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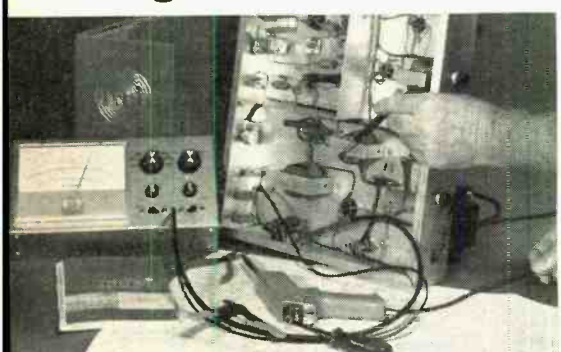

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ZIFF-DAVIS PUBLISHING COMPANY
Editorial and Executive Offices
One Park Avenue, New York, New York 10016
212 679-7200

POPULAR ELECTRONICS Including ELECTRONICS WORLD, March, 1973, Volume 3, Number 3. Published monthly at One Park Ave., New York, NY 10016. One year subscription rate for U.S., U.S. Possessions and Canada, $6.00; all other countries, $7.00. Second class postage paid at New York, N.Y. and at additional mailing offices. Authorized as second class mail by the Post Office Department, Ottawa, Canada and for payment of postage in cash. Subscription service and Forms 3579: P.O. Box 2774, Boulder, CO 80302. Editorial offices for manuscript contributions, reader inquiries, etc.: One Park Ave., New York, NY 10016.

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Editorial

By Milton S. Snitzer, Editor

THE TRANSISTOR—AFTER 25 YEARS

A little over 25 years ago, three scientists at the Bell Laboratories invented a device that would revolutionize the world of electronics. These three are John Bardeen, Walter H. Brattain, and William Shockley. Later, in 1956, they were named Nobel laureates in physics for the invention of the transistor.

A recent issue of the "Bell Laboratories Record" recalled and celebrated the event by asking the three to give their recollections of the transistor's invention and to assess its impact on science, technology, and society. Some of what they had to say is worth a larger audience.

Bardeen wrote about all the technical breakthroughs that have followed from the invention—single crystals, zone refining, diffusion, oxide masking, planar technology, integrated circuits of greater and greater complexity, semiconductor rectifiers that have revolutionized the electric power industry, light emitting diodes and lasers, microwave oscillators and charge-transfer devices. Though based on some previously observed facts, he continued that there had to be a close interaction between theory and experiment: "At each stage we tried to have at least a qualitative understanding of what was going on."

Brattain also credited basic research and experimentation in order to try to understand what was really going on. He then wrote "The technological use that society makes of the understanding that science gives is not always what the scientist would recommend or condone. I feel strongly, however, that the scientist has no right to dictate how his understanding is used. He does have the right to advise and to act as any other citizen when it comes to deciding what society should do, and all citizens are equally responsible for what is done." He goes on to state: "The use of the transistor of which I am proudest is the small battery-operated radio. This has made it possible for even the most underprivileged peoples to listen . . . The thing I deplore most is the use of solid-state electronics by rock and roll musicians to raise the level of sound to where it is both painful and injurious."

William Shockley recalled that exploiting the transistor's potential caused many headaches. He continued: "A colleague branded it a 'persistor', because persistence was what it took to make it—several years and improved experimental facilities were needed before really good ones were fabricated. But three years later, the first microwatt junction transistors were what really inaugurated the transistor era."

Bell Labs' most important policy was not to keep the new transistor information a secret. The semiconductor industry's almost overnight growth was due in large measure to the relatively open information exchanges. Continuing research and development are still underway today. Charge-coupled semiconductor devices are being fabricated which will lead to solid-state flat TV pickup and picture tubes; new types of MOS (metal oxide semiconductors) are being worked on to improve switching techniques; new devices are being researched for use in the microwave frequencies and beyond. In short, the last 25 years of transistor history have been remarkable but we expect that the next 25 years will be even more so.

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