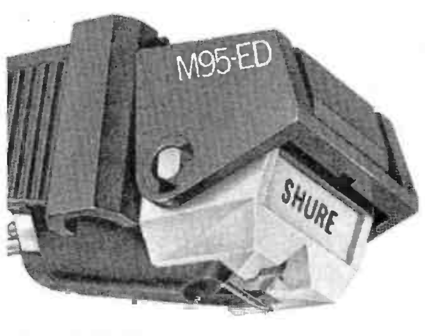
The effectiveness of the expander depends to a great extent on program dynamics. With most records and tapes, especially where the program has been allowed to retain some of its dynamic content, the results are nothing short of fantastic. A commercially taped piano solo, for example, was reproduced with its pianissimo portions barely audible, while fortissimo passages drove the amplifier to more than 200 watts/channel output. The sound was highly realistic, since one never had the sense that the system's gain was being manipulated.

It is our opinion that the IAD Model B3A can restore a substantial amount of the compressed dynamics to much of today's recorded program material. The degree to which its function can be utilized depends to a great extent on the capabilities of the power amplifier and speaker systems with which it is used. We found the expander to be compatible with good 30-watt/channel receivers as well as with super-power amps in the greater than 200-watt/channel class. In any event, we cannot imagine any way in which the expander could degrade any program fed through it if the amplifier and speaker system ratings are not exceeded.

CIRCLE NO. 65 ON FREE INFORMATION CARD

SHURE MODEL M95ED STEREO PHONO CARTRIDGE

Moderately priced, it has "sound" of more costly V-15 Type III.



The new Shure M95ED stereo phono cartridge falls between the company's top-of-the-line V-15 Type III and its moderately priced Model M91ED. The new cartridge has a pole piece that is similar to the one used in the Type III, although it is not constructed of laminated elements. The design makes possible a lower winding inductance, which results in a flat frequency response that is almost identical to that of the Type III. A low stylus mass of 0.5 mg promises excellent high-frequency "trackability."

The physical appearance of the cartridge is similar to that of the Type III, including an integral swing-away stylus guard as part of the replaceable stylus assembly. The trackability of the cartridge throughout the audio range is such that at its nominal operating force of 1 gram it is about equal to the Type III operating at 0.75 gram.

The retail price of the Shure Model M95ED stereo phono cartridge is $59.95.

Laboratory Measurements. We installed the cartridge in the tonearm of a high-quality record player for our tests. Operating the cartridge at a 1-gram tracking force, we soon confirmed that it was able to track very high velocities at low and midrange frequencies on our Cook and Fairchild test records. With another tracking test record, produced by the German Hi-Fi Institute, the cartridge tracked 300-Hz tones recorded at a 60-micrometer amplitude without distortion at 1 gram. At its maximum rated force of 1.5 grams, it was able to track the 90-micrometer band on the record. (Most fine cartridges can track 60 to 70 micrometers, but few can cope with the higher levels.)

High-frequency tracking ability tests using the specially shaped 10,800-Hz tone bursts of the Shure TTR-103 test record revealed the excellence of the cartridge's high-frequency performance. Tracking distortion was on a par with the best cartridges we have tested. A more conventional intermodulation-distortion (IM) measurement with the Shure TTR-102 record that mixes 400- and 4000-Hz tones indicated that the IM was only 2% maximum up to 22.5 cm/s.

The output from the cartridge at 3.54 cm/second was 4.3 mV/channel. The stylus's resonance of about 20,000 Hz revealed itself as a ringing of several cycles on a 1000-Hz square wave from the CBS STR/111 test record.

Initially, we tested the cartridge's frequency response with the standard cable and tonearm capacitance of the record player (200 pF, which is typical for many players). The response had a peak of about 4 dB at 16,000 Hz. Since Shure recommends a load capacitance of 400 to 500 pF for flattest response, we added capacitance to bring the total to 440 pF and measured the response again. This time it was notably flat, varying ±1 dB from 40 to 17,500 Hz and dropping to −4 dB at 20,000 Hz. The separation, which was identical on both channels, was better than 30 dB at frequencies below 2000 Hz and gradually reduced to 17 dB at 10,000 Hz and 5 dB at 20,000 Hz.

User Comment. Comparing Shure's specifications for the new cartridge and the slightly less expensive M91ED, the only apparent difference is 2 dB greater "trackability" at 400 Hz for the former. Although this is certainly desirable, it would not in itself warrant the creation of a new cartridge. The real difference, however, is in the sound quality of the two cartridges.

The M91ED has a slightly depressed output in the upper midrange that gives its response curve a "sway-backed" appearance. On the other hand, the M95ED has the same flat response characteristic as the V-15 Type III. Therefore, although it is priced nearer the M91ED, it can sound very much like the costlier Type III.

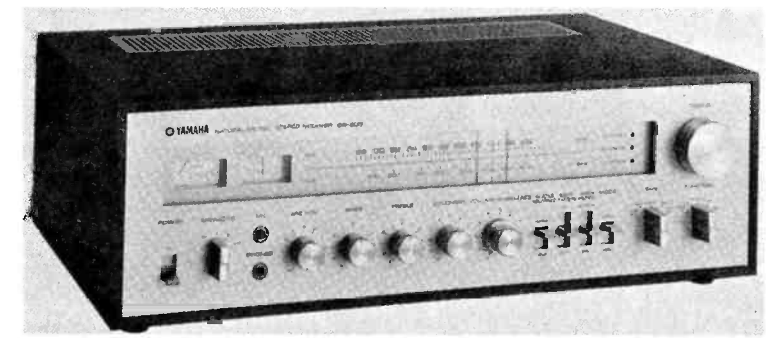
We compared the M95ED to the M91ED because the two are very close in price. In an A-B comparison, the latter had a warmer, somewhat heavier sound, while the M95ED was brighter and sharper in its apparent definition. It would be impossible to say that one cartridge sounds better than the other—only that each has a different sound that must be judged by the listener.

If you like the "sound" of the expensive V-15 Type III, the M95ED should be a moderately priced alternative.

CIRCLE NO. 66 ON FREE INFORMATION CARD

YAMAHA MODEL CR-800 AM/STEREO FM RECEIVER

Medium-power unit has superb FM performance.



Ranking next to the top of Yamaha's receiver line is the Model CR-800. This AM/stereo FM receiver is very conservatively rated at 45 watts/channel into 8-ohm loads. The receiver features top-quality performance and a full complement of controls. It has the distinctive Yamaha equipment styling, characterized by a clean, uncluttered satin-aluminum front panel and large dial cutout area.

The receiver measures 17¾"W × 11¾"D × 6¼"H (45.1 × 29.8 × 15.9 cm) and weighs 31 pounds (14 kg). It retails for $580.

General Description. The relatively short FM dial scale is linearly calibrated at 0.5-MHz intervals. To the left of the scales are the FM zero-center and AM/FM relative signal strength meters, the latter calibrated logarithmically over a 100-dB range. Three red LED's to the right of the scale indicate when the receiver is on, when a station is tuned in, and when a stereo-FM transmission is being received.

The large tuning knob is located to the right of the dial window. All other controls are located on the lower half of the receiver's front panel. Lever switches are provided for controlling receiver power, a 20-dB audio attenuator for temporary level reduction, stereo/mono switching, and the filters. Three-position, center-off switches are used for the filters.

The low-cut filter provides a choice of 20- or 70-Hz cutoff frequency, with a 12-dB/octave slope. When the high-cut filter is in its down position, it introduces a 6-dB/octave rolloff beyond 8000 Hz. In the up position, it partially blends the high audio frequencies to reduce noise on stereo programs. The center positions of both switches disable the filters. (Many receivers use a similar system for stereo FM noise reduction, but this Yamaha receiver is the first we have seen to apply it to *all* program sources.)

The BASS and TREBLE controls have 11 detented positions. The BALANCE control is a center-detented ring concentric with the VOLUME control. A separate LOUDNESS control, also with 11 detented positions, gradually introduces bass and treble boost as it lowers the midrange level. It is used in conjunction with the VOLUME control to provide correct low-level volume compensation that is independent of the setting of the VOLUME control. A separate MICROPHONE volume control, with an OFF position, is provided for adjusting the level from a microphone plugged into an adjacent jack.

The other controls are rotary switches, operated by bar knobs whose settings can be seen at a glance. One switch is for activating either, both, or neither of two pairs of speaker systems connected to the receiver's outputs. Another is for controlling the interface between the receiver and two tape decks. In its center position, the selected program source is heard through the speaker systems. Moving it one position to either side of center permits monitoring of the playback output from either tape deck. An additional two postions per-

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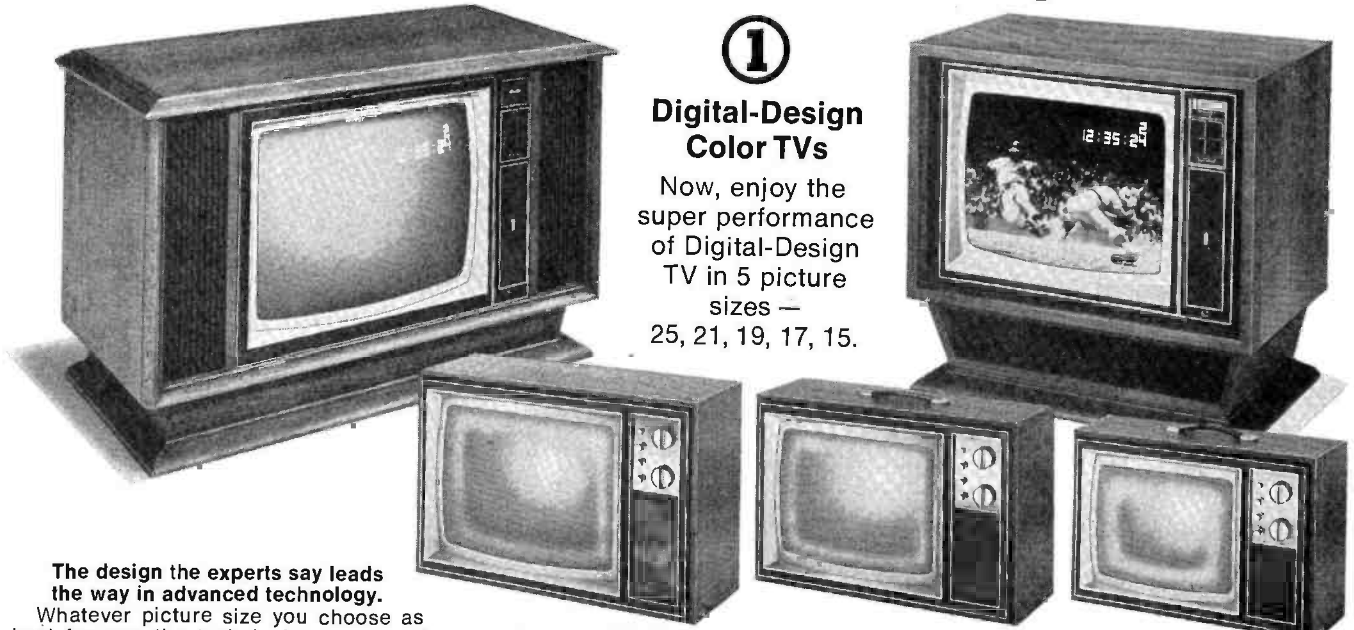

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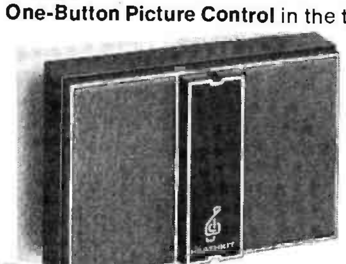

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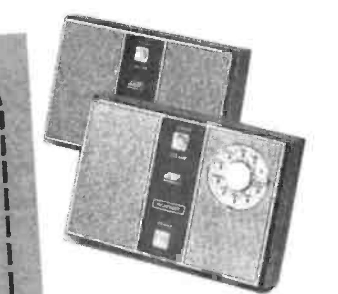

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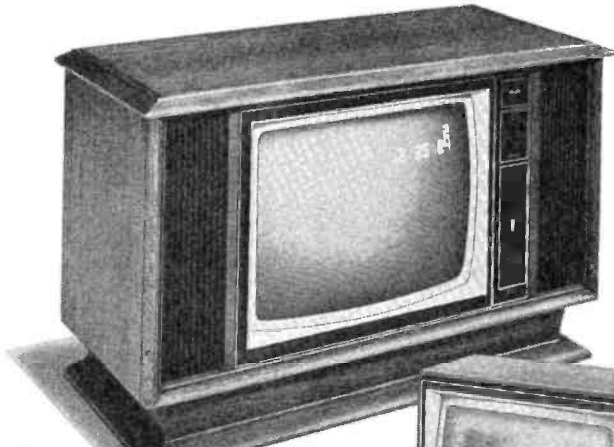

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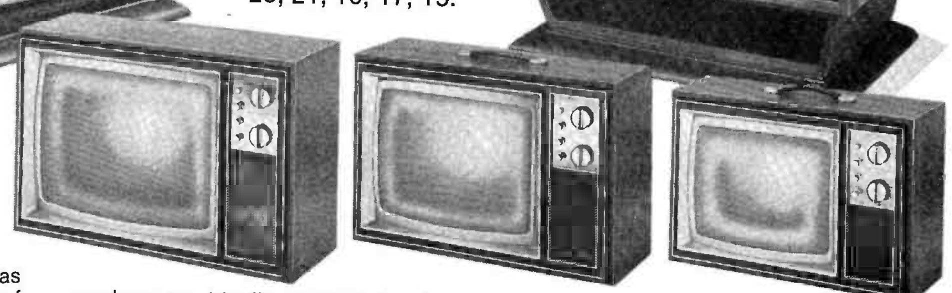

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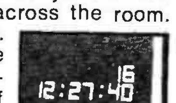

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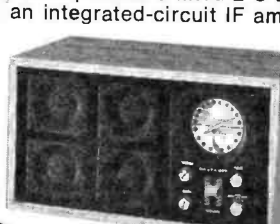

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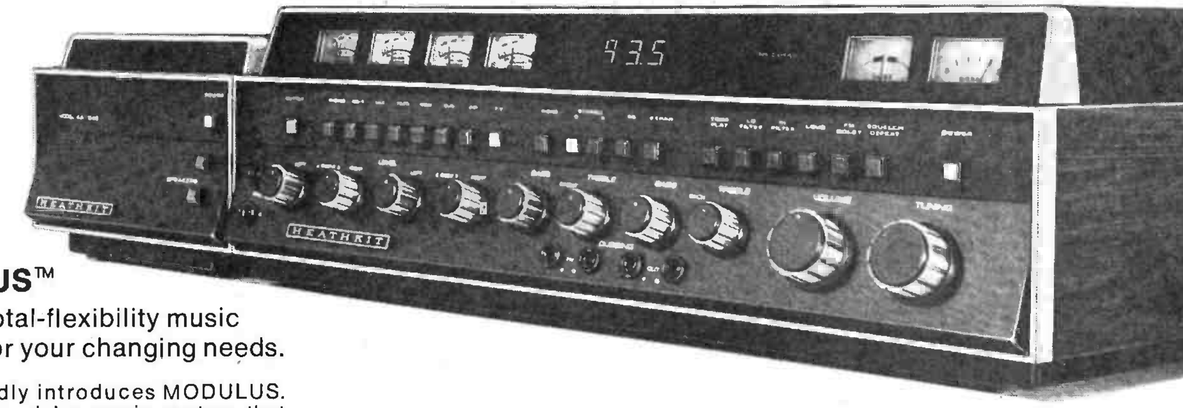

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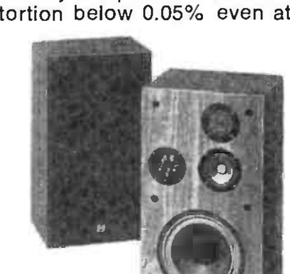

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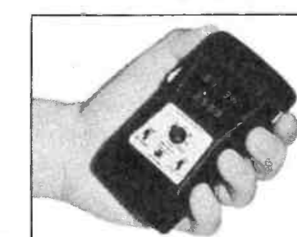

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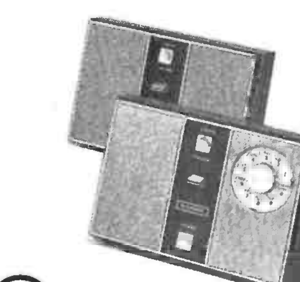

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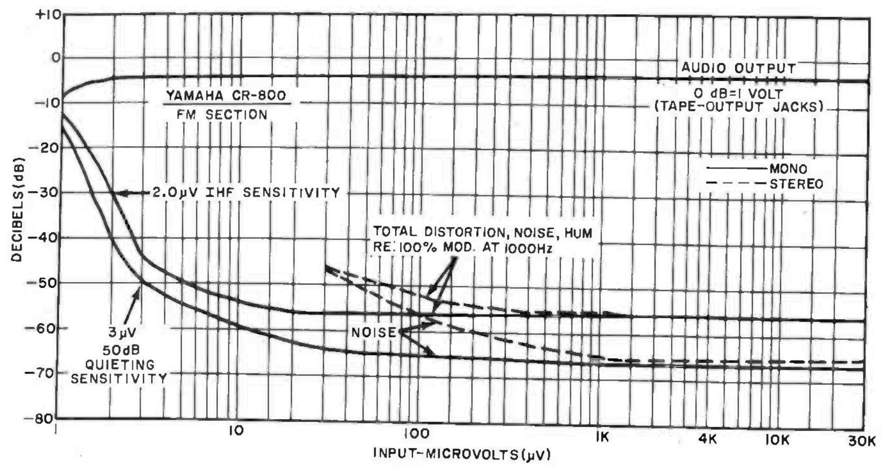
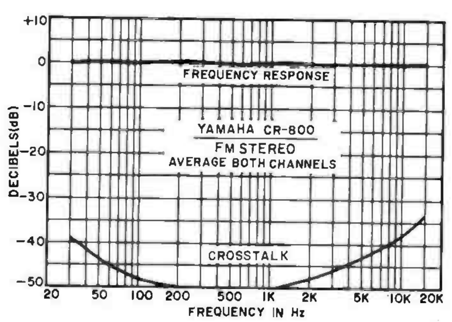


mit connecting the recorders for dubbing from either machine to the other. (The normally selected program source is not heard in this mode.) Finally, the desired program source is selected by a switch with positions for AUX, two magnetic PHONO cartridges, FM with and without interstation noise muting, and AM. A headphone jack is located below the microphone jack.

On the rear apron of the receiver are the various inputs and outputs, plus separate preamplifier outputs and main amplifier inputs that permit independent operation of the two receiver sections or insertion of accessories (active equalizer, active crossover system, etc.) The inputs are normally joined to the outputs in pairs by an adjacent slide switch. The speaker outputs are insulated spring clips. An IF OUT jack is presumably intended for use with a 4-channel FM adapter. In spite of its nomenclature, it is apparently a detected composite stereo signal without deemphasis.

There are antenna inputs for 300- and 75-ohm FM antennas and a wire AM antenna, plus a pivoted ferrite rod AM antenna. Two of the four accessory ac outlets on the rear apron are switched.



Laboratory Measurements. The measured performance of our test receiver speaks for itself. In virtually every respect, the receiver far surpassed its published ratings!

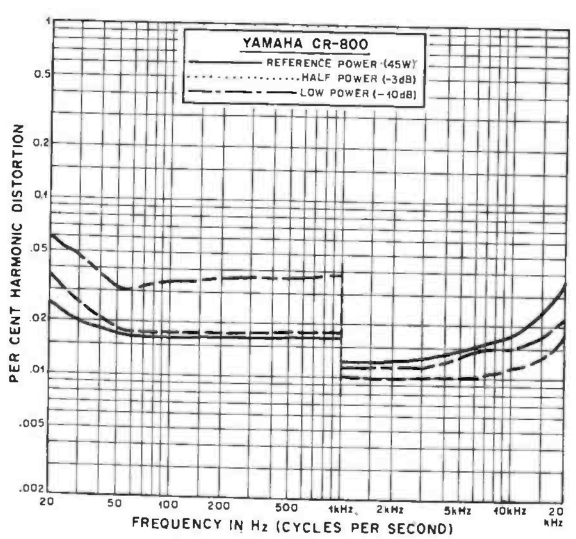
With both channels driven into 8-ohm loads at 1000 Hz, the audio outputs clipped at 61 watts/channel. Into 4- and 16-ohm loads, clipping occurred at 79 and 41 watts/channel, respectively. The THD at 1000 Hz was below the noise level up to several watts output. It measured less than 0.03% from 0.7 to about 60 watts output. The IM distortion was less than 0.03% from 0.1 to 30 watts, reaching 0.05% at 60 watts output. (The conservatism of the receiver's ratings is illustrated by its rated 45 watts/channel from 20 to 20,000 Hz at less than 0.1% THD.)

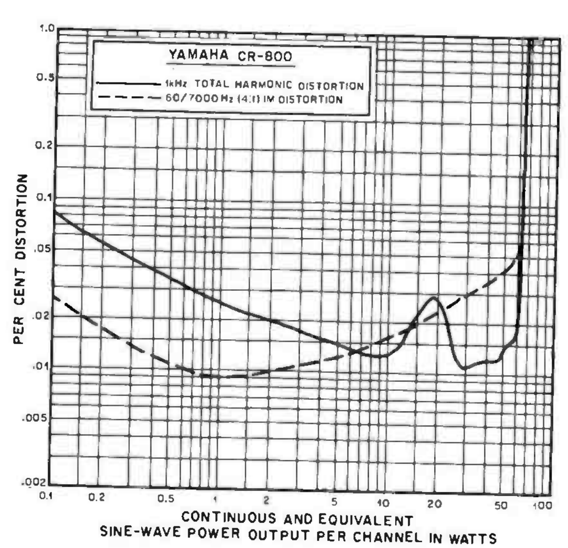
At the rated 45-watt output, the distortion was less than 0.035% from 20 to 20,000 Hz, typically measuring less than 0.015%. It was roughly the same at half power and even at one-tenth power did not exceed 0.06% over the full audio range.

A reference 10-watt power output required an input of 57 mV at the AUX, 1.2 mV at the PHONO, and 1.1 mV at the MIC inputs. The respective unweighted S/N figures were 80, 78, and 74 dB, referred to 10 watts. These represent exceptionally quiet amplification, especially through the low-level PHONO and MIC inputs. The phono preamp overloaded at a very high 250 mV, while the microphone preamp input overloaded at 700 mV—a new high in our experience with receivers and amplifiers.

The receiver easily handled the one-hour preconditioning period at one-third power before the distortion and power measurements were made. Even more remarkable, it was accidentally subjected to 30 minutes of severe overloading, driven into hard clipping on both channels, without suffering any damage.

The RIAA phono equalization was accurate to within ±0.5 dB from 30 to 20,000 Hz. It was affected by cartridge inductance to about the same extent as most good amplifiers and receivers, with a reduction of output at 15,000 Hz of 1 to 2 dB, depending on the specific cartridge used.





The filters had the rated characteristics, with excellent low-cut action but a gradual high-frequency rolloff that was of little use in hiss reduction. The tone controls had considerably more range at the low than at the high frequencies, the former with a sliding inflection point and the latter with a hinged characteristic.

The loudness compensation was both unusual and effective. The first few steps of loudness reduction produced only a trace of low- and high-frequency boost. Further operation of the control produced the rather extreme characteristics of most loudness-control systems.

The FM tuner's IHF usable sensitivity measured 2.0 μV. Its 50-dB quieting sensitivity was 3.0 μV. The stereo switching threshold (and the muting threshold) was between 15 and 22 μV. This is somewhat high for such a sensitive tuner, but it does assure that all received signals will be of good quality. The ultimate unweighted S/N ratio was 67 dB in mono and 66 dB in stereo. At 1000 μV, the distortion was a low 0.15% in both mono and stereo.

The FM capture ratio was an outstanding 0.9 dB, and the AM rejection was far above average at 70 dB. Similarly impressive measurements were obtained for image rejection (79 dB) and alternate-channel selectivity (88 dB). The 19-kHz pilot carrier leakage into the audio ouputs was unmeasurable, being more than 85 dB below the 100% modulated program level.

The stereo FM frequency response was literally ruler-flat, with a variation of less than ±0.3 dB from 30 to 15,000 Hz. This is especially noteworthy in view of the pilot carrier rejection of the receiver, since most tuners use low-pass filters for rejection to prevent appreciable attenuation at 15,000 Hz. The stereo channel separation exceeded 40 dB from 30 to 7500 Hz and 50 dB from 150 to 1500 Hz. It was still a healthy 33 dB at 15,000 Hz.

The AM frequency response was down 6 dB at 140 and 3200 Hz.

User Comment. As the laboratory tests reveal, this is a receiver that invites the use of superlatives. For example, the FM tuner performance comes close to matching that of the $1200 Yamaha Model CT-7000 FM tuner and is far better than what we would expect from a receiver at any price. The convenient FM tuning system features afc defeat when the TUNING knob is touched and dimly lights the AFC/STATION LED on the dial when a signal is properly tuned. Releasing the knob permits the afc to gradually come on, bringing the LED to full brilliance. Although afc is certainly not needed to correct for drift, which is essentially nonexistent, it makes the tuning procedure simpler than it would otherwise have been.

The dial calibrations were very accurate and easy to read against the hair line on the movable illuminated plastic indicator. The tuning meter gives a useful indication of relative signal strength, from levels too weak to operate the muting system to the highest that will ever be encountered. All the controls operate smoothly and with positive action, and a total lack of unwanted electrical transients must be experienced to be appreciated.

The FM muting system is one of the best we have used. It had no trace of thumps or noise bursts. As with most stereo receivers, the AM section of the Model CR-800 is below "hi-fi" quality, with the contrast made even more vivid by the superb FM performance of the receiver.

We usually take a dim view of loudness-compensation systems, which tend to make everything sound boomy and unnatural. However, with the system in this receiver, we make an exception. When the control is set to maximum and the volume is set to the loudest level you expect to use, reducing the LOUDNESS control setting preserves a natural frequency balance. At the lowest settings, the compensation becomes rather great. Over most of its range, one is hardly aware of the action of the loudness compensation, which is as it should be.

Obviously, our experience with the Model CR-800 receiver has left us enthusiastic. There are a few other receivers whose quality is similarly above reproach, and we would not attempt to rank them in any order of preference. On the other hand, we can say with assurance that we have never used a stereo receiver whose performance surpasses that of the Model CR-800 in any significant respect. Other receivers might be more powerful or have some features lacking in this one, but none can outrank it in sheer performance and attention to the small details of human engineering that make it such a satisfactory product.

CIRCLE NO. 67 ON FREE INFORMATION CARD

ELECTRA BEARCAT 101 "DIGITAL" SCANNING MONITOR

Vhf-uhf scanner programs 6000 frequencies without plug-in crystals.

THE Bearcat 101 from Electra offers something new in the way of a scanning FM monitor receiver. Highly advanced, it contains the latest in modern technology, including a computer-type digital frequency-synthesis system that eliminates the need for plug-in crystals. The receiver provides scanning of 16 frequencies in the 30-to-50-Mhz low-vhf, 148-to-174-MHz high-vhf, 416-to-450-Mhz uhf, and 470-to-512-MHz T uhf Public Safety bands. Included in the coverage is the 146-to-148-MHz segment of the 2-meter Amateur radio band.

Any 16 out of more than 15,000 possible frequencies in these bands can be set up in any order or band combinations or be changed by the user simply by programming them from the front panel.

In operation, the appropriate r-f circuits for each band are automatically switched in and tuned for each frequency. This ensures peak performance over the entire range of each

Introducing JOLT™

. . .the world's lowest cost computer system

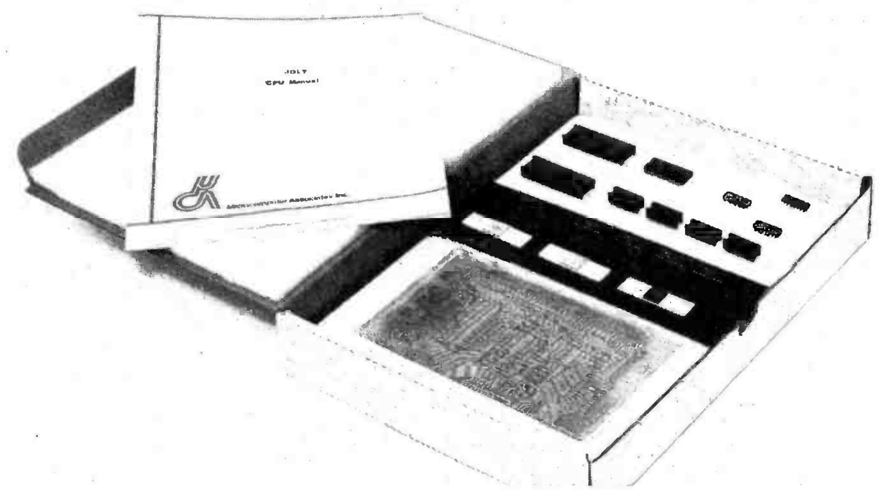
JOLT™ is the new, fully-tested microcomputer with the exclusive on-board DEMON™ debug monitor. You can build it, plug it in and talk to it in three hours or less . . . for a price of just $249!

The basic JOLT™ card includes an 8-bit MOS Technology Model 6502 CPU, which requires no clock, can directly address 65k of memory, has two index registers, 58 instructions with 11 addressing modes, two interrupts and includes both single step and address halt capability. And that's only a part of it.

JOLT's™ CPU card is available IMMEDIATELY* in either kit form or assembled ($249 for the kit in single quantity and $348 assembled). Either way, the JOLT™ CPU is completely tested prior to delivery. It comes complete with a terminal interface (TTY or EIA) and a unique software DEbugger/MONitor called DEMON™, for which full documentation is provided. It is very easy to program, and any JOLT™ delivery includes an easy-to-follow assembly instruction manual, showing you exactly how to put everything together . . . correctly. Complete assembly should take you no more than three hours if you choose the CPU in kit form. Besides the JOLT™ CPU — the 6502 from MOS Technology — the basic JOLT™ card has a fully static memory accommodating 512 bytes of the user RAM. The JOLT™ CPU memory also has 64 bytes of interrupt vector RAM. ROM Program memory on the basic card consists of 1k bytes of monitor/debugger with an automatic Power-On bootstrap program — so you can start talking to JOLT™ and it to you as soon as you plug it in to your terminal. On-board Input/Output devices on the JOLT™ CPU card include TTY 20 milliamp current loop and an EIA interface, both full duplex. The card has high speed reader interface lines and 16 fully programmable user I/O lines with full TTL drive.

Nobody, but nobody, except MAI can offer you an on-board debugger/monitor like DEMON™. It's fully documented, too.

The exclusive DEMON™ Debug Monitor really makes JOLT™ one of the most outstanding computer systems offered at any time, at any price. Even without DEMON™ and its superior software features, JOLT™ is the lowest cost computer system in existence. And DEMON™ is a bonus you'll have to use to believe. First, it self-adapts to any terminal speed from 10-30 CPS. With it, you can display and alter your CPU register and memory locations, plus you can read, write and punch Hex formatted data . . . with Write/Punch BNPF format data for PROM programmers. It has unlimited breakpoint capability along with separate non-maskable interrupt entry and identification. External device interrupts can be directed to any location you choose, or they can be defaulted to DEMON™ recognition. DEMON™ also gives you (1) a completely protected ROM resident debug/monitor; (2) the capability to begin execution at any location in memory; (3) the capability to bypass DEMON™ entirely to permit full control by you over your system; (4) a high-speed 8-bit parallel input option; and (5) it includes user callable DEMON™ I/O subroutines. MOST IMPORTANT, DEMON™ IS INCLUDED AS STANDARD WITH ANY JOLT™ CPU KIT OR ASSEMBLED BOARD!

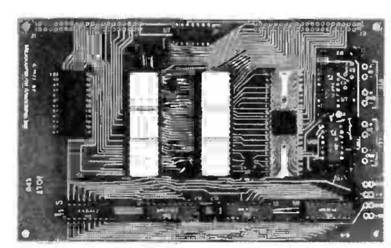


All kits are delivered with a complete instruction manual and packaged for easy visual identification of parts to aid you in assembly.

Obviously, the JOLT™ basic card is a computer in and of itself. But you can add significantly to its capacity and versatility by adding 4k RAM JOLT™ memories — in one card or a whole bunch. A RAM card kit is only $265 ($320 assembled). Now.

The JOLT™ memory card is a fully static 4,096-bit Random Access Memory (RAM) with 1 microsecond access time and on-board decoding. It is also available now.* And the quantity of one price is what you might expect to pay in quantities of 100 . . . very inexpensive!

There's also a JOLT™ I/O card for you, our Peripheral Interface Adapter. You can't beat the price — single kit 96 bucks — or the function.

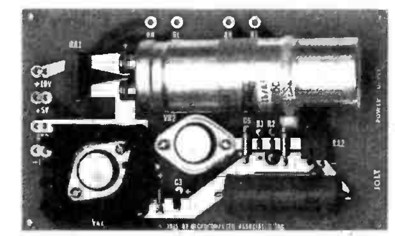


Pictured above is the assembled JOLT™ CPU card with DEMON™, just plug it in and you're ready to go.

The JOLT™ PIA (Peripheral Interface Adapter) I/O card includes two PIA LSI chips, 32 input/output lines, two interrupt lines, on-board decoding and standard TTL drive. It is also fully programmable and available IMMEDIATELY* in either kit or assembled form . . . at a very attractive single unit price ($140 assembled).

Considering the function and capacity of the JOLT™ Power Supply Card, you probably think the quantity of one price — $145 — is a misprint. It isn't.

The JOLT™ family also includes a power supply card, which operates at any of three voltages — +5, +12 and −10. The power supply supports the basic JOLT™ CPU card, plus 4,096 bytes of RAM and I/O. The only two words for the price are "dirt cheap." It is available for delivery immediately with a single unit kit price of $145 ($190 assembled).



The assembled power supply card shown above powers the JOLT™ CPU, I/O, and RAM Memory cards.

You can also choose a blank JOLT™ universal card. Or several.

The JOLT™ Universal card is completely nude. It's a blank you can use any way you wish, for control panels, T.V. interfaces, keyboards, LED's, or any other interface logic, because the card's holes are drilled to accept 14, 16, 24, or 40 pin sockets and has the same form factor as the other JOLT™ cards. The single unit price is just $25.

If you think you need extra cables, wires and the like, choose a Super Value JOLT™ Accessory Bag. A $55 Value for just $40.

The JOLT™ Accessory Bag includes 25 separate parts, enough hardware to connect one JOLT™ card to another. Order an Accessory Bag for each additional JOLT™ card. The Bag contains such necessary items as flat cable, connectors, cord spacers, hardware, wire, etc.

THE JOLT PLAIN ENGLISH WARRANTY

All components in the JOLT™ family are new and fully tested prior to shipment. Kit components are fully warranted during the first 60 days of ownership. Assembled parts are fully warranted during the first 6 months of ownership. If your properly assembled kit does not work, just ship your order back to Microcomputer Associates Inc. and we'll repair, replace, or refund your money.

20% BONUS

NOW! Special ONE TIME BONUS DISCOUNT. Order one CPU before **November 10, 1975** and deduct 20% off of all additional cards and accessories. (Note: Discount does not apply to CPU cards, assembled or unassembled.)

We told you JOLT™ was the world's lowest priced computer system. These prices prove it.

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(ALL PAYMENTS MUST BE IN U.S. DOLLARS)
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	1-4	5-19	20-49	50-99	100 up
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JOLT™ RAM	265	255	250	245	235
JOLT™ I/O	96	90	88	82	75
JOLT™ POWER SUPPLY	145	135	130	128	115
JOLT™ UNIVERSAL CARD	25	20	18	16	14
JOLT™ ACCESSORY BAG	40	36	34	32	30

ALL JOLT™ KITS ARE DELIVERED COMPLETE WITH A DETAILED AND ILLUSTRATED ASSEMBLY MANUAL

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(ALL PAYMENTS MUST BE IN U.S. DOLLARS)
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JOLT™ CPU	$348	$325	$320	$315	$305
JOLT™ RAM	320	305	300	295	280
JOLT™ I/O	140	125	120	115	105
JOLT™ POWER SUPPLY	190	175	170	165	150

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______	JOLT™ POWER SUPPLY KIT	______
______	JOLT™ UNIVERSAL CARD	______
______	JOLT™ ACCESSORY BAG	______
______	JOLT™ CPU ASSEMBLED	______
______	JOLT™ RAM MEMORY ASSEMBLED	______
______	JOLT™ I/O ASSEMBLED	______
______	JOLT™ POWER SUPPLY ASSEMBLED	______
	TOTAL	$ ______
	+U.S./CANADA SHIPPING/HANDLING/INSURANCE	4.86
	NOTE: CALIFORNIA RESIDENTS, +6% SALES TAX	______
	TOTAL REMITTANCE (U.S. DOLLARS ONLY)	$ ______

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MAIL YOUR ORDER TO: Pehaco Corporation, JOLT™ Sales Agents
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111 Main St., Los Altos, Ca 94022
All orders subject to the prior approval of the manufacturer.

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International Orders: Payment should be cabled to Account #00417-06355 Bank of America, 215 So. Murphy Avenue, Sunnyvale, California, USA, 94086

band (there are no restrictions as to the band-coverage limits). Each channel can also be set up for automatically providing a one-second rescan delay or no delay at all at a particular channel.

Among the customary features to be found are LED channel indicators, manual/automatic scanning, channel-disable switches, adjustable squelch, volume control, front-facing speaker, telescoping whip antenna, jacks for external antenna and speaker, and terminals for connecting an accessory. A kit consisting of a power converter and mounting hardware is available for mobile installations. Operated from a 117-volt ac line, the receiver draws 30 watts of power.

The receiver measures 9"W × 7¼"D × 3⅝"H (23 × 18 × 9 cm) and weighs 6¼ pounds (3.8 kg). Suggested retail price is $349.95

Technical Details. The receiver employs a single-conversion design, to a 10.8-MHz i-f. Selectivity is provided by a six-pole monolithic crystal filter. High sensitivity, low noise, and good signal-handling capabilities are obtained by use of dual-gate MOSFET's in the r-f and mixer stages for the vhf bands. Uhf-band operation is optimized by a separate r-f and mixer system that uses bipolar transistors. IC's are used in the i-f, detector, and a-f (including the output) stages.

Each band to which the receiver can be tuned has its own separate r-f circuit. The circuits are automatically selected according to the frequency for which the working channel is set. Tuning to each frequency is accomplished by variable-capacitance diodes that are controlled by the programmed information set up for each channel. Hence, the sensitivity/gain characteristics are uniform over the entire range for which the receiver can be set.

Our measurements, conducted with 50 ohms across the antenna input terminals, indicated 20 dB of quieting with a 0.35-to-0.4-μV input signal and a usable sensitivity of about 0.25 μV on the lower bands. The sensitivity dropped off somewhat on the uhf bands.

The maximum extension of the telescopic whip antenna was 22½" (57.2 cm). This is quite short for the 30-to-50-MHz band. However, the efficiency is raised by an antenna-loading inductor that is automatically switched in when this range is used.

Frequency Synthesizer. Custom-designed MOS and TTL IC's are used for scanning at a rate of about 20 channels per second for the frequency-synthesis system. The synthesizer employs the method in which a standard reference signal is derived from a crystal-controlled master oscillator or clock. The local oscillator signal at the receiver's mixer is obtained from a voltage-controlled oscillator (vco).

A vco comparison signal, obtained via a programmable counter-type divider system, is compared against the standard reference in a phase discriminator. Any discrepancy detected creates an error voltage that shifts the vco frequency to the point where these two signals are locked in phase with each other. This results in the proper vco frequency according to the division ratio programmed for the desired channel.

The logic for the switch positions is programmed through a special "nonvolatile" memory system that retains the information even after power is removed from the receiver. Therefore, no reprogramming is ever necessary, unless channel frequencies are to be changed.

User Comment. The receiver is initially programmed at the factory for 16 national frequencies. Reprogramming from a choice of 6000 other assigned Public Safety frequencies is easily accomplished by referring to the manual provided with the receiver. Tables in the manual indicate the required operations for each frequency.

The reprogramming procedure is as follows: You push a READY switch, set all channel switches to their down positions, and operate the MANUAL switch to step the LED indicators to the channel number to be programmed. Then, you push up certain channel switches as indicated in the tables for the desired frequency. (The one-second rescan delay for any particular channel can also be programmed at this time.) Following this, you momentarily depress an ENTER momentary- contact switch. Then, by pressing the READY switch to its up position, and placing the channel switches up for only those channels you want to scan, the receiver is programmed to selectively scan.

Manual or automatic scanning is selected and controlled by a separate lever switch. With manual scanning, any one channel can be kept open until scanning is resumed. There is no priority channel.

The two-meter Amateur frequencies are listed in the manual's tables in multiples of 10 kHz. However, the receiver's selectivity was broad enough to allow reception of local repeaters operating at odd multiples of 5 kHz with the scanner set to the nearest 10 kHz multiple.

Our measured selectivity indicated a 10-kHz adjacent-channel rejection of approximately 40 dB. Operationally, with the 148-to-174-MHz assigned channels at 15-kHz multiples, adjacent-channel interference from our local police transmitter (located some 2½ blocks away) produced only a slight buzzing with low-level audio distortion. It was apparent that no significant problems should be expected in this regard.

Best signal efficiency is obtained from the use of an external outdoor antenna, such as a dipole or ground plane designed for the particular frequency band you plan to use. However, we obtained good readability using only the whip antenna supplied with the receiver at our third-floor indoor location from signals originating 40 or so miles away.

The output power from the audio section measured 2.5 watts into 8 ohms, with 3% distortion from a 1000-Hz sine-wave signal. At 3 watts output, the distortion rose to 10%, and the waveform exhibited slight clipping. Audio intelligibility from the front-facing speaker was good to excellent.

CIRCLE NO. 68 ON FREE INFORMATION CARD

LECTROTECH MODEL BG-10 COLOR GENERATOR

Battery-powered, miniature generator for field servicing.

FIELD-SERVICE test equipment has come a long way in less than five years. Test gear that once had to be left back at the shop because of its bulk and weight can now be conveniently carried to a field job. A case in point is the color bar/dot generator used in color TV receiver servicing. Older generators were large and heavy and tied to the ac line. Lugging them along on a call was like lugging around an extra tube caddy. Fortunately, that situation has changed for the better.

Lectrotech, Inc., is currently marketing a Model BG-10 color generator that should make every color TV serviceman jump for joy. Measuring a compact 5½"L × 3"W × 1¼"D (14 × 7.6 × 3.2 cm), it is hardly larger than many portable calculators. In fact, it comes in a zipper-type soft vinyl carrying case that resembles many calculator cases.

The color generator is completely independent of ac line operation, using only a pair of 9-volt batteries. The generator's circuit employs low-current-drain CMOS digital IC technology to yield the maximum battery life possible.

The retail price of the generator is $89.50

Technical Details. The color generator is extremely simple to operate. There are only three switches that need concern the user. One two-position switch selects the row in which a desired pattern is located, while a three-position switch is used to zero in on the desired pattern. The front cover is silk-screened with the six patterns available, which are keyed to the swtiches with heavy black lines. The patterns available include: single dot, three color bars, single vertical/horizontal lines, full-screen dots, full-screen crosshatch, and 10 color bars.

The third switch is labelled COLOR ON/OFF. This switch must be set to ON whenever the three- or 10-bar pattern is selected and to OFF for any other pattern.

There isn't even a power switch per se. To apply power, a mechanical locking mechanism at one end of the generator's case must be squeezed, while the bottom of the case is being slid out, at which time power automatically comes on. (A plastic "cam" on the upper half of the case passes over a leaf switch when the case is opened, closing the contacts. When the case is shut, the cam disengages and opens the contacts.) When power is on, a LED on the control panel comes on. The locking mechanism prevents the case from accidentally opening and running down the batteries, while a mechanical stop prevents the bottom half of the case from sliding all the way out.

The test leads for the generator are permanently built in. They neatly fold away to fit into a small well in the instrument's case. Since it is necessary to open the case to get at the test leads, power comes on automatically and the instrument is ready to use.

The r-f oscillator in the instrument is factory tuned to TV Channel 4. It can, however, be adjusted with a hex tuning wand to provide an r-f output on either TV Channel 3 or 5 if preferred. Access to the tuning slug is provided through two holes in the side of the case that line up when the instrument is on.

User Comment. This miniature color generator can do virtually everything the full-sized instruments can do. The major advantage to the serviceman is not so much that it performs like an "in-shop" color generator of five years ago, but that it is small enough to be tucked into a tube caddy without taking up vital space for other supplies and tools.

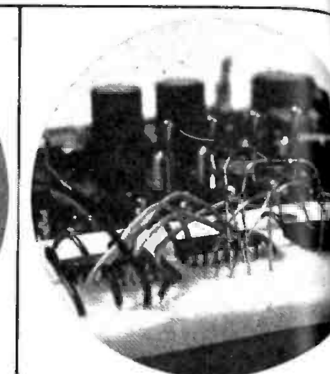
We used it on a number of service calls and can honestly report that it was a great convenience in terms of getting it to the job and its performance on the job. The fact that this is a *battery-powered* instrument was greatly appreciated, since an ac outlet is often not available.

CIRCLE NO. 69 ON FREE INFORMATION CARD

Communications Engineering

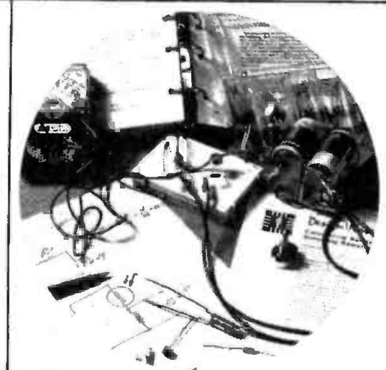
Aeronautical & Navigational

Television Engineering



Computer Engineering

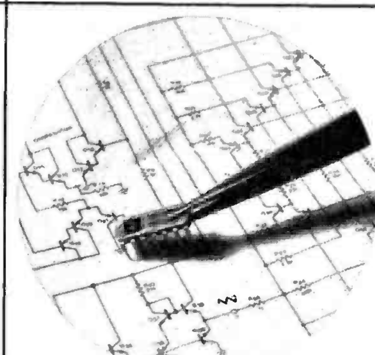
Automatic Control Engineering



Missile & Spacecraft Guidance

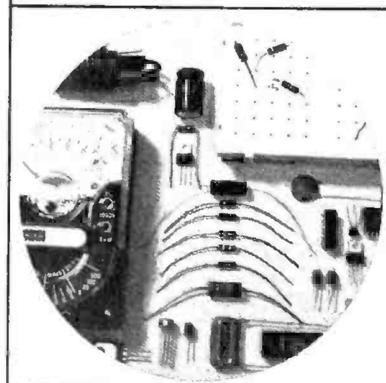
Radar & Sonar Engineering

Digital Communications

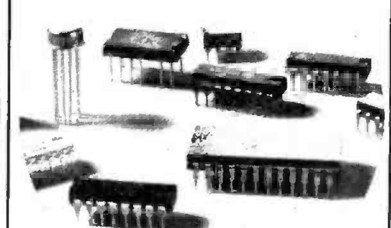


Industrial Electronics

Electronic Systems Engineering



Microwave Engineering



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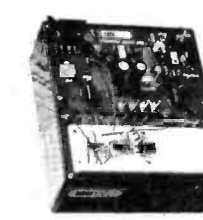

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Solid State

By Lou Garner

CALCULATOR CHIPS FOR OTHER CIRCUITS

UBIQUITOUS, innocuous and relatively inexpensive, calculator IC's (popularly called "chips" by engineers) are suitable only for the assembly of pocket and desk calculators. Right?

Wrong! More and more circuit designers are using these devices in noncalculator applications and, unlikely as it may seem, one day they may be used almost as extensively in other type of equipment as they are in calculators today. Some calculator chips have such powerful capabilities, in fact, that a number of original equipment manufacturers are considering their use in specialized instrument and control systems in place of minicomputer subsystems and expensive microprocessors. One industry executive has predicted that by 1977 not less than 20% of the total calculator chips manufactured will be used in commercial equipment and systems rather than in conventional calculators.

Calculator chips can be used to assemble computers; specialized types of watches and clocks; laboratory, industrial and service test equipment; medical instruments; process monitors; communications equipment; surveillance and security systems; and automotive, appliance and industrial controls. Under development and scheduled for early release (if not on the market by the time this appears in print) is a miniature combination calculator wristwatch.

Typical of one class of noncalculator applications, an easily duplicated counter circuit featuring a calculator IC is given in Fig. 1. Abstracted from *Calculator Chip Makes A Counter* (application note AN-112) published by the National Semiconductor Corporation (2900 Semiconductor Drive, Santa Clara, CA 95051), this is the simplest of seven circuits featured in the 6-page publication. The other circuits include a higher speed counter, an "up-down" counter and a combination counter/calculator.

Suitable for either pc or perf board assembly, the counter circuit requires only a type MM5736 calculator IC, a type DM75492 digit driver, a type NSA1166 six-digit LED display, three spst switches, and a 6.5-to-9.5-volt dc power source, such as a standard 9-volt transistor battery. Capable of handling counts of up to 999,999, the circuit's average maximum counting rate is approximately 60 Hz, but the actual maximum rate may range from as low as 40 Hz to as high as 150 Hz due to IC chip tolerances. It can be actuated by a pushbutton, mat, or reed switch, by magnetic relays, by a microswitch, or by any of a number of contact arrangements. Therefore, it is suitable for a wide variety of practical applications. Depending on the type of count control switch (*S3*), the counter can be used, typically, for inventory control, production line counting, recording game scores, or for counting the number of customers entering or leaving a store or business office.

The counting function is achieved simply by using the calculator chip to add "1" repeatedly. This is accomplished by interconnecting the chip's terminals (K3 and D4) which initiate the "addition" step through an external COUNT switch, *S3*. In practice, the operator first clears the circuit by depressing CLEAR switch *S1*, then enters "1" into the count by closing the START switch, *S2*. From this point, each closure of the COUNT switch causes "1" to be added to the total count up to the display's maximum capability.

By definition, a computer is a device or system capable of solving problems by accepting and retaining data, performing prescribed operations on that data, and supplying and/or storing the results of those operations. If the capability of accepting and retaining a planned program of operations is added to a calculator chip, then, in effect, the calculator/programmer combination becomes a basic computer.

Not too long ago, a programmable calculator required

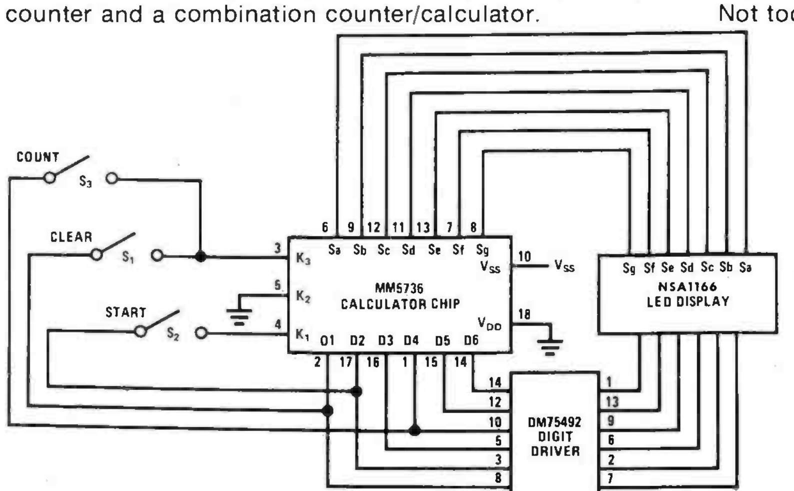

Fig. 1. In this six-decade counter circuit (from a National Semiconductor Application Note), a calculator IC and a digit driver control an LED readout. Depending on the type of counting switch used, the circuit has many different applications.

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several LSI chips to provide the necessary calculation, memory and programming functions, keyboard debounce circuits to prevent false entries, separate segment and digit drivers for the display, a multidigit display, power supply regulation circuits and, of course, a suitable keyboard. As a result, commercial programmable calculators cost as much as several hundred dollars each.

Several months ago, the National Semiconductor Corporation made it possible for equipment manufacturers to design moderately priced programmable calculators when it introduced a series of four special-function single-chip calculator IC's together with a compatible programmer chip capable of converting any of the four chips into a fully programmable "learn mode" calculator. Using these new devices, a programmable calculator can be assembled with only three IC's, a LED display, an appropriate keyboard, a dc power source, and a few small components.

National's five new IC's include the MM5760 slide-rule circuit, the MM5762 business and financial calculator, the MM5763 statistical calculator, the MM5764 international conversion calculator, and the MM5765 calculator programmer. All four calculator chips provide standard arithmetical functions. In addition, the MM5760 offers a complete set of log and trig functions, while the MM5762 provides a single-key computation of present and future value of compound interest, deposit or sinking fund amounts, payment or loan installments, and sum-of-the-digits calculations. The MM5763 includes linear correlation and regression, y-intercept, mean and standard deviation, summation of X or Y values, and related statistical functions. The MM5764 is designed to provide automatic conversions of length, volume, area, or temperature between two different measuring systems, such as British and metric. Finally, the MM5765 programmer circuit, used in conjunction with any of the calculator chips, can provide computational programs of up to 102 steps.

All of the circuits in the new series feature automatic display cutoff to conserve battery power, trailing zero suppression, power-on clear, and a low battery signal display (when used with a suitable digit driver).

Reader's Circuits. Suitable for use in electronic music synthesizers, waveform generators, operational control sequencers, and similar projects, the circuits illustrated in Figs. 2 and 3 were submitted by reader Frank J. Canova, Jr. (725 Myrtle Ave., Green Cove Springs, FL 32043). Each circuit is capable of delivering a repetitive series of different output voltage levels when triggered by a chain of

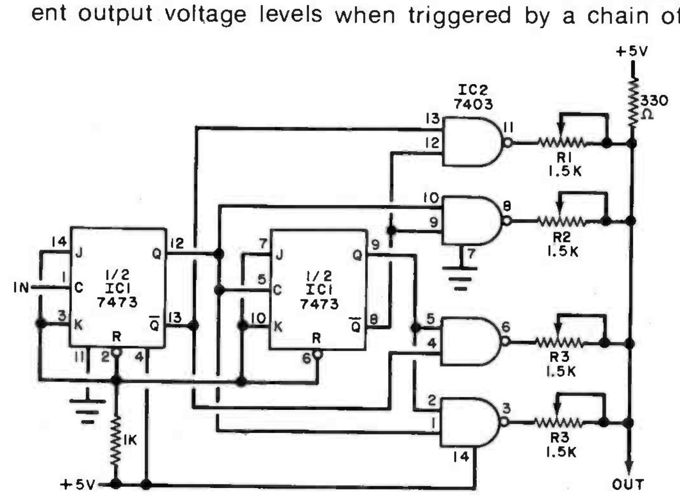


Fig. 2. Circuit provides four output voltage levels.

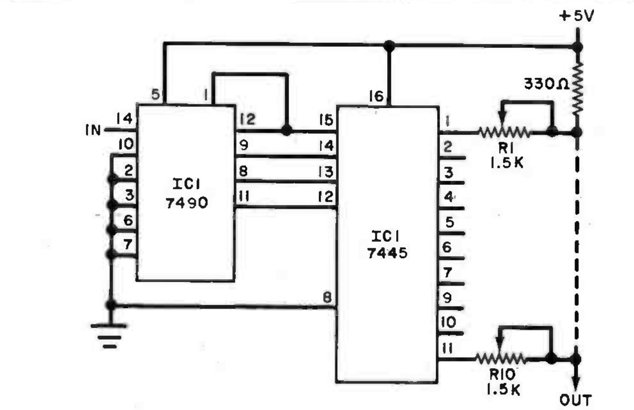


Fig. 3. Ten-step sequence or function generator.

pulse signals from a logic "clock" circuit or relaxation oscillator. Both circuits utilize readily available 7400 series digital logic IC's and both are designed for operation on standard 5-volt negative-ground dc sources.

As shown in Fig. 2, a 7473 dual J-K flip-flop, *IC1*, and 7403 quad 2-input positive NAND gate, *IC2*, are used to provide four output voltage levels in sequence when a pulse chain is applied to the circuit's input terminal. Each output voltage is preset (or programmed) by adjusting a potentiometer (*R1* to *R4*) in series with one of the four NAND gate output terminals and the dc source voltage through a 330-ohm resistor. The flip-flops are inter-connected to form a binary counter.

The sequence starts with pins 8 and 13 of binary counter *IC1* "high," driving only the top NAND gate on and shunting *R1* to ground. At this point, the output voltage, established by the voltage division between the common 330-ohm resistor and *R1*, is somewhere between 0 and 4 volts (approximately), depending on *R1*'s adjustment. When the first input pulse is applied, the input flip-flop changes state, with pin 12 (*IC1*) going "high," pin 13 "low." The top NAND gate is switched off, the second NAND gate on, and *R2* is connected to ground, changing the output voltage to a level determined by *R2*. In a similar fashion, the next pulse causes both flip-flops to change state, with pins 13 and 9 of *IC1* high and the third NAND gate switched on, all others off, and changing the output voltage to a level determined by *R3*. Finally, the fourth input pulse switches pin 12 (*IC1*) high, driving only the last NAND gate on and delivering an output voltage established by *R4*. The next pulse causes both flip-flops to change state and re-establishes the original conditions, starting a new cycle.

The circuit given in Fig. 3 operates in somewhat similar fashion, but utilizes a type 7490 decade counter and a type 7445 (or 74145) BCD-to-decimal decoder/driver to provide *ten* adjustable output levels. Again, separate potentiometers, *R1* to *R10*, are used to control each output voltage level.

Standard components are used in both designs. The potentiometers are 1500-ohm linear-taper types and can be either conventional knob-controlled units or screwdriver-adjusted trimmers, depending on the circuit's intended application. The fixed resistors are half-watt types. Any standard input and output connectors can be used, although shielded (coaxial) types are preferred. For optimum performance, the circuit(s) should be powered by a well-regulated 5-volt dc supply, with additional filtering provided on each circuit board to prevent possible cross-coupling. Frank recommends a 100-μF electrolytic capacitor shunted by a 0.1-μF plastic film or ceramic type, connected as close to the IC power terminals as is practicable.

Neither lead dress nor component layout are critical but soldering to the IC leads should be done with a 30-watt soldering pencil. Beginners may prefer to provide sockets for the IC's. Either pc or perf-board construction is satisfactory.

The completed circuit(s) can be used in any of a variety of applications, depending on the type of equipment involved and the frequency of the input drive signal, as well as upon the adjustment of the individual potentiometers determining the output voltage levels. If used with a music synthesizer, for example, the programmed output signal could serve to control vco (voltage controlled oscillator), vcf (voltage controlled filter), or gain circuits, or even a combination of these. The 10-step version (Fig. 3) is preferred for function generator applications. Here, the circuit can serve to create virtually any waveform that can be approximated by ten distinct voltage levels. As a general (but not inflexible rule) lower frequency drive signals are used in sequencer and music synthesizer applications, higher frequency signals up to the kHz and lower MHz range for waveform generation. An input drive signal of at least two volts amplitude is required for positive operation.

R & D Tidbits. While it may not be the ultimate answer to the nation's energy crisis, the semiconductor solar cell is certainly the simplest device currently available for converting sunlight into electricity. The chief limitations to its widespread use in the past have been its comparatively high cost and relatively low efficiency. However, both of these limitations may become less critical as the result of recent scientific breakthroughs, and the solar cell might well become a serious challenger in the energy race.

A new type of solar cell promising high efficiency at low cost has been developed by a research team at NASA's Jet Propulsion Laboratory in Pasadena, California. The new solar cell—dubbed AMOS, for Antireflection Coated Metal-Oxide-Semiconductor—is made from oxidized gallium arsenide with an extremely thin, nearly transparent gold film on its surface. Some samples have demonstrated an efficiency of about 15 per cent in terrestrial sunlight, which is better than the average silicon solar cell now in standard use. Perhaps more important, the device is potentially adaptable to production using very low-cost polycrystalline film techniques, with only a modest reduction in efficiency.

Another breakthrough, also with gallium-arsenide photoelectric devices, has been made by a scientific team at Varian Associates, Palo Alto, CA. Using a concave reflector to concentrate the sunlight by a factor of 1000:1, the Varian Associates group has achieved an output of *10 watts* from a solar cell measuring only 1 cm in diameter. This was made possible, in part, by gallium arsenide's ability to operate at high temperatures and high current densities beyond the reach of silicon devices. In addition, the Varian units have exhibited efficiencies as high as 23%, and Joe Feinstein, vice president of research at the firm, suggests that efficiencies as high as 35 to 40% may be possible within a few years.

In another area, scientists at Stanford University have been testing a new thick-film CMOS transducer capable of converting sound waves directly into electrical impulses which can be injected into an animals's auditory nerve system. The new transducer performs a function similar to that of the hair cells in the inner ear. Current tests are with cats' ears.

Engineers at the Bell Telephone Laboratories, Murray Hill, New Jersey, have designed and built the first solid-state TV camera that meets the resolution requirements for commercial broadcast use. The experimental camera, measuring only 2.5 x 2.5 x 6 inches, was built to demonstrate the feasibility of high resolution videotelephone systems. Its small size was made possible by the use of a solid-state charge-coupled device (CCD) as the imaging sensor. With an imaging area equivalent in size to the scanned area of a standard one-inch-diameter vacuum tube used in conventional TV cameras, the new CCD has 496 vertical interlaced scan lines and 475 horizontal picture elements and contains a quarter of a million sensing elements, representing a significant improvement in resolution over other known solid-state imaging devices.

Measuring 16 x 20 mm, the image sensor is the largest single chip device ever made.

Finally, in fulfillment of another of the predictions made in last January's column, the LEAA (Federal Law Enforcement Assistance Administration) has contracted for the development of a *personal fitness monitor* —essentially a wristwatch-sized solid-state instrument that will instantly tell its wearer his pulse rate, temperature, blood pressure, and other critical information, with a built-in alarm to warn the user if his bodily signs have reached a dangerous level.

Device/Product News. In addition to its new calculator and programmer chips, discussed earlier, the National Semiconductor Corporation has recently introduced a number of other devices which should be of interest to serious experimenters, students, engineers, and hobbyists, including a new display driver, a 12-bit successive approximation register, and a new pair of line drivers.

Combining the best features of both CMOS and bipolar technologies, National's new display driver, the CD4511, incorporates a BCD decoder/driver and an integral latch on a single chip. The decoding functions and the latch are made with a CMOS process, which insures very low input current and power requirements. The output drivers, on the other hand, are constructed with a bipolar process, permitting the CD4511 to source segment currents of up to 25 mA. Logically, the device provides the functions of a 4-bit storage latch, a BCD-to-seven segment decoder, and seven high-current output drivers. Lamp test, blanking, and latch-enable inputs are provided for display testing, turning-off or brightness modulation, and storing the BCD code, respectively.

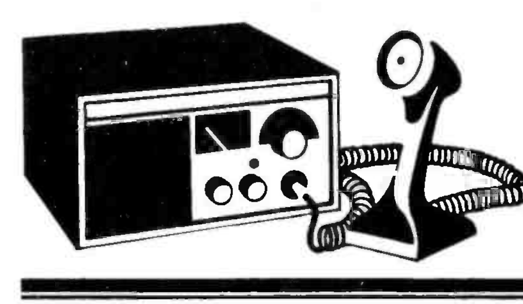
Designated type MM74C905, National's new CMOS 12-bit successive approximation register contains all of the digital control and storage necessary for building a 12-bit A/D (analog-to-digital) converter. Designed for operation over a supply range of from 3 to 15 volts, the device has a guaranteed noise margin of 1.0 volt. Provision is made for register expansion or truncation, and the circuit can function in either start/stop or continuous conversion modes, selectable by the user.

Manufactured using both CMOS and bipolar processes, National's new line drivers, types MM88C29 and MM88C30, can operate on 3 to 15 volts, provide a noise immunity of (typically) 45% of the power supply, have an on resistance of only 20 ohms, and are capable of sourcing 80 mA (typ.). Both devices are offered in 14-pin Epoxy-B or ceramic DIP's. The MM88C30 is a dual differential line driver that also performs the dual four-input AND or the dual four-input NAND function.

An all-electronic solid-state tuning system designed primarily for TV sets has been developed by the General Instrument Corp. (New York, NY). Dubbed *Omega*, the new tuner features an MNOS nonvolatile memory, a CMOS D/A converter, and ion-implanted logic. It is approximately one quarter the size of corresponding electromechanical tuners. In operation, a metal-nitride-oxide semiconductor (MNOS) memory digitally stores all the tuning information needed for each TV channel, retaining the memory for up to 10 years, even with power removed. When the operator selects a station, information in the MNOS memory for that channel is coupled to a 14-bit CMOS D/A converter, developing a corresponding analog voltage, which can then be applied to a Varactor diode to tune in the selected station.

Two new npn power transistors, types 2N6465 and 2N6466, have been announced by RCA's Solid State Division (Box 3200, Somerville, NJ 08876). The new devices are complements of pnp types 2N6467 and 2N6468, respectively, and, as such, are useful in complementary-symmetry circuits for audio-frequency linear amplifier applications, as well as in linear modulators, servo amplifiers, and operational amplifiers. The 2N6465 is a 100-volt, 40-watt device with a dc beta of 15-150 measured at 1.5 A collector current, while the 2N6466 offers the same dissipation rating and beta range, but at 120 volts. Both types normally are supplied in hermetic JEDEC type TO-66 packages.

Correction. In our September column, we erroneously listed a 416-page Data-book from Unitrode as being free for the asking to anyone who wishes to obtain a copy. This book is available only to Unitrode's customer list as recommended by the company's Sales and Representative Staffs. We sincerely regret any inconvenience our error has caused. ◈



CB Scene

By Len Buckwalter, K10DH

SPEECH PROCESSING

IF YOU make the rounds at a CB coffee break or jamboree, chances are you'll hear conversations about "speech processing" and how it can improve communication intelligibility. Let's examine what it is and what it can do for you.

Voice Signals. Speech processing changes the characteristics of a voice signal generated by a microphone. Observe that the signal shown in Fig. 1A is sharp, intermittent and non-repetitive. Moreover, there is a large difference between the average and peak values of the waveform. This is also true of the complex signal we get when the signal modulates an r-f carrier (Fig. 1B).

The desired result of the whole process—intelligibility—is dependent on the *average* power output of the transmitter. Typically, human speech that is fully modulating the carrier on *voice peaks* will only produce 30% of the peak power most of the time. Thus, the ratio of the average power to the peak power is about 1 to 3. What we end up with is a carrier that loafs along, carrying much less intelligence than it actually could.

If we could find a way of increasing this average/peak ratio, our signal would become a lot more readable.

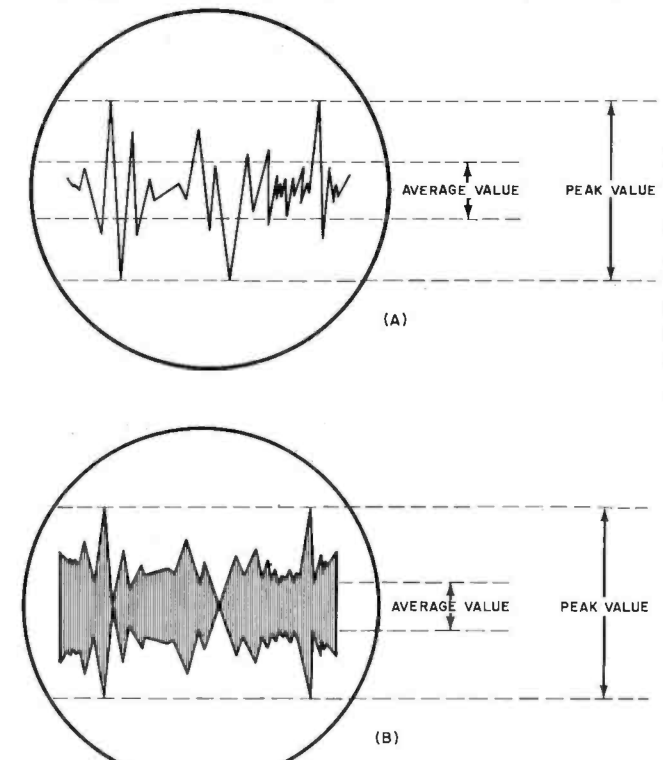


Fig. 1. At (A) is a typical voice signal. Voice peaks are high, but average level of speech is low. At (B) the signal modulates a carrier and the result has strong peaks but a low average modulation level.

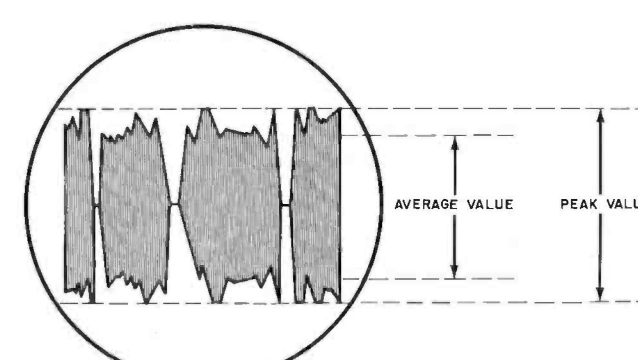


Fig. 2. In overmodulated signal, mike gain increases average level of signal but peaks have been clipped.

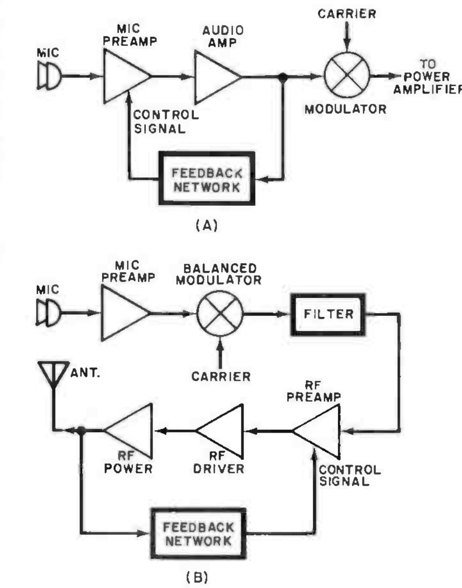


Fig. 3. Two methods of compression: audio and r-f.

One simple way to do this is to crank up the audio gain control. The resulting signal is shown in Fig. 2. Although the average value is a lot closer to the peak, the tops of the waveform are clipped off because the transmitter can't deliver the additional power required. Also, the carrier is interrupted on negative voice peaks. These result in "splatter" onto other channels and poor intelligibility on the desired one. "More modulation means a better signal," is only true when talking about modulation percentages up to the optimum of 100%. Trying to load more information onto the carrier than it can handle causes interference to other CB signals, TV receivers, etc. Also, it's illegal!

Speech processing, however, can increase the average power of the modulated signal without generating a clipped and interrupted wave. There are four basic types that we'll consider: audio compression, audio clipping, r-f compression, and r-f clipping. Each deals with the problem in differ-

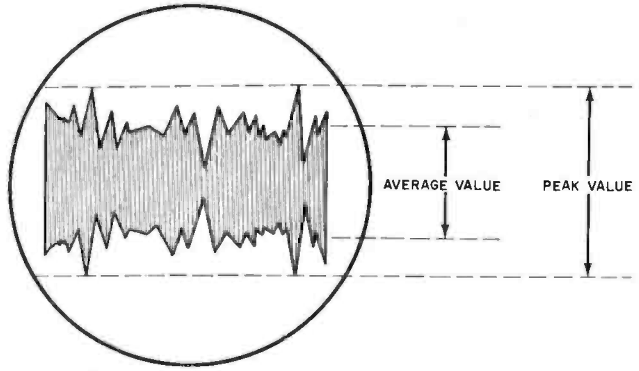


Fig. 4. In compressed modulated waveform, average signal level is high but peaks are compressed to avoid clipping.

ent ways. Predictably, each has advantages, disadvantages, and a varying degree of effectiveness.

Compression. One way of increasing the average degree of modulation is to use a "flexible" amplifier. That is, one with a lot of gain for weak signals, but very little for strong ones. These circuits have been around for a long time, and often assume the alias "automatic gain control" or simply agc. There are two methods of compression: audio and r-f, as shown in Fig. 3.

An audio compression system (Fig. 3A) works on the signal that comes straight from the microphone. This signal is amplified by the MIC PREAMP, and in turn by the AUDIO AMP. As the amplified version appears at the output of the AUDIO AMP, a small portion gets routed into the FEEDBACK NETWORK. In this stage, the sampled signal is rectified and filtered into a dc control voltage, which in turn determines the gain of the MIC PREAMP. When a strong signal appears at the AUDIO AMP output, a high dc level appears at the CONTROL SIGNAL input of the MIC PREAMP, cutting down its gain.

Sounds like a dog chasing its tail, doesn't it? In this case, however, the FEEDBACK NETWORK works fast enough to control the PREAMP gain while the strong (or weak) signal is still going through it.

A weak signal into the MIC PREAMP will generate a small control voltage, providing lots of amplification. Accordingly, the average level of the modulating waveform will be increased; and, consequently, the carrier will be more fully modulated most of the time (Fig. 4).

A similar compression system operates on the modulated waveform, as shown in Fig. 3B. The r-f compressor (in this case, installed in an SSB transceiver) controls the gain of the r-f amplifiers by sampling a portion of the POWER AMP's output. The FEEDBACK NETWORK converts the r-f sample into a dc control voltage, which determines the gain of the R-F PREAMP. The same type of compression action occurs as in the audio system. The output signal would look like the one in Fig. 4.

Clipping. Another approach to speech processing is clipping, which is performed on either audio or r-f signals. In an audio clipper (Fig. 5A), the mike output is amplified by the MIC PREAMP, and filtered by the low-pass filter. Any audio frequencies above 3000 Hz are shunted to ground, since they don't carry useful information and could cause problems. The AUDIO AMP then boosts the signal, and its output drives the AUDIO CLIPPER.

If we compare the output from this stage with Fig. 2, we would see almost the same waveform. This occurs because in most systems the clipper is really an amplifier running wide open. So the signal peaks get clipped off since they're too strong to be reproduced by the amplifier. But wait a minute—didn't the clipping action of Fig. 2 also imply splatter, harmonic radiation, etc.? Yes, but in this case we smooth the waveform by filtering out the audio highs, and then follow up the clipper with another LOW PASS FILTER. This rounds off the clipped corners of the signal, making it much more tolerable. Finally, an AUDIO AMP makes up for filter loss, and drives the modulator as in a conventional system. The output of the AUDIO AMP is shown in Fig. 6. The average value is close to the peak value, and signal peaks are smoothed out.

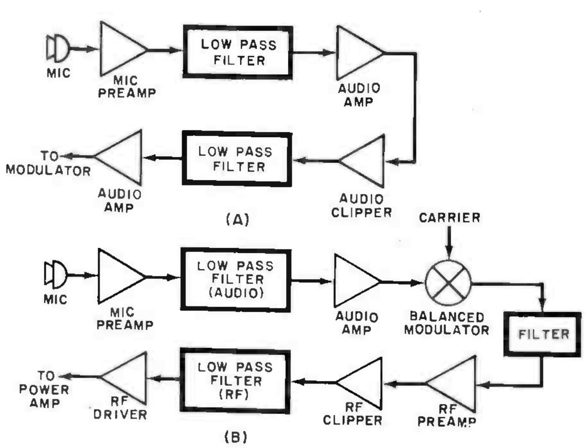


Fig. 5. At (A) audio clipper shapes voice waveform before modulation. R-f clipping (B) processes modulated signal and requires shielding and filter.

Clipping can also be accomplished in the r-f portion of a transmitter. Figure 5B shows the processing chain in a typical SSB transmitter. The MIC PREAMP boosts the modulating signal from the microphone. An audio LOW PASS FILTER eliminates highs, and the filtered waveform is boosted again by an AUDIO AMP. Then, the audio signal is combined with a carrier by the BALANCED MODULATOR, and a double sideband, suppressed carrier signal appears at the output. Since we need only one sideband, the FILTER eliminates the undesired one (upper or lower, depending on our preference).

Now we have a single sideband signal, albeit a weak one. The R-F PREAMP gives it a shot in the arm, and an R-F CLIPPER amplifies the signal so much that the tops get closed. As we mentioned before, the sharp corners of a clipped waveform contain many harmonics, so an r-f LOW PASS FILTER shunts the offending components to ground, and smooths out the signal. Finally, an R-F DRIVER adds signal gain to drive the power amp. The resulting waveform is shown in Fig. 6. Again, note that the average/peak ratio is a lot better, and the sharp edges are smoothed out.

Which Is Best? We've examined four methods of speech processing, and all appear to perform the desired function. The average level of modulation is greatly increased, but no spurious signals are generated. But which system is best to use, in terms of ease of construction and/or installation, and degree of effectiveness?

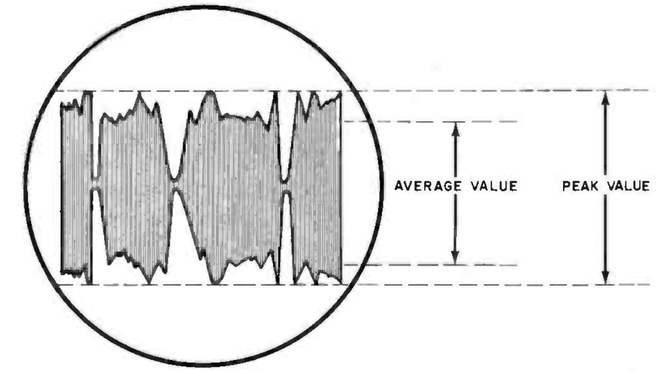


Fig. 6. A clipped and shaped waveform. Average modulation levels are higher, but filtering eliminates splatter.

In general, audio systems are easier to use, because they work with the existing transmitter circuitry. We can build an audio compressor or clipper in a small box, plug the mike into it and run a cable from the processor output to the mike jack on the transceiver. Audio compressors are simpler to build than clippers, since they don't require filtering stages. R-f systems, on the other hand, have to be inserted at a point within the r-f circuitry of the transceiver, thus requiring some "surgery." In general, r-f clippers are more complex and expensive than compressors, because of the strict filtering requirements.

But in terms of what the CB'er wants most, increased "talk power," r-f systems are superior to audio ones. For a given amount of speech processing, say 20 dB, r-f clipping will increase the signal-to-noise ratio at the receiver by 8 dB (over one S unit). Audio clipping will improve the S/N by about 5 dB, or just under one S unit. Audio and r-f compression will both give an S/N about one dB better than an unprocessed signal.

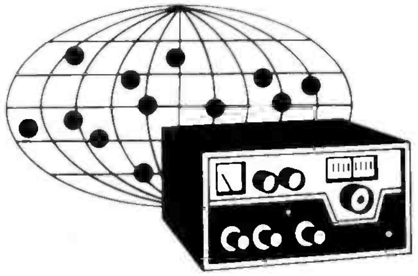
Transmitter Requirements. In order to get the most out of a speech processor, the transmitter must be designed along certain guidelines. Most important of these concerns the type of tubes or transistors used in the driver and power amplifier stages. Since the average modulation level is a lot higher, these devices will be handling much more power most of the time. This means they'll run hotter, and must be able to dissipate the extra heat generated. Otherwise, thermal effects will reduce their useful lifetimes.

Further, the power supply that supports these active devices must be "stiff," since the average power demand will be a lot higher. This means that larger filter capacitors, higher-current rectifiers and voltage regulators must be used. Some compact chassis may require a cooling fan to move more air around heat-generating components. And, of course, inboard clippers will necessitate the use of stringent filtering and shielding techniques.

All this adds to the cost of producing a CB rig. Is it worth it? From on-the-air listening experience, speech compressors can do an impressive job of boosting signal readability. An 8-dB (6.3 times) signal boost can make that marginal contact a solid one!

Intelligibility. But copying a message easily is not just a question of signal levels. How clean the received signal is can be just as important. If we compare the original modulating signal (Fig. 1A) to the unprocessed, modulated carrier (Fig. 1B), we can see that the envelope of the waveform is a good replica of the voice signal. The processed signals (Figs. 4 and 6) contain envelopes which are distortions of the original. Inevitably, any speech processing introduces a certain amount of distortion. In most cases though, you'll find that the processed version is still quite recognizable—and more intelligible—than the original.

Most speech processors available to CB'ers are audio compressors—whether they are built-in, add-on accessories, or packaged inside an optional microphone. As we've already seen, clipping is more effective, especially when the r-f method is used. As more and more CB'ers learn of the advantages of speech processing, more effective methods will be included in new transceivers. It's a safe bet that you'll hear an increasing number of *properly* clipped signals on the air! ◈



DX Listening

By Glenn Hauser

WHAT TO LOOK FOR IN A SHORTWAVE RECEIVER

IT'S not too early to start hinting for a new shortwave receiver for Christmas. But unless you pick it out yourself, you may be disappointed. Choosing the best receiver is rather involved. You must know what to look for and how important certain features will be to you.

If you're just starting in DX listening, and not sure how deeply you want to get involved, you may prefer a low-priced portable, to get a feel for what it's all about. The trouble is, the portable may turn you off—unless you realize that most of the problems you have with it can be eliminated with a more expensive receiver.

Image rejection is a common problem in receivers with only one i-f stage. It's possible to be tuned to a station on a desired frequency and also simultaneously pick up both that station and an interloper on another frequency. This interfering "image" signal will be found at a frequency displaced above or below the desired frequency by an amount equal to twice the receiver's i-f. Hence, if you're simultaneously receiving 14-MHz Amateur transmissions and 15-MHz broadcasts, your 455-kHz i-f receiver can't sort out the two signals spaced 910 kHz apart. To minimize such problems, it's best to get a dual- or triple-conversion receiver right at the beginning.

Crowded dials cause frustration. Unless a receiver has adequate *bandspread*, you'll end up sweeping past a host of stations as soon as you touch the tuning dial. But a well-designed receiver with 1-kHz calibration marks spaced ⅛" apart can be a joy to operate. It will allow you to easily home in on a rare station with a high degree of accuracy. Best, but costly, are the digital frequency synthesizer receivers.

Selectivity is one of the most important characteristics of a good receiver. On better receivers, you can select different bandwidths as required; but lacking this feature, can you separate two strong signals only 5 kHz apart?

Sensitivity is an important consideration, too. Although it's great to have a receiver that can respond to signal levels of a fraction of a microvolt, such sensitivity is useless if masked by receiver-generated noise. An S/N ratio of at least 10 dB is acceptable.

If you want to copy SSB and CW signals, a *bfo* and *product detector* are essential. They also allow you to accurately determine the frequency of AM carriers (by tuning for zero beat).

If you live in an electrically noisy area and/or listen to especially noisy signals, a *noise limiter*—better still, a *noise blanker*—will make broadcasts intelligible.

To Buy or Not to Buy. In some cases, the deficiencies of your present receiver can be compensated for with an add-on accessory. For example, you can boost sensitivity by placing a properly designed FET or IC preamplifier between the antenna lead-in and receiver. A Q multiplier can add selectivity, as can an audio filter and/or an antenna tuner. The antenna tuner is particularly helpful in improving the selectivity of the front end. A crystal-controlled converter can eliminate image problems.

In short, sometimes it's not justified to buy a whole new receiver. In some cases, however, buying a new receiver is unavoidable. Poor mechanical and/or electrical stability, crowded tuning dials, and a wobbly tuning mechanism demand extensive work beyond the capability of many DX'ers.

Where and What to Buy. We would all like to have a state-of-the-art receiver. But most of us simply can't afford to make a large investment for one of these receivers. What then is a realistic alternative?

There are a handful of fine new SW and general-coverage receivers around that range in price from about $160 to $600. The lower in price you go, the less you get in reception and general handling ability. Too, you might consider a used communication receiver that's in good condition. Many have crystal or mechanical filters, concentric tuning mechanisms, notch filters, and rock-solid construction, among other features. Their most desirable attribute is low price, and many of them—especially military surplus receivers—can be obtained for a fraction of their original cost.

If you're looking for one of these receivers, check the ads in amateur radio magazines. Surplus dealers and amateur radio supply houses in your area are also worth a visit. Two points are worth remembering, however. First, try to simulate your actual receiving conditions as close as possible. The best way to do this is to arrange to take the receiver home for a trial period—if the owner agrees.

Among the SW receivers currently used by DX'ers actively reporting to major clubs are the Hammarlund HQ180, HQ145, HQ160, and SP-600; R390 series of military receivers; and Drake SPR4, SW4, and R4B. Some are Amateur-band-only receivers and require additional local oscillator crystals. Others are for SW and broadcast-band only reception. The latter cover the major international bands (13, 16, 19, etc., meters), but they can't be used out-of-band where some rare catches lurk.

Swan On the Air Again. Last summer, Jack Jones in Jackson, Miss., discovered a new Honduran station calling itself "Radio Swan de Honduras" on 6185 kHz. The station takes an anti-communist line and operates 24 hours a day. The mailing address is in San Pedro Sula.

The Brazilian Shuffle. This is not a new dance, but a complicated new set of frequency assignments in the tropical bands—perhaps to show rural stations the central government is still boss, or just to confuse DX listeners! Here are the changes so far uncovered, thanks to monitoring in Brazil by Jack Perolo, Robert Veltmeijer and Cláudio Moraes, and in Paraguay by Tony Jones. Throw out your old lists, and go by this one when DX'ing Brazil. Best times are 0800-0900 GMT, and sunset to 0200. R=Radio; D=Difusora; Cl=Clube; Cu=Cultura.

kHz New	kHz Old	Station
2420	2410	R São Carlos
2424	2420	R Carajá
3205	3265	R Ribeirão Prêto
3225	4935	Lins RCl
3235	3255	RCl Marília
3245	4825	RCl Varginha
3255	3355	RD Uberlândia
3255	3305	R Educadora Cariri
3265	4885	RCu Poços de Caldas
3285	3385	RCl Teresina
3287	3375	R Olinda
3305	3283	RC1 Fluminense
3325	3315	R Gazeta Alagoas
3335	3345	R Alvorada Londrina
3345	3295	R Educadora Uberlândia
3365	4825	R Educadora Parnaíba
3365	4915	RCu Araraquara
3385	4795	R Congonhas
4756	3295	R Ed. Rural Campo Grande
4765	5035	R Espírito Santo
4775	4985	A Voz do Oeste
4785	4755	R Brasil Campinas
4790v	5025	RD Aquidauana (varies to 4795)
4808v	4805	RD Amazonas
4815	3365	RD Paraná/Londrina
4825	4815	RD Petrópolis
4825	4945	R Ed. Bragança
4835	4845	RD Teresina
4855	4865	RCl do Pará
4865	4765	R Sociedade Feira de Santana
4915	5035	R Anhanguera
4925	4855	RD Taubaté
4935	4945	R Capixaba
4935	4945	RD Mearim
4945	5015	RD Poços de Caldas
4945	5025	Voz de São Francisco
4965	4835	R Sociedade Triângulo Mineiro
4965	4937	R Poti
4985½	4995	R Brasil Central
5015	5055	RCu de Cuiabá
5015	4975	R Copacabana
5015	4880	R Pioneira
5025	3325	R Borborema
5025	5055	R Vitória
5035	4985	R Aparecida
5045	3335	R Presidente Prudente

This list does not include some stations on the same and other frequencies, which have not moved.

More on RCI. Radio Canada International is solving its QSL versus programming problem by disbanding its shortwave club, dropping DX and mailbag shows after November 1. The new requirement is that QSL seekers fill in details themselves, starting next spring.

Change of Address. When the Executive Editor of the International Radio Club of America, Fr. Jack Pejza, was transferred to a new assignment, ending the club's San Diego HQ, a new group in Seattle stepped forward to keep the club in business. IRCA's new address is Box 21462, Seattle, WA 98111. Samples of the 34-issue-per-year *DX Monitor*, covering all aspects of DX'ing the mediumwave (AM) band, are 50¢ each. ◈

ENGLISH-LANGUAGE SHORTWAVE BROADCASTS FOR NOV. THRU FEB.
by Richard E. Wood

TO EASTERN NORTH AMERICA

TIME—EST	TIME—GMT	STATION	QUAL*	FREQUENCIES, MHz
6:00-7:30 a.m.	1100-1230	London, England	G	5.990 (via Sackville), 15.07
6:00-6:30 a.m.	1100-1130	Tirana, Albania	F	9.48, 11.985
6:00-9:00 a.m.	1100-1400	**VoA, Washington, U.S.A.	G	5.955, 9.73
6:15-7:15 a.m.	1115-1215	Montreal, Canada	G	5.97
6:15-7:45 a.m.	1115-1245	Melbourne, Australia	G	9.58
7:00-7:55 a.m.	1200-1255	Peking, China	F	11.685
7:30-8:30 a.m.	1230-1330	London, England	G	15.07
7:15-10:00 a.m.	1215-1500	HCJB, Quito, Ecuador	G	11.74, 15.115
7:30-8:00 a.m.	1230-1300	Stockholm, Sweden	G	17.71
8:15-8:45 a.m.	1315-1345	Berne, Switzerland	G	15.14
9:00-9:30 a.m.	1400-1430	Stockholm, Sweden	G	17.71
		Oslo, Norway	F	17.795 (Sun. only)
		Helsinki, Finland	G	15.185
10:00-11:15 a.m.	1500-1615	London, England	G	17.84 (via Ascension)
10:00-11:30 a.m.	1500-1630	HCJB, Quito, Ecuador	G	11.74, 15.115, 17.88

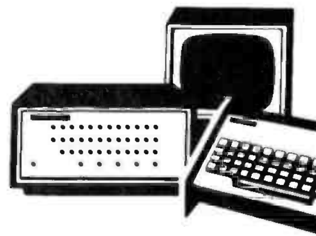
11:00-11:30 a.m.	1600-1630	Oslo, Norway	F	15.175 (Sun. only)
3:00-3:55 p.m.	2000-2055	Jerusalem, Israel	G	5.90, 7.395, 9.815
4:15-5:45 p.m.	2115-2245	London, England	G	5.975, 9.58, 11.75, 15.26 (via Ascension)
4:30-5:50 p.m.	2130-2250	Hilversum, Holland	G	5.965, 9.715 (Sun.: Dutch)
5:00-5:30 p.m.	2200-2230	Oslo, Norway	P	6.18 (Sun. only)
5:30-6:20 p.m.	2230-2320	Johannesburg, South Africa	G	9.525, 11.90, 11.97, 15.155
5:45-10:30 p.m.	2245-0330	London, England	G	5.975, 7.325, 9.58, 15.26 (last two via Ascension)
5:55-6:15 p.m.	2255-2315	Brussels, Belgium	F	9.73
6:00-6:30 p.m.	2300-2330	Stockholm, Sweden	F	6.035, 9.605, 11.705
6:00-7:30 p.m.	2300-0030	Moscow, U.S.S.R.	G	7.105, 7.15, 7.165, 7.205, 7.355, 7.39, 9.665, 12.05
6:45-7:45 p.m.	2345-0045	Tokyo, Japan	F	11.725, 15.27
7:00-7:30 p.m.	0000-0030	Tirana, Albania	G	7.065, 9.78
		Oslo, Norway	F	6.18, 9.645 (Sun.)
7:00-7:55 p.m.	0000-0055	Peking, China	F	9.94, 11.945, 15.06, 15.52, 17.673
		Sofia, Bulgaria	F	9.70
7:00-9:00 p.m.	0000-0200	**VoA, Washington, U.S.A.	G	6.13, 9.65, 11.71, 15.205
7:30-8:00 p.m.	0030-0100	Kiev, U.S.S.R.	G	7.15, 7.205, 9.685 (Mon./Thu./Sat.)
		Vilnius, U.S.S.R.	F	7.32, 7.355 (Fri./Sat.)
		HCJB, Quito, Ecuador	G	5.97, 9.56
7:40-8:00 p.m.	0040-0100	Brussels, Belgium	G	6.08
8:00-8:15 p.m.	0100-0115	Vatican City	G	5.995, 6.165, 9.605
8:00-8:20 p.m.	0100-0120	Rome, Italy	G	6.01, 9.575
8:00-8:45 p.m.	0100-0145	Berlin, Ger. Dem. Rep.	P	9.73
		Madrid, Spain	G	6.065, 11.925
8:00-8:55 p.m.	0100-0155	Peking, China	G	7.12, 9.78 (via Tirana), 11.685, 11.945, 11.965, 15.06, 15.52
		Prague, Czechoslovakia	G	5.93, 7.345, 9.54, 11.99
8:00 p.m.-2:00 a.m.	0100-0700	HCJB, Quito, Ecuador	G	5.97, 9.56, 11.915 (includes some Eskimo)
8:00-9:00 p.m.	0100-0200	Montreal, Canada	G	6.085
		Moscow, U.S.S.R.	G	7.105, 7.15, 7.165, 7.205, 7.355, 9.665, 9.70 (via Sofia), 11.86, 12.05
8:30-8:50 p.m.	0130-0150	Cologne, Ger. Fed. Rep.	G	6.01, 6.04, 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
8:30-9:25 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, 6.12, 9.535, 11.715
9:00-9:30 p.m.	0200-0230	Budapest, Hungary	F	6.00, 7.22, 9.833, 11.91 (except Sun.)
		Oslo, Norway	F	6.18, 9.645 (Sun.)
		Lisbon, Portugal	F	6.025, 11.935
9:00-9:55 p.m.	0200-0255	Peking, China	F	11.965, 12.055, 15.06
9:00-10:00 p.m.	0200-0300	Moscow, U.S.S.R.	G	7.105, 7.165, 7.205, 7.355, 9.61, 9.665, 9.70 (via Sofia), 11.86, 12.05
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
9:00-11:00 p.m.	0200-0400	Warsaw, Poland	P	6.095, 6.135, 7.27, 9.675, 11.815 (mixed Polish/English)
9:30-10:00 p.m.	0230-0300	Beirut, Lebanon	P	9.675
10:00-10:30 p.m.	0300-0330	Budapest, Hungary	F	6.00, 7.22, 9.833, 11.91
		Helsinki, Finland	P	9.55
10:00-11:00 p.m.	0300-0400	Buenos Aires, Argentina	G	9.69 (Mon.-Fri.)
		Peking, China	G	7.12, 9.78 (via Tirana)
		Prague, Czechoslovakia	G	5.93, 7.345, 9.54, 11.99
		Moscow, U.S.S.R.	G	7.15, 7.165, 7.205, 7.355, 9.70 (via Sofia)
10:30-10:55 p.m.	0330-0355	Tirana, Albania	G	6.20, 7.30
		Vienna, Austria	P	6.155, 9.77
10:30-11:00 p.m.	0330-0400	Kiev, U.S.S.R.	G	7.205, 7.39, 9.685 (Mon./Thu./Sat.)
10:30-11:30 p.m.	0330-0430	London, England	G	5.975, 9.58 (via Ascension)
10:30 p.m.-1:00 a.m.	0330-0600	Havana, Cuba	G	11.76
11:00-11:25 p.m.	0400-0425	Bucharest, Rumania	F	5.99, 9.57, 9.68, 11.775, 11.94
11:00 p.m.-1:00 a.m.	0400-0600	Moscow, U.S.S.R.	G	7.15, 7.165, 7.205, 7.355, 9.665
12 mdt.-12:15 a.m.	0500-0515	Jerusalem, Israel	G	5.90, 7.395, 9.009, 9.815
1:00-1:30 a.m.	0600-0630	Oslo, Norway	F	6.18 (Mon.)

TO WESTERN NORTH AMERICA

TIME-PST	TIME-GMT	STATION	QUAL*	FREQUENCIES, MHz
3:00-4:30 a.m.	1100-1230	London, England	G	5.99 (via Sackville),
4:15-5:15 a.m.	1215-1315	London, England	F	11.75 (via Tebrau)
4:15-7:00 a.m.	1215-1500	HCJB, Quito, Ecuador	G	11.74, 15.115
5:00-5:15 a.m.	1300-1315	Tokyo, Japan	G	5.99
5:00-8:00 a.m.	1300-1600	**VoA, Washington, U.S.A.	G	6.11, 9.76, 11.715
6:00-6:30 a.m.	1400-1430	Tokyo, Japan	G	5.99
7:00-7:30 a.m.	1500-1530	Tokyo, Japan	G	5.99
7:00-8:30 a.m.	1500-1630	HCJB, Quito, Ecuador	G	11.74, 15.115, 17.88
8:00-8:30 a.m.	1600-1630	Oslo, Norway	F	15.345 (Sun.)
8:00-9:15 a.m.	1600-1715	London, England	G	15.365 (via Sackville)
8:42-8:51 a.m.	1642-1651	Hilversum, Holland	G	15.14, 15.19 (via Bonaire; mixed English/Dutch)
9:00-9:15 a.m.	1700-1715	Tokyo, Japan	G	5.99
10:00-10:15 a.m.	1800-1815	Tokyo, Japan	G	5.99
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
1:00-1:15 p.m.	2100-2115	Tokyo, Japan	G	9.505
1:15-3:00 p.m.	2115-2300	London, England	F	15.26 (via Ascension)
2:00-2:15 p.m.	2200-2215	Tokyo, Japan	G	15.105
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, 15.26 (via Ascension)
4:00-4:15 p.m.	0000-0015	Tokyo, Japan	G	15.105
4:00-6:00 p.m.	0000-0200	**VoA, Washington, U.S.A.	G	9.545, 11.78, 15.25, 17.895
4:30-7:30 p.m.	0030-0330	London, England	G	6.175 (via Sackville), 9.51 (via Greenville), 9.58, 15.26 (via Ascension)
4:30-5:00 p.m.	0030-0100	HCJB, Quito, Ecuador	G	5.97, 9.56
5:00-5:15 p.m.	0100-0115	Tokyo, Japan	G	15.105
5:00-5:55 p.m.	0100-0155	Peking, China	G	11.945, 11.965, 12.055, 15.06, 15.52
5:00-7:00 p.m.	0100-0300	Melbourne, Australia	G	15.32, 17.795
		Moscow, U.S.S.R.	G	12.05, 15.18, 17.72, 17.87 (via Soviet Far East)
5:00-11:00 p.m.	0100-0700	HCJB, Quito, Ecuador	G	5.97, 9.56, 11.915 (includes some Eskimo)
5:30-6:30 p.m.	0130-0230	Tokyo, Japan	G	15.195, 15.235, 17.725, 17.825
6:00-6:15 p.m.	0200-0215	Tokyo, Japan	G	15.105
6:00-6:55 p.m.	0200-0255	Peking, China	G	11.455, 11.965, 12.055, 15.06, 17.855
6:00-7:50 p.m.	0200-0350	Taipei, Taiwan	F	11.86, 15.125, 17.72
6:30-7:00 p.m.	0230-0300	Stockholm, Sweden	F	9.695, 11.705
7:00-7:15 p.m.	0300-0315	Tokyo, Japan	G	15.105
7:00-7:30 p.m.	0300-0330	Seoul, Korea	P	15.335
7:00-7:45 p.m.	0300-0345	Madrid, Spain	P	6.065, 11.925
7:00-7:55 p.m.	0300-0355	Peking, China	G	7.12, 9.78 (via Tirana), 11.445, 12.055, 15.06, 15.385, 17.735, 17.855
7:30-8:15 p.m.	0330-0415	Berlin, Ger. Dem. Rep.	P	5.955, 6.08, 9.73
7:30-8:30 p.m.	0330-0430	London, England	G	6.175 (via Sackville) 9.58 (via Ascension)
7:30-9:30 p.m.	0330-0530	Moscow, U.S.S.R.	G	5.98, 7.17, 7.265, 9.54, 9.58, 9.61, 9.735, 9.78, 11.69, 11.86, 15.14, 15.18, 17.755
8:00-8:15 p.m.	0400-0415	Tokyo, Japan	G	9.505
8:00-8:30 p.m.	0400-0430	Sofia, Bulgaria	F	9.70
		Budapest, Hungary	F	6.00, 7.22, 9.833, 11.91 (Tues., Fri.)
8:00-9:00 p.m.	0400-0500	Montreal, Canada	G	6.135, 9.655
8:30-9:00 p.m.	0430-0500	Lisbon, Portugal	F	6.025, 11.935
		Berne, Switzerland	F	6.045, 9.725
9:00-9:15 p.m.	0500-0515	Tokyo, Japan	G	9.505
		Jerusalem, Israel	F	5.90, 7.395, 9.815
9:00-10:00 p.m.	0500-0600	Montreal, Canada	G	6.135, 9.655
9:00-10:20 p.m.	0500-0620	Hilversum, Holland	G	6.165, 9.715 (via Bonaire)
9:30-9:50 p.m.	0530-0550	Cologne, Ger. Fed. Rep.	F	6.075, 6.185, 9.545
9:30-10:00 p.m.	0530-0600	Moscow, U.S.S.R.	G	5.98, 7.15, 7.17, 7.265, 9.54, 9.58, 9.61, 9.735, 9.78, 15.18
10:00-10:15 p.m.	0600-0615	Tokyo, Japan	G	9.505
10:00-10:30 p.m.	0600-0630	Oslo, Norway	F	9.645 (Sun.)
10:00-11:00 p.m.	0600-0700	Buenos Aires, Argentina	G	9.69 (Mon.-Fri.)
10:00-11:30 p.m.	0600-0730	Moscow, U.S.S.R.	G	5.98, 7.11, 7.15, 7.17, 7.265, 7.305, 9.54, 9.58, 9.61, 9.735, 9.78, 11.69, 15.18
10:30 p.m.-12 mdt.	0630-0800	Havana, Cuba	G	9.525
11:00-11:15 p.m.	0700-0715	Tokyo, Japan	G	9.505
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	Tokyo, Japan	G	5.99

*Reception quality, East Coast (West Coast) location: G-good, F-fair, P-poor
**Not intended for North America, but receivable satisfactorily

Frequencies are accurate as of press time, but subject to change especially for Sweden, U.S.S.R. and Lebanon.



Computer Bits

SOFTWARE TOOLS

By Jerry Ogdin

NO MATTER how small the computer, even the most dedicated programmer will rapidly become bored with binary notation.

Some hobbyists use a Teletype as there are several older models on the market at reasonable prices. Even with a Teletype, though, you need some software to convert those keystrokes into something meaningful in memory. If you can't afford a Teletype, you can almost always use an encoded keyboard. These are frequently on the surplus market for less than $25.00.

A terminal is important, but it is only one tool in the computer hobbyist's kit. Once you've written a program and gotten it into storage, you ought to use the cassette interface (HIT) described in September's column. With this tool, you have to "button in" the program bit-by-bit only once. After it is in storage, you can write it out to be taped and read in the next time you want it. Of course, if your only storage medium is RAM, you'll lose the memory contents when you turn the computer off. So, it's a good idea to copy the latest version of a program out to tape as a backup.

Also, if your only storage medium is RAM, you'll have to reenter the tape reading routine laboriously through the switches (or the terminal) each time the computer power is turned on. That is a good reason for having a small program, called a *bootstrap loader*, kept in read-only memory. This program makes it possible to read data from the tape and then execute that data. Such a read-in program is usually somewhat larger and more powerful, so it reads in several records (perhaps using the bootstrap program as a subroutine), which make up an even larger and more sophisticated program. The effect, then, is to use one group of records to read the next group in, thus "pulling" the program in by its own bootstraps.

```
                ; THIS IS THE POPULAR FLECTRONICS SUPER-
                ; SIMPLF MONITOR.  COMMANDS ARE:
                ;     D XXXX   (DUMP FROM XXXX)
                ;     L XXXX   (LOAD FROM XXXX)
                ;     G XXXX   (GO TO XXXX)
                STACK  EQU  03FFH        ;YOUR STACK ORIGIN
                CRLF   EQU  0106H        ;YOUR CR, LF ROUTINE
                WRCHR  EQU  0103H        ;YOUR OUTPUT ROUTINE
                RDCHR  EQU  0100H        ;YOUR READING ROUTINE
                ;
                ; MONITOR ENTRY POINT
                ;
0040: 31FF03    PEMON: LXI  SP,STACK     ;INITIALIZE
      CD0601           CALL CRLF         ;ISSUE CARRIAGE RETURN,
      3E3F             MVI  A,'?'        ;   LINE FEED AND ?
      CD0301           CALL WRCHR
      CD0001           CALL RDCHR        ;AWAIT COMMAND
      E67F             ANI  07FH         ;STRIP OFF PARITY BIT
      FE4C             CPI  'L'
      CA6300           JZ   LOAD         ;"LOAD" COMMAND
      FE44             CPI  'D'
      CA7400           JZ   DUMP         ;"DUMP" COMMAND
      FE47             CPI  'G'
      C24000           JNZ  PEMON        ;ERROR
                ; THIS THE THE "GO" COMMAND PROCESSOR.  WE
                ; NOW EXPECT A 16-BIT DESTINATION ADDRESS
                ; AND THEN TRANSFER TO IT
005F: CDB700           CALL RDNUM
      E9               PCHL              ;"GO"
                ; THIS IS THE "LOAD" COMMAND PROCESSOR.  THE
                ; USER IS EXPECTED TO TYPE IN A 16-BIT ADDRESS
                ; FOLLOWED BY DATA BYTES TO LOAD INTO SUCCESSIVE
                ; LOCATIONS.  ANY NON-HEX CHARACTER SFPARATES
                ; THE BYTES FROM ONE ANOTHER.  ANY BYTE THAT IS
                ; TERMINATED WITH A COLON WILL BE IGNORED.
0063: CDCD00    LOAD:  CALL RDNR2        ;GET USER'S ADDRESS
      CDB700           CALL RDNUM        ;GET A BYTE
      FE3A             CPI  ':'
      CA6600           JZ   LOAD+3       ;SKIP IF FOLLOWED BY ':'
      7D               MOV  A,L          ;GET LAST TWO HEX DIGITS
      02               STAX B            ;STORE THEM AWAY
      03               INX  B
      C36600           JMP  LOAD+3       ;(GET W/ CPU RESET)
                ; THIS IS THE "DUMP" COMMAND PROCESSOR.
                ; THE USER IS EXPECTED TO SUPPLY A 16-BIT
                ; STARTING ADDRESS.  WHFNEVER THE LEAST-SIG-
                ; NIFICANT FOUR BITS OF THE ADDRESS OF THE
                ; NEXT BYTE ARE ZERO, THE CARRIAGE IS RETURNED
                ; AND THE ADDRESS IS PRINTED (FOLLOWED BY COLON).
0074: CDCD00    DUMP:  CALL RDNR2        ;GET STARTING ADDRESS
      79               MOV  A,C          ;CHECK TO SEE IF
      E60F             ANI  15           ;  NEW-LINE TIME.
      C2A200           JNZ  MORE         ;NO.  JUST PRINT
      CD0601           CALL CRLF         ;START NEW LINE
      78               MOV  A,B          ;GET MSB OF ADDRESS
      1F               RAR
      1F               RAR
      1F               RAR
      1F               RAR
      CDED00           CALL CVTAS
      78               MOV  A,B          ;GET 2ND DIGIT
      CDED00           CALL CVTAS
      79               MOV  A,C          ;GET 3RD DIGIT
      1F               RAR
      1F               RAR
      1F               RAR
      1F               RAR
      CDED00           CALL CVTAS
      79               MOV  A,C          ;DO LAST DIGIT
      CDED00           CALL CVTAS
      3E3A             MVI  A,':'        ;MARK ADDRESS SPECIALLY
      CD0301           CALL WRCHR
      3E20             MVI  A,' '
      CD0301           CALL WRCHR
00A2: 0A        MORE:  LDAX B            ;FETCH BYTE TO DUMP
      1F               RAR
      1F               RAR
      1F               RAR
      1F               RAR
      CDED00           CALL CVTAS        ;ISSUE MSB
      0A               LDAX B
      CDED00           CALL CVTAS
      3E20             MVI  A,' '
      CD0301           CALL WRCHR
      03               INX  B            ;ACQUIRE NEXT CELL
      C37700           JMP  DUMP+3
                ; THIS ROUTINE READS ONE OR MORE HEXADECIMAL
                ; DIGIT CHARACTERS ('0'..'9', 'A'..'F') IN
                ; AND ACCUMULATES A SIXTEEN-BIT NUMBER IN
                ; THE (H,L).  EACH NEW DIGIT IS SHIFTED INTO
                ; THE LEAST-SIGNIFICANT FOUR BITS OF THE (H,L).
                ; CONTROL IS RETURNED WHENEVER THE DEPENDENT
                ; ROUTINE ("RDHEX") SETS THE CARRY BIT TRUE.
00B7: 210000    RDNUM: LXI  H,0          ;START OFF VALUE AT 0
      CDD600           CALL RDHEX        ;GO GET A HEX DIGIT
      DAB700           JC   RDNUM        ;AWAIT HEX DIGIT
00C0: 29        RDNXT: DAD  H            ;SHIFT (H,L) LEFT 4
      29               DAD  H
      29               DAD  H
      29               DAD  H
      B5               ORA  L            ;PLACE NEW FOUR BITS IN
      6F               MOV  L,A
      CDD600           CALL RDHEX        ;GO GET NEXT DIGIT
      D8               RC                ; THE NUMBER'S FINISHED
      C3C000           JMP  RDNXT        ;GO PROCESS NEXT DIGIT
                ; THIS ROUTINE READS A NUMBER VIA "RDNUM" AND
                ; PLACES IT INTO THE (B,C) PAIR
00CD: CDB700    RDNR2: CALL RDNUM        ;GET THE VALUE IN (H,L)
      44               MOV  B,H          ; THEN MOVE IT
      4D               MOV  C,L
      C9               RET
                ; THIS ROUTINE READS IN AN ASCII CHARACTER,
                ; STRIPS OFF PARITY AND EXAMINES IT FOR
                ; MEMBERSHIP IN THE HEX-DIGIT SET.  IF IT IS
                ; A HEX-DIGIT THE A-REGISTER IS LEFT AT THE FOUR
                ; BIT VALUE APPROPRIATE AND THE CARRY IS CLEARED.
                ; ANY OTHER CHARACTER IS LEFT UNTOUCHED AND THE
                ; CARRY IS SET.
00D3: D630      RDDIG: SUI  '0'          ;TRANSLATE '0'..'9'
      C9               RET
00D6: CD0001    RDHEX: CALL RDCHR        ;***ENTRY POINT***
      E67F             ANI  07FH         ;REMOVE PARITY BIT
      FE30             CPI  '0'
      D8               RC                ;CHAR LESS THAN '0' (NOT HEX)
      FE3A             CPI  '9'+1
      DAD300           JC   RDDIG        ;IN RANGE 0..9
      FE41             CPI  'A'
      D8               RC                ;BETWEEN 9 AND A
      FE47             CPI  'F'+1
      3F               CMC
      D8               RC                ;NOT HEX CHARACTER
      D637             SUI  'A'-10       ;TRANSLATE 'A'..'F'
      C9               RET
                ; THIS ROUTINE CONVERTS A BINARY NUMBER IN THE
                ; LEAST-SIGNIFICANT BITS OF THE A-REGISTER TO
                ; AN ASCII CHARACTER REPRESENTING THE HEX VALUE
                ; AND THEN ISSUES IT AS OUTPUT.
00ED: E60F      CVTAS: ANI  15           ;ISOLATE FOUR BITS
      C630             ADI  '0'          ;SHIFT DIGITS INTO ASCII
      FE3A             CPI  '9'+1        ; SEE IF IT WAS 0..9
      DA0301           JC   WRCHR
      C607             ADI  'A'-'0'-10   ;CONVERT TO 'A'..'F'
      C30301           JMP  WRCHR
```

Using a Monitor. The ability to preserve a program for later recall is important, but it doesn't solve two major nuisances: (1) you still have to key in the program bit-by-bit the first time; and (2) every time you make an error in the program, you have to key in the changes, some of which may be traumatic and complex. One of the best ways to solve this kind of inconvenience is to provide a small *monitor*. A monitor is just another computer program, but one that is designed to make computer use more convenient. This program reads characters from a terminal (or a separate keyboard), with these characters specifying the bit patterns to put into memory.

The simplest monitor has three basic *commands:* Load, Dump and Go. A command is a single letter typed at a time when the monitor is not otherwise engaged in some activity. Typical commands are single letters like "L" for Load, "D" for Dump and "G" for Go. When you type in "L" you are directing the monitor program to accept keyboard input and load it into memory; "D" means you want to display contents of memory on your terminal or display device; "G" is your means of transferring control out of the monitor into the program you have previously loaded.

Most programmers now use the hexadecimal number system for communicating with the machine, although there are "pockets" of users of octal. Hex and octal are, of course, just shorthand notations for binary code. Hex digits allow us to specify four bits with one symbol, octal allows three. The hexadecimal digits are 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, and F. (The letters A through F stand for decimal values 10 through 15, respectively.) The monitor, for utmost simplicity, uses only hexadecimal digits for the specification of addresses and data byte values.

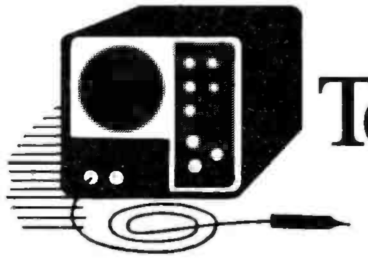
Each of the command letters (L, D or G) is followed by an address that specifies where to start. For the Load command, that address is where the first byte of data from the keyboard will be stored; for Dump, it is the address from which data will begin being displayed; for Go, it is the address that is to be placed into the CPU's program counter. Whenever the Go command's address has been supplied, control is transferred to that location. Whenever the Dump command's address has been given, data displaying will begin. However, after the Load command's address, the monitor will expect more bytes (one after another) to be loaded into successive locations in memory.

A small monitor for the 8080 microprocessor that you can use as a model is shown opposite. Each command is stopped by resetting the CPU, thus returning control to the top of the monitor. Notice some error correction conventions that have been instituted to save you some time: numbers are assumed to consist of any number of hex digits but if the monitor wants an address, only the least-significant four digits are used. Likewise, for a data byte, only the least-significant two hex digits are preserved. This means that if you've made an error, just keep typing. Hex digits end with any character that is not a hex digit; most people find that the space character is the most convenient.

News Items. The extremely popular 8080, originally from Intel, is now being supplied by other semiconductor makers as well. The TI TMS8080 is identical to the original 8080, which Intel no longer makes. Intel's newer device, the 8080A, is functionally identical but has better current drive capacity. Intel has another part, the 8080A-1, that'll go faster so that AMD's 9080 (which is supposed to run 50% faster than the original Intel part) will have a competitor. So, if you are using the 8080, be sure to check the diagrams to see that your part matches the requirements.

The new MOS Technology 6501 is destined to become a popular CPU among hobbyists, if only because of its dramatically low price ($20 at press time). The device is modelled after Motorola's 6800, although with some major differences. All of the Motorola support parts like memory I/O chips can be used with the 6501, so you can get on board quickly. The Motorola software, however, cannot be executed on the 6501 without revision.

The 6501 is capable of operation at twice the Motorola part's speed; some parts may operate three times as fast. The introduction of this part is likely to start the real price war that has been brewing in the microprocessor business. Even with the new support chip for the 8008 that Intel has announced, it seems unlikely that it can compete with the 6501 for hobbyist use. ◈



Test Equipment Scene

By Leslie Solomon

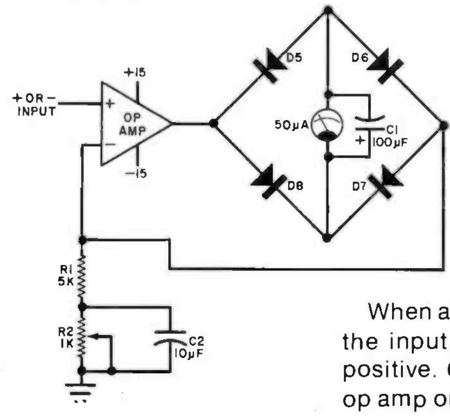
A DUAL-POLARITY DC METER

HOW CAN you get a dc meter to indicate upscale with either a positivie or negative input, without reversing the leads? It's very simple with an operational amplifier and a few other components as shown in the diagram.

The op amp is connected as a non-inverting dc amplifier using the diode full-wave bridge and the combination of *R1* and *R2* to determine the gain. Capacitor *C2* bypasses any ac component that might be across *R2*. The op amp can be almost any type with a high slew rate. For some op amps, frequency compensation may be required to remove any tendency for the op amp to oscillate at a high frequency, which would produce erratic meter indications.

Since the op amp is powered by a balanced +15-V and −15-V supply and the inverting (−) input is referenced to the common, a positive-going voltage on the input produces a positive voltage at the op amp output. Conversely, a negative-going input produces a negative output. The amplitude of either output is proportional to the level of the input voltage up to the 15-V limit. The output is referenced to the common.

Obviously, if the input is zero, the output is zero. Actually, there is a very small switching area about the zero point where operation may be erratic; and there may also be a slight offset that can be removed by proper compensation as detailed in the op amp specifications.



When a positive voltage is applied at the input, the output starts to swing positive. Current then flows from the op amp output through *D8*, the meter, *D6, R1,* and *R2* to ground. This current generates a positive voltage at the inverting input of the op amp. When it reaches the same level as the voltage on the noninverting input, the op amp stabilizes and the meter remains at some upscale indication (which can be adjusted by *R2*).

When a negative voltage is applied to the noninverting input, the output of the op amp swings negative and the circuit is through *R2, R1, D7, M1,* and *D5*. This current produces a negative voltage at the inverting input; and when it reaches the same value as that at the input, the op amp is stabilized. The meter once again settles at an upscale indication. In both cases, the current flows in the same direction through the meter.

Capacitor *C1* is used to smooth any voltage fluctuations across the meter —especially when the meter is measuring low-frequency ac. Such voltage integration removes flutter from the meter movement.

The voltage difference between the two inputs to the op amp is measured in millivolts so the positive-to-negative transition is very sharp. With some accurately known dc (either polarity) applied to the input, *R2* can be adjusted to give the correct indication on the meter. ◈

Hobby Scene Q&A

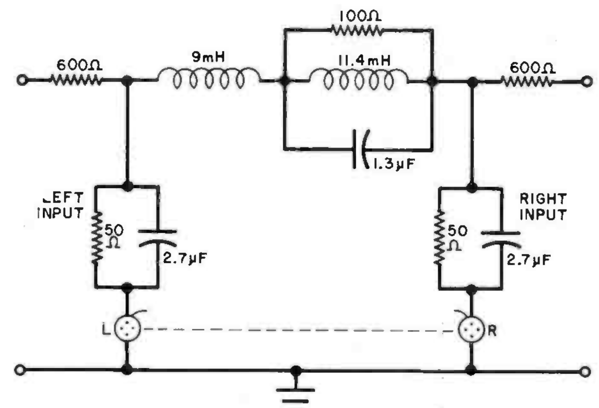
By John McVeigh

"STEREO" HEADPHONE SOUND

Q. ***My stereo headphones don't sound "stereo", but rather like two separate sound sources. Why not? Can I build a circuit that will make them sound stereophonic?***

—D. Whelan, Jersey City, NJ

A. "Stereo" headphones have two electrically *and* acoustically separate channels. Loudspeakers, on the other hand, have a certain amount of acoustical "crosstalk" or blending between them. The circuit shown will electrically introduce the appropriate amount of crosstalk (in both amplitude and phase) to make the headphones sound "stereophonic" rather than "binaural". Be sure to use nonpolarized capacitors. If you can't find the required values, use smaller capacitors, paralleling them until the desired capacitance is reached.

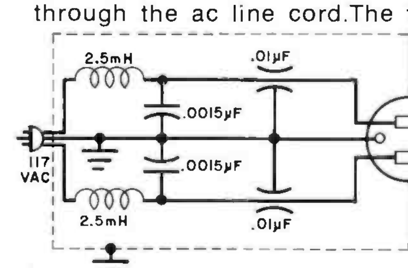


FLUORESCENT LAMP FILTER

Q. ***Whenever I turn on both my AM radio and my fluorescent desk lamp, "hash" comes out of the speaker. Is there any way to eliminate this interference?***

—D. Rigg, Southampton, NY

A. R-f coming from the lamp can get into the radio by direct radiation or through the ac line cord. The filter



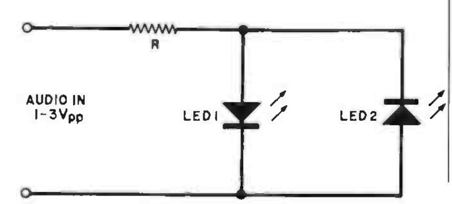
shown, when constructed in a metal box connected to a good ground, will take care of r-f on the line cord. For lamps up to 35 W, use two Miller 6304 coils in parallel for the required 2.5-mH inductors. Bypass capacitors should be 500-WVDC disc ceramics, and the feedthrough capacitors should be Allen-Bradley CL003-HA503P units or equivalent. If the problem persists, it will be necessary to shield the lamp housing with fine-mesh screening. Ground both the screening and lamp base (if metal).

LED ZERO BEAT DISPLAY

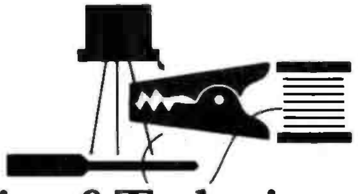
Q. ***Is there any visual means of detecting when I have "zero-beated" my vfo and a received signal?***

—M. Farber, Las Vegas, Nev.

A. If your receiver has an S meter, you can adjust for zero beat while watching its needle. As the two frequencies approach each other, the needle will swing back and forth more and more



slowly. At zero beat, the needle will hold one position. The circuit shown will also give a visual display of zero beat. When the vfo has come within 25 Hz of the signal's carrier, the LED's will alternately flicker. At zero beat, neither LED will light up. The circuit can also be used as a polarity checker for dc applications. When the top input terminal is positive, *LED1* will glow, while *LED2* turns on when the bottom input terminal is positive. Select *R* to limit LED current to a safe value, or use a voltage divider.



Tips & Techniques

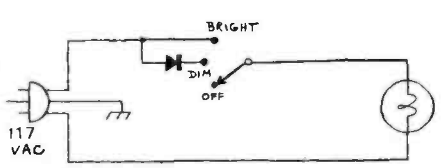
Tracing Foil Patterns

Etching simple printed-circuit boards from pc blanks can be very easy if you use masking tape to trace the resist pattern. Cover the copper surface of the blank completely with broad masking tape, taking care not to overlap the tape or to leave gaps between each strip. Then trace the outline of the foil pattern on the etching and drilling guide, using a sheet of carbon paper between the tape and the guide. Carefully cut out the tape from the areas to be etched using a sharp knife or razor blade. Then apply the resist using the "stencil" made from the masking tape. When the etch resist is dry, score it with a razor blade where it touches the tape. After the remaining tape is removed, the board is ready to be etched.

—*Anthony Barake, Quebec, Canada*

An Inexpensive Lamp Dimmer

If you want more than one light-level output from an incandescent bulb, this circuit is useful. What's more, it can lengthen bulb life considerably, while saving you money on electric bills *and* make expensive three-way bulbs and dimmers unnecessary. When the power switch is turned to the DIM position the diode allows only positive half-cycles of the ac power to flow



through the bulb. In the BRIGHT position, the bulb behaves normally. Be sure to use an adequately rated diode (both PIV and forward current) for the power consumption (in watts) of the light bulb.

—*Bill Drislane, Topsfield, MA*

IC Breadboards

Breadboarding IC projects is a common practice and many commercial boards are available. However, an inexpensive substitute can easily be made in a pinch. Using 0.1-in. (0.25-cm) grid P-pattern board as a template, drill holes in a piece of perforated board to accept the pins of a 14- or 16-pin DIP. Wire the pins to two rows of spring clips (Vector T-32A or similar). Place extra clips along board edges for use as tie-points. Install push-in flea clips at each corner to elevate the board. Several assemblies can be secured to a larger board for combining subsystems. A strip of masking tape along the terminals permits markings for pin numbers and functions to be made.

—*Raymond F. Arthur, New Kensington, PA*

Home-Made Adapter Lets You Measure Dwell with Ohmmeter

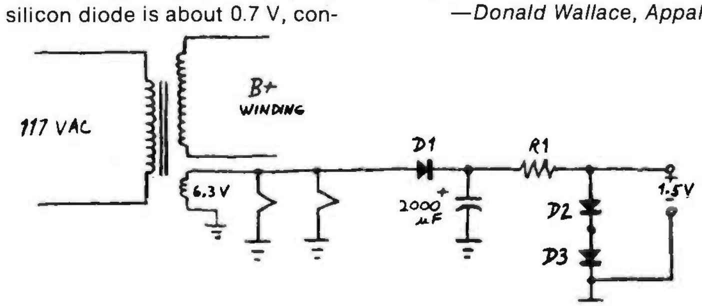
To use an ohmmeter to measure a car's dwell time, a 1N34 or similar diode must be placed in series with the meter's "hot" test lead. The easiest way to install the diode is to house it in an adapter that can be quickly inserted into and removed from the test setup. This eliminates the need to modify the ohmmeter. To make the adapter, first slot a tip jack to accept the blade of a screwdriver. The next step is to enlarge the barrel of a standard short-barrelled test prod just enough to permit the tip jack to be screwed tightly into it. After prethreading the barrel, solder one lead of the diode to the tip jack (which lead depends on the polarities of the voltages at the meter's test jacks and the car's electrical ground). Use an insulated spacer and finish assembling the adapter.

—*Paul E. Griffith*

Battery Eliminator For VTVM'S

If you're tired of replacing the 1.5-volt battery in your VTVM, here's a simple circuit that will eliminate the need for the cell. Diode *D1* rectifies the 6.3-V ac filament supply, and a 2000-µF capacitor smooths out the dc. Since the forward voltage drop across a silicon diode is about 0.7 V, connecting two of them in series from the dc supply to ground provides a voltage drop of nearly 1.5 volts. *R1*, a current-limiting resistor, is composed of two 68-ohm, 2-watt resistors in parallel. All diodes should be 500-mA, 50-PIV or greater units. The electrolytic capacitor ought to have a 15-WVDC rating.

—*Donald Wallace, Appalachia, VA*



Operation Assist

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

Citi-Phone Model Cd-5 CB transceiver. Tube layout, schematic, and/or service manual. Randy Venable, 2009 Princeton Ave., Bradenton, FL 33507.

United Scientific Laboratories Contact 23 CB transceiver. Schematic and/or service info. R. T. Henley, 139 Mardi Gras, El Paso, TX 79912.

Precision Model E-400 sweep generator, **Amp. Corp. of America** Model ACA-100DC PA amplifier, **Challenger Amp. Co.** Model CH30 PA amplifier. Schematics or manuals. Ray Gill, 3717 Tidewater Trail, Fredericksburg, VA 22401.

Tektronix Model 513D oscilloscope. Schematic and/or service manual. David Mason, 1117 Woodland Dr., Tallahassee, FL 32304.

RCA radios, Models K-80 (Chassis No. RC-415-D) and 812-K, chassis No. 7Y-14(?) **Truetone** radio Model D-727, chassis No. 175E (175EAW). Schematics. Also want source for old radio tubes and **Rider** Radio Schematic Books No. 1-14. Milton Obuch, 1308 N. 4th St., Sayre, OK 73662.

Cathedral-style radio, with "TATRO-A" stenciled on bottom. Circa 1925. Contains 2 #38 tubes, 1 #75, 1 #78, and 1 6A7. Magnavox Model 154D 114-ohm speaker. Made to operate off a Delco generator/storage battery power plant. Any restoration information. F. Keith Haywood, Box 537, Angier, NC 27501.

Scott all-wave receiver, serial T-499. Chrome plated, two tweeters and a woofer (electrodynamic), 4 2A3 output tubes, neon regulator with bayonnet base, 2 5U4-type rectifiers. Schematic and/or servicing info. Technical Engineering Laboratories, 787 Mesa Way, Richmond, CA 94805.

Capital Model HP-875 tape deck. Parts lists, source(s), schematics. Vaughan Williams, 6356 DeSoto, Detroit, MI 48238.

Lancer Model LA 1010 stereo amplifier. One output transformer (FT-3083445-B 100 6932) needed or source for same. Robert Davenport, 51 Meander Lane, Levittown, NY 11756.

Precision Model 10-12 tube and battery tester with G-104 adapter. Need updated tube roller chart or source for same. Phillip Coulter, 2023½ Wheaton Ave., Millville, NJ 08332.

E.H. Scott navy-type receiver, Model RCH 1czc-46209. Schematic and/or operator's manual. Randall Barbett, 36678 Suffolk Dr., Mt. Clemens, MI 48043.

WWII-vintage VLF receiver (15-600 kHz) Model CFT-46154 serial 649. Operator's manual, parts list, service info, and schematic needed. Tom Dycus, 1507 Katie NE, Albuquerque, NM 87110.

Muskat Model 72MPX10 FM/AM/Tape Player. Schematic and transformer needed. Sam Pope, Sam's TV Service, 717 5th St. SE, Hickory, NC 28601.

Analab 1120 oscilloscope type 700. Schematic diagram. Mihailo Repovic, 39 Pierce Rd., Watertown, MA 02172.

Monroe 820CRT calculator. Readout tube and schematic needed. Earl Leininger, Suite 500, Financial Center, 3443 N. Central Ave., Phoenix, AZ 85012.

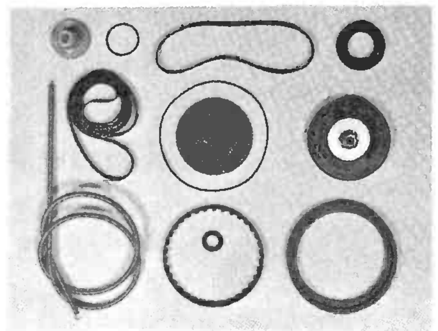
Dumont Model 164-E oscilloscope. Schematic and/or service manual. Joseph Lipsky, Rte. 8, Box 264, Brooksville, FL 33512.

Advancetron Model 404A phase meter. User/service manuals and/or schematics. Wesley Kranitz, RR2, Box 823, Lot 357, Pompano Beach, FL 33067.

Superior Instruments Co. Model TD-55 tube tester. Accurate Instrument Co. Model 154 VOM. Service manuals and/or schematics. Frank Waldren, Box 13305, St. Louis, MO 63157.

Nippon Sound Co. AM/FM Stereo Serial No. 1105. Schematic. Richard Gillespie, 6147 Oakbank Dr., Azusa, CA 91702.

RCA CTC9N receiver with remote control CTP7A. Any service information on remote control receiver or transmitter CRK3A. Robert Brandenburg, 1400 Albany St., Apt. 2, Los Angeles, CA 90015.



Electronics Library

TOWERS' INTERNATIONAL TRANSISTOR SELECTOR
by T.D. Towers

Over 10,000 transistor types are covered, with specifics on ratings, characteristics, case details, terminal indentities, applications, and manufacturers. Substitution equivalents are given for both U.S. and European transistors. Some Japanese devices are also included. The major portion of the book is arranged in tabular form. Appendices contain explanatory notes, package diagrams, case outlines, manufacturer's house codes, and a list of manufacturers.

Published by Tab Books, Blue Ridge Summit, PA 17214. 138 pages. $4.95 soft cover.

LOW- AND MEDIUM-FREQUENCY SCRAPBOOK
by Ken Cornell, W2IMB

Produced for the experimenter in communications below 1600 kHz, this book covers receivers, transmitters, coils and coil winding techniques, antennas and FCC regulations. Among its features is information on the nonlicensed bands open to the public, from 160 to 190 kHz, and 510 to 1600 kHz (the AM broadcast band). Power limitations, antenna length, and transmitter design are discussed within the context of government standards. An addendum includes a power mains filter, an audio filter, and an IC crystal-controlled transmitter. FCC rules covering nonlicensed communications are reproduced as an appendix.

Published by Ken Cornell, 225 Baltimore Ave., Pt. Pleasant Beach, NJ 08742. 105 pages (8½" × 11"). $4.75, soft cover.

COMPUTER ALGORITHMS AND FLOWCHARTING
by G. and J. Silver

This work introduces the reader to the special procedures that must be used in setting up computer problems. It concentrates on the logical enumeration and organization of a particular task. This sets the problem in a form (algorithm) that a digital computer can handle. Emphasis is also placed on coding, keypunching and keyboarding, running and debugging, and documentation. The flowchart, or "computer roadmap," is introduced in accordance with the symbols and definitions established by the American National Standards Institute. Many programming applications are included.

Published by McGraw-Hill Book Co., 1221 Ave. of the Americas, New York, NY 10020. 170 pages (8½" × 11"). $6.96 soft cover.

Experimenter's Corner

By Forrest M. Mims

THE LIGHT-ACTIVATED SCR

THE SCR has been around for some time, and most of us have used them in a variety of circuits. There's one SCR, however, that doesn't get much experimenter use. It's the so-called LASCR (Light Activated Silicon Controlled Rectifier).

Lots of the parts dealers now sell LASCR's at bargain-basement prices. Depending on the voltage rating, you can buy good quality units at prices less than 50¢ to about $1.75. Not bad for a component with lots of practical uses.

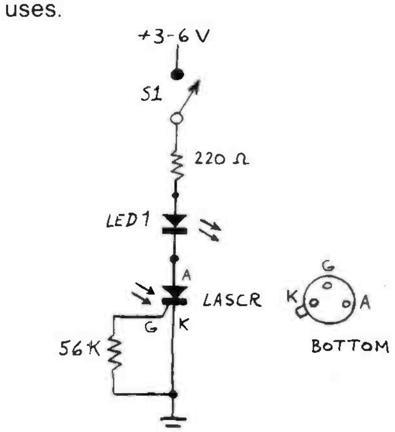


Fig. 1. LASCR test rig.

You can make a simple LASCR test rig in a couple of minutes with an LED, a couple of resistors, a switch, and two flashlight cells. Connect the parts as shown in Fig. 1 and you're in business. First close *S1*. Normally the LASCR will be off, but an increase in the light level at its sensitive surface will generate a photocurrent which will turn the device on. The resulting current will light up the LED. Open *S1* to turn the LASCR off.

Figure 2 is a neat little circuit in which the LASCR operates as a low-voltage relaxation oscillator. Capacitor *C1* charges to the supply voltage through the 100,000-ohm resistor. The potentiometer is a voltage divider which feeds some of the charge on *C1* to the LASCR's gate. When its turn-on voltage is reached, the LASCR switches on and dumps the charge on *C1* through the LED. Since *C1* is now discharged, the LASCR turns off, *C1* begins charging again, and the cycle repeats.

I've operated this circuit from slightly less than one volt! You may have to adjust the light level at the LASCR with a flashlight to start the oscillator at very low voltages.

Like any SCR, the LASCR is a four-layer, three-junction device whose structure is shown in Fig. 3. The anode and gate connections form two terminals of a pnp transistor. There is no base lead, so you cannot use a conventional SCR as a transistor. But you can use the anode-gate leads of a LASCR as a pnp *phototransistor*. To do this, hook up the test circuit in Fig. 4. Toss some light on the LASCR and you've got an instant light meter. I measured 10 μA forward current from a typical LASCR basking in the rays from a #222 lamp 50 mm away.

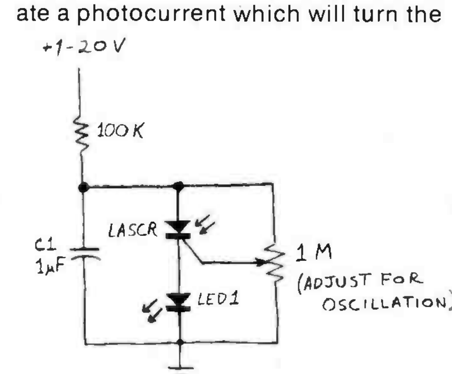


Fig. 2. Relaxation oscillator.

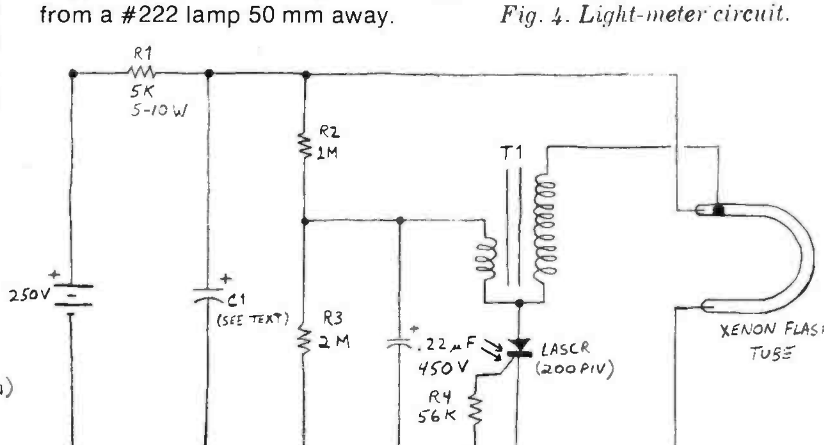


Fig. 5. Slave flash for photography.

So far we've just been tinkering around so now let's get down to business with a circuit that really exploits the versatility of the LASCR. The circuit in Fig. 5 (a slave flash) is ideal for supplying filler light for flash photos. If photography isn't your thing, you might want to use the circuit for a novelty device or as a demonstration of how a relatively puny pulse of light can trigger an eye-dazzling flash from a powerful xenon lamp.

The circuit is a conventional strobe, but don't let its simplicity deceive you! Capacitor *C1* will be charged to a voltage high enough to vaporize a screwdriver tip, so use care when building the circuit. Mount all the parts on a piece of perf board, use insulated hookup wire, and cover all

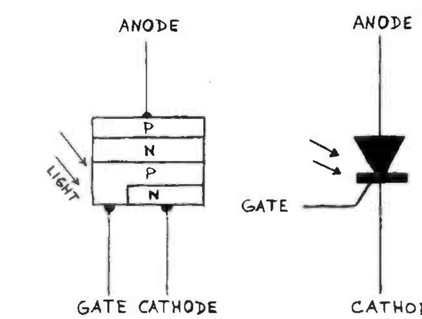


Fig. 3. Structure of LASCR.

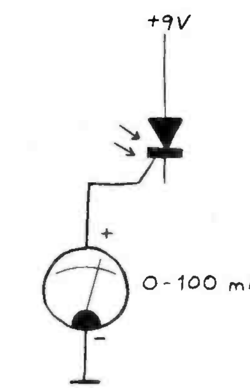


Fig. 4. Light-meter circuit.

exposed leads and junctions with sleeving and corona dope for safety. Then house the entire circuit in an insulated enclosure with an aperture for the flash tube.

You can power the circuit with a 300-volt dry battery or a combination of batteries which gives 250 to 300 volts. Buy your battery from a dealer who sells lots of high-voltage batteries to make sure you get a fresh one.

Use an electrolytic capacitor for *C1*. Several hundred microfarads will give you plenty of light, and you can probably get by with a lot less than that. Use a 450-volt unit and be sure to observe polarity. Use any standard trigger transformer for *T1* and any xenon flash tube.

Incidentally, a good source for parts for this project is the cheap flash units originally designed for discontinued Instamatic™ cameras. Several surplus dealers sell these units for about $10. You might be able to pick up some trade-in flash units at camera stores for a few bucks.

Figure 6 is a scope photo of several half-millisecond flashes from a LASCR triggered slave flash. It's fairly impressive when you can trigger a brilliant burst of light with just a little penlight.

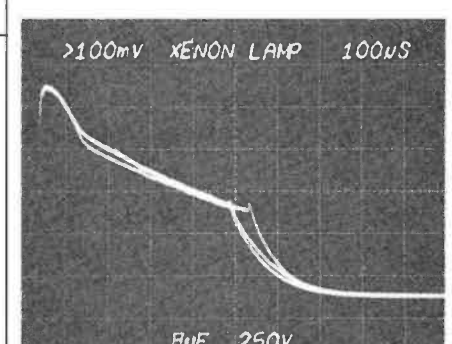


Fig. 6. Scope photo of triggered slave flash.

You can make the LASCR immune to ordinary lights by adding a 1-henry inductor across *R4*. The choke will appear as a short circuit to steady-state and slow transients, keeping the LASCR off. But a very fast pulse from a master flash unit will bypass the choke (which will appear as an open circuit) and turn on the LASCR.

These are just a few uses for the remarkably versatile and often overlooked LASCR. Pick up a few and try them out. You'll probably come up with some applications of your own. ◈

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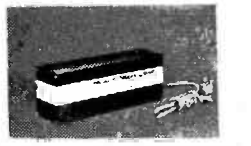

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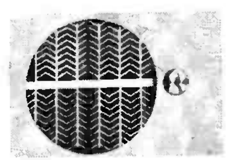

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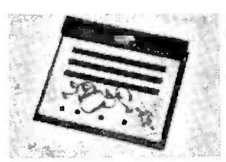

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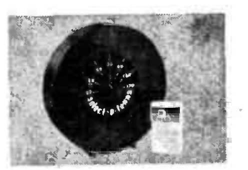

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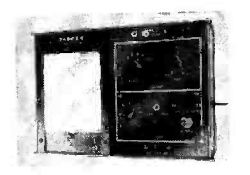

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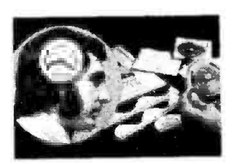

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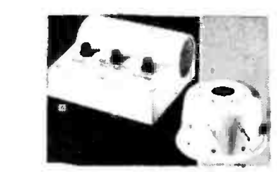

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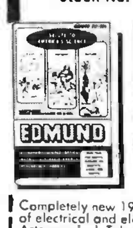

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EXAR FUNCTION GENERATOR KITS

features sine, triangle and square wave; THD 0.5% typ.; AM/FM capability

XR-2206KA SPECIAL $16.95
Includes monolithic function generator IC, PC board, and assembly instruction manual.

XR-2206KB SPECIAL $26.95
Same as XR-2206KA above and includes external components for PC board.

TIMERS			
XR-555CP	Monolithic Timer	SPECIAL	$ .68
XR-320P	Precision Timer		1.50
XR-556CP	Dual-555 Timer		1.70
XR-2556CP	Dual Timing Circuit		3.10
XR-2240CP	Programmable Counter/Timer	SPECIAL	3.20
PHASE LOCKED LOOPS			
XR-210	FSK Demodulator		5.10
XR-215	High Frequency PLL		6.50
XR-567CP	Tone Decoder (mini DIP)		1.90
XR-567CT	Tone Decoder (TO-5)	SPECIAL	.99
STEREO DECODERS			
XR-1310P	PLL Stereo Decoder		3.10
XR-1310EP	PLL Stereo Decoder		3.10
XR-1800P	PLL Stereo Decoder		3.10
WAVEFORM GENERATORS			
XR-205	Waveform Generator		8.30
XR-2206CP	Monolithic Function Generator	SPECIAL	4.39
XR-2207CP	Voltage-Controlled Oscillator		3.75
OTHER EXAR IC'S			
XR-1468CN	Dual + 15V Tracking Regulator	SPECIAL	2.90
XR-1488N	Quad Line Driver		5.70
XR-1489AN	Quad Line Receiver		4.70
XR-2208CP	Operational Multiplier		5.10
XR-2211CP	FSK Demodulator/Tone Decoder		6.60
XR-2261	Monolithic Proportional Servo IC System w/4 ea. Driver Transistor		3.70

7400N TTL

7400N	$.13	7443N	.95	74104N	1.20	74165N	1.30
7401N	.16	7444N	1.05	74105N	.50	74166N	1.30
7402N	.14	7445N	.90	74107N	.30	74170N	2.50
7403N	.16	7446N	.90	74109N	.90	74173N	1.50
7404N	.19	7447N	.80	74110N	.72	74174N	1.10
7405N	.20	7448N	.80	74114N	.93	74175N	1.20
7406N	.29	7450N	.16	74118N	1.52	74176N	1.25
7407N	.29	7451N	.16	74121N	.45	74177N	1.40
7408N	.18	7453N	.16	74122N	.45	74180N	.73
7409N	.20	7454N	.16	74123N	.70	74181N	3.00
7410N	.18	7460N	.16	74125N	.50	74182N	.70
7411N	.26	7470N	.30	74126N	.50	74184N	2.00
7412N	.33	7472N	.30	74128N	.90	74185N	2.29
7413N	.58	7473N	.37	74132N	1.00	74188N	4.80
7414N	1.23	7474N	.32	74136N	.95	74190N	1.20
7416N	.28	7475N	.59	74141N	1.20	74191N	1.20
7417N	.33	7476N	.32	74145N	1.00	74192N	1.20
7420N	.17	7480N	.59	74147N	2.40	74193N	1.00
7421N	.33	7481N	1.18	74148N	1.80	74194N	1.15
7422N	.50	7482N	.89	74150N	1.00	74195N	.80
7423N	.50	7483N	.65	74151N	.80	74196N	1.70
7425N	.34	7484N	3.00	74152N	1.40	74197N	.80
7426N	.25	7485N	1.20	74153N	1.00	74198N	1.75
7427N	.31	7486N	.35	74154N	1.40	74199N	1.40
7428N	.50	7489N	2.30	74155N	1.00	74200N	5.60
7430N	.20	7490N	.50	74156N	1.18	74221N	1.70
7432N	.24	7491N	.90	74157N	1.00	74251N	2.00
7433N	.60	7492N	.55	74158N	1.20	74278N	2.95
7437N	.35	7493N	.58	74160N	1.30	74279N	.90
7438N	.33	7494N	.80	74161N	1.20	74293N	1.00
7439N	.38	7495N	.80	74162N	1.40	74298N	2.20
7440N	.16	7496N	1.50	74163N	1.40		
7441N	.95	74100N	1.00	74164N	1.30		
7442N	.50						

HIGH SPEED TTL

74H00N	$.33	74H20N	.33	74H53N	.36	74H73N	.90
74H01N	.25	74H21N	.33	74H54N	.36	74H74N	.87
74H02N	.30	74H22N	.33	74H55N	.36	74H76N	.90
74H04N	.33	74H30N	.33	74H60N	.36	74H101N	.80
74H05N	.33	74H40N	.36	74H61N	.36	74H102N	.80
74H08N	.40	74H50N	.36	74H62N	.36	74H103N	1.10
74H10N	.33	74H51N	.36	74H71N	.80	74H106N	.95
74H11N	.33	74H52N	.36	74H72N	.74		

LOW POWER TTL

74L00N	$.31	74L10N	.33	74L51N	.34	74L90N	1.62
74L02N	.33	74L20N	.33	74L73N	.69	74L93N	1.74
74L03N	.39	74L42N	1.49	74L74N	.90	74L95N	1.62
74L04N	.33						

74LS

74LS00	.46	74LS27	.50	74LS112	.58	74LS170	5.80
74LS01	.58	74LS30	.46	74LS113	.92	74LS174	2.20
74LS02	.46	74LS32	.50	74LS138	2.06	74LS175	2.42
74LS03	.50	74LS38	.46	74LS139	2.06	74LS181	7.00
74LS04	.50	74LS51	.50	74LS151	1.92	74LS194	2.40
74LS08	.46	74LS54	.48	74LS153	1.92	74LS195A	2.40
74LS09	.58	74LS55	.58	74LS157	1.68	74LS196	2.76
74LS10	.46	74LS73	.58	74LS158	1.68	74LS251	2.06
74LS11	.46	74LS74	.58	74LS160	3.06	74LS253	2.42
74LS15	.58	74LS76	.92	74LS161	3.06	74LS257	2.06
74LS20	.46	74LS78	.92	74LS162	3.06	74LS258	2.06
74LS21	.58	74LS107	.92	74LS163	2.90	74LS260	.58
74LS22	.58	74LS109	.92				

SCHOTTKY TTL

74S00N	$.44	74S51N	.80	74S140N	.80	74S189N	4.40
74S02N	.60	74S64N	.80	74S151N	2.20	74S194N	3.30
74S03N	.75	74S74N	1.20	74S153N	3.40	74S195N	3.30
74S04N	.55	74S85N	6.10	74S157N	2.40	74S251N	2.20
74S08N	.80	74S86N	2.50	74S158N	2.20	74S253N	2.40
74S10N	.55	74S112N	1.00	74S160N	3.90	74S257N	2.40
74S11N	.65	74S113N	1.50	74S161N	4.70	74S258N	2.40
74S20N	.65	74S132N	3.60	74S174N	3.30	74S260N	1.20
74S30N	.80	74S133N	.80	74S175N	2.90	74S280N	5.70
74S32N	.80	74S138N	2.20	74S181N	8.40	74S289N	4.00
74S40N	.65	74S139N	2.20				

9300 SERIES

9300PC	$1.00	9318PC	2.30	9366PC	1.75	93L18	3.50
9301PC	1.20	9321PC	1.20	93L00	1.50	93L21	1.50
9304PC	1.50	9322PC	1.30	93L01	1.60	93L22	1.80
9306PC	6.90	9324PC	2.00	93L08	3.20	93L24	2.80
9308PC	2.50	9328PC	2.50	93L09	1.80	93L28	3.70
9309PC	1.60	9334PC	2.95	93L10	2.80	93L34	4.00
9310PC	1.50	9338PC	3.30	93L11	4.20	93L38	4.20
9311PC	2.30	9340PC	5.00	93L12	1.80	93L40	6.50
9312PC	1.20	9341PC	4.10	93L14	1.70	93L41	6.50
9314PC	1.30	9342PC	1.15	93L16	3.20	93L60	3.00
9316PC	1.50	9360PC	1.75	93L18	3.50	93L66	2.70

AUDIO AMPS

TYPE	V	W	Ω	PRICE
LM352	6-15	1.15	8	1.60
TAA611B12	6-15	1.15	8	1.60
TAA621A12	6-27	1.40	8	2.00
TAA641B11	6-18	2.20	4	3.00
TBA800	5-30	4.70	8	2.20
TBA810AS	4-20	2.50	4	3.00
TBA820	3-16	0.75	4	1.70
TCA830	5-20	2.00	4	2.20
TCA940	6-24	6.50	8	4.40

IC SOCKETS

SOLDER-TIN DIP PIN	1-24	25	100	WIRE-WRAP GOLD PIN	1-24	25	100
8	.21	.19	.17	14	.45	.41	.37
14	.25	.22	.20	16	.54	.49	.44
16	.28	.25	.23				
24	.67	.61	.56				
28	.88	.80	.72				
36	1.09	.98	.89				
40	1.24	1.12	.92				

SOLDER - GOLD

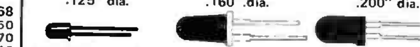
14	.34	.28
16	.37	.31

TEFLON TO-5

3 PIN	.55 EA
4 PIN	.65 EA
6 PIN	.90 EA
8 PIN	1.10 EA
10 PIN	1.40 EA

LEDs

.125" dia. / .160" dia. / .200" dia.



209 RED	$.25	216 RED	$.25	220 RED	$.25
209 YELLOW	.35	216 YELLOW	.30	220 YELLOW	.30
209 GREEN	.35	216 GREEN	.30	220 GREEN	.30

LOW PROFILE

226 RED	$.25	5053 RED	$.35	MV50 RED $.30
226 YELLOW	.30	5053 YELLOW	.40	
226 GREEN	.30	5053 GREEN	.40	*216 = MV5024*
226 ORANGE	.30	5053 ORANGE	.40	*5053 = MV5053*

DISPLAYS

OPCOA

SLA1 RED	2.25
SLA11 GREEN	3.50

XCITON

XAN72 RED	2.00
XAN52 GREEN	2.00

OPTOISOLATORS

MONSANTO MCT2 1.35

LITRONIX

DL80	RED	6.00
DL81	RED	6.00
DL10	RED	6.00
DL10A	RED	4.00
DL101	RED	4.90
DL57	RED	9.90
DL61	RED	12.00
DL33	RED	4.00
DL44	RED	6.00
DL402	RED	4.00
DL701	RED	3.40
DL704	RED	2.25
DL707	RED	2.35
DL747	RED	2.50
IL1		1.30
IL12		1.40
IL16		1.80
IL74		1.35
ILD74		1.75
ILQ74		3.40

EP 9125 9-DIGIT DISPLAY $7.90
1/8" Character Ht. Compact, Thin PC Pkg., Wide Viewing Angle

ELECTRONIC ARRAYS

EA1500AJ	
1-24	$21.00
25	16.80
100	14.00
EA 1500ASJ	
1-24	$16.00
25	14.40
100	12.00

LINEAR IC's

H=TO-5 N=DIP M=MINI-DIP D=CER-DIP K=TO-3

LM114H	$3.00	LM311H	$1.70	LM711CN	$ .90
LM300H	1.20	LM311D	1.90	LM715CH	3.50
LM300N	1.20	LM311M	1.75	LM715CD	4.60
LM301AH	.80	LM311N	2.00	LM723CH	.90
LM301AM	.80	LM312H	2.70	LM723N	.70
LM301AN	1.10	LM318H	1.70	LM725CH	4.50
LM301M	.90	LM324N	1.90	LM725CD	5.00
LM301H	.90	LM331N	2.20	LM733CH	1.40
LM302D	3.50	LM339N	2.90	LM733CD	3.50
LM302N	1.30	LM320-5K	2.90	LM733CN	1.30
LM302H	1.40	LM320-5T	2.50	LM741CH	.45
LM304H	1.40	LM320-12K	2.90	LM741CD	1.25
LM305H	.85	LM320-12T	2.50	LM741CM	.40
LM305AH	1.05	LM340-05K	2.60	LM741CN	.70
LM305N	1.00	LM340-06K	2.60	LM747CH	1.60
LM306H	.95	LM340-08K	2.60	LM747CN	.90
LM307H	.75	LM340-12K	2.60	LM747CD	2.50
LM307M	.95	LM340-15K	2.60	LM748CM	.55
LM307N	1.50	LM340-18K	2.60	LM748CN	.55
LM308H	1.00	LM340-24K	2.60	LM777CH	2.15
LM308AH	5.00	LM555CM	.90	LM777CM	2.10
LM308D	2.00	LM556CN	1.30	LM3046CN	.95
LM308M	1.20	LM709CH	.45	LM3054CN	1.50
LM309H	1.75	LM709CN	.45	SG4501T	2.40
LM309K	1.50	LM710CH	.90	SG4501N	2.40
LM310H	1.60	LM710CN	.90	LM5000K	7.50
LM310M	1.80	LM711CH	.90		

C-MOS

	1-9	10up		1-9	10up		1-9	10up
4000AE	.26	.22	4022AE	1.11	1.00	4051AE	1.34	1.13
4001AE	.26	.22	4023AE	.26	.22	4052AE	1.34	1.33
4002AE	.26	.22	4024AE	.90	.88	4053AE	1.34	1.33
4004AE	5.83	5.82	4025AE	.26	.22	4055AE	2.68	2.00
4006AE	1.35	1.34	4026AE	3.72	3.70	4056AE	2.43	1.86
4007AE	.26	.22	4027AE	.60	.50	4060AE	1.50	1.25
4008AE	1.79	1.78	4028AE	.98	.90	4066AE	.90	.72
4009AE	.60	.50	4029AE	1.27	1.16	4069AE	.38	.34
4010AE	.59	.50	4030AE	.44	.37	4071AE	.26	.22
4011AE	.26	.22	4033AE	3.01	3.00	4076AE	1.68	1.48
4012AE	.26	.22	4035AE	1.27	1.16	4081AE	.26	.25
4013AE	.47	.40	4040AE	1.49	1.25	4508AE	2.30	2.20
4014AE	1.49	1.25	4041AE	4.06	4.05	4510AE	1.98	1.46
4015AE	1.26	.90	4042AE	.75	.64	4516AE	1.98	1.46
4016AE	.56	.45	4043AE	.60	.50	4518AE	1.28	.98
4017AE	1.20	1.00	4044AE	.60	.50	4520AE	1.28	.98
4018AE	1.49	1.25	4047AE	3.54	3.53	4528AE	2.30	2.20
4019AE	.52	.44	4048AE	1.43	1.42	4901AE	.43	.36
4020AE	1.49	1.25	4049AE	.52	.50	4911AE	.43	.36
4021AE	1.34	1.25	4050AE	.52	.50			

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9601PC	1.20
9602PC	2.10
9614PC	2.30
9615PC	2.40
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9617PC	3.50
9620PC	4.00
9621PC	4.00

75107

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

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7522N	4.25
7523N	1.75
7524N	2.00
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1404AH	4.50
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2525V	3.50
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2602-1	4.00
2602-2	4.00
3341PC	7.00
4034	5.50
4035	4.95
4102	4.95
7552	4.95
7552-1	5.40
7552-2	5.50
8102	4.90
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MM5056N	5.50
MM5057N	5.50
MM5058N	5.50

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MM

MM404H	12.00
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1-24: $ 2.40
25 up: 2.30

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8008	$24.80	P2102-1	1-9	$4.00	10 up	$3.00
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EXAR XR205K $25.00

Here's a highly versatile lab instrument at a fraction of the cost of conventional unit. Kit includes two XR205 IC's, data & applications, PC board (etched & drilled, ready for assembly) and detailed instructions.

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	10	100	1000
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1N4005	1.40	11.00	100.00
1N4006	1.50	12.00	110.00
1N4007	1.60	13.00	120.00

INTERSIL 8038 PRECISION WAVEFORM GENERATOR & VCO

For simultaneous sine, square and triangular waveforms <.001 Hz to 1MHz.

Part No.	1-9	10 up
8038CCPD	$3.90	$3.70

XR-2206KA/XR-2206KB

The Function Generator Kit features sine, triangle and square wave, THD 0.5% typ., AM/FM capability.

XR-2206KA FUNCTION GENERATOR KIT $16.95
Includes monolithic function generator IC, PC board, and assembly instruction manual.

XR-2206KB FUNCTION GENERATOR KIT $26.95
Same as XR-2206KA above and includes external components for PC board.

HYBRID POWER AMPLIFIERS

SI-1010G	10W	$6.40
SI-1020G	20W	9.90
SI-1030G	30W	18.70
SI-1050E	50W	24.90
SI-1050G	50W	24.90

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BU204	3A	1300V	$4.14
BU205	3A	1500V	4.95
BU206	3A	1700V	5.94
BU207	6A	1300V	5.85
BU208	6A	1500V	6.93
BU209	6A	1700V	8.64

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THE SMALLEST AC/DC POWER SUPPLY EVER!
Only 1.70"x1.00" x 0.85", output preset ±5%. 9 models:

5	140
8	115
10	100
12	90
15	70
18	50
20	35
22	25
24	15

$39.80 each

ADTECH

Model No.	Output Vdc	Output Amps	1-4	5 up
APS5-3	5	3.0	$26.95	$25.60
APS12-1.6	12	1.6		
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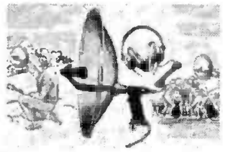

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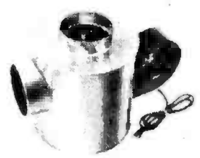

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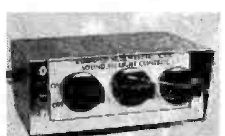

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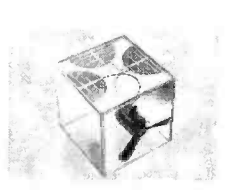

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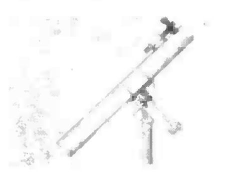

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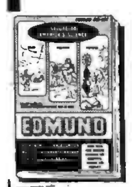

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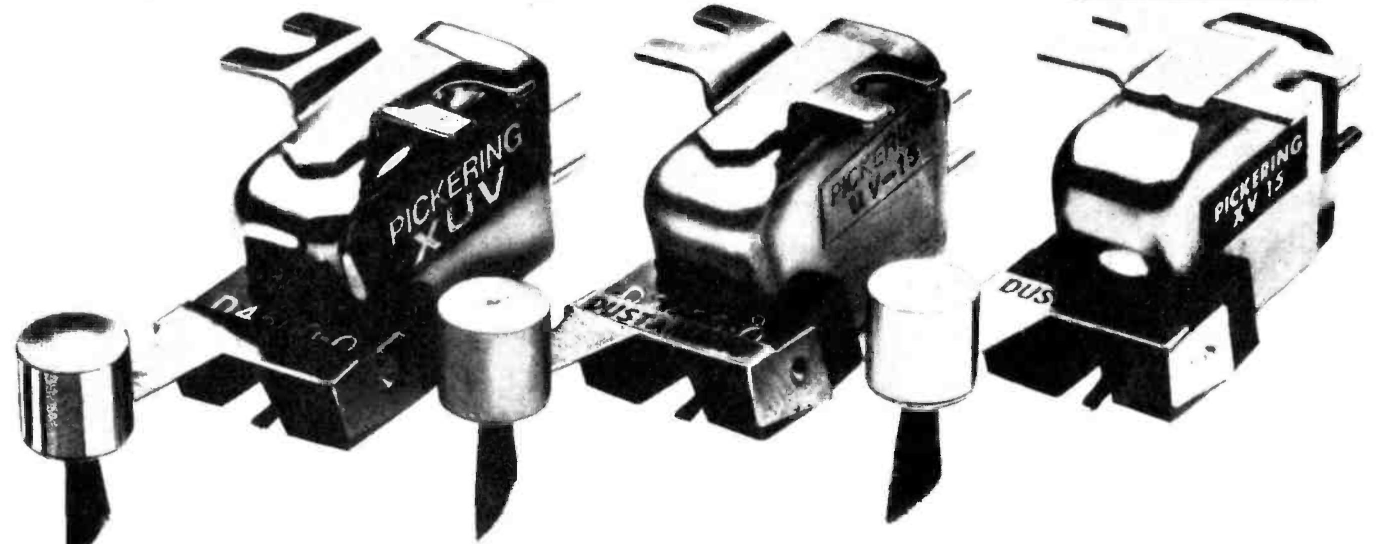

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Which brings us to turntables . . . and Dual.

Each year we hear from a sampling of Dual owners in response to a lengthy questionnaire. A high percentage tell us they're now on their second Dual. An even higher percentage formerly owned manual turntables. And nearly all rate their Duals as either "excellent" or "good."

Although there are other fine turntables, few match Dual's reputation for quality performance and reliability, and none match Dual's operational versatility. For example, if you want to be able to play records in sequence, you have four single-play/multi-play Duals to choose from. If you simply want fully automatic convenience in a single-play-only turntable, you have two to choose from. And there is now a semi-automatic Dual.

The way a tonearm is moved to and from the record is not critical. Nor is the type of drive system. What is critical is how faithfully the tonearm permits the stylus to follow the contours of the groove and how accurately and quietly the platter rotates. To compromise with quality in these respects can risk damage to your precious records and produce sounds which were never recorded.

Every Dual, from the 1225 to the CS701, provides more precision than you may ever need. Which is why more component owners—audio experts, hifi editors, record reviewers and readers of the music/equipment magazines—own Duals than any other turntable.

There's no better recommendation we can offer you. Or that you can offer to your best friend. Unless you happen to own a Dual yourself.

Dual 1225

Dual 1225. Fully automatic, single-play/multi-play. Viscous damped cue-control, pitch-control. 10⅝" platter. $139.95, less base. Dual 1226, with cast platter, rotating single-play spindle, $169.95. Dual 1228, with gimballed tonearm, synchronous motor, illuminated strobe, variable tracking angle, $199.95.

Dual 1249. Fully automatic, single-play/multi-play. Belt drive. 12" dynamically-balanced platter. $279.95, less base. Full-size single-play models include: Dual 510, semi-automatic, $199.95; Dual 601, fully automatic, $249.95. (Dual CS601, with base and cover, $270.)

Dual CS701. Fully automatic, single-play. D.C. brushless, electronic direct drive motor; tuned anti-resonance filters. $400, including base and cover.

Dual 1249

Dual CS701

United Audio Products, 120 So. Columbus Ave., Mt. Vernon, N.Y. 10553

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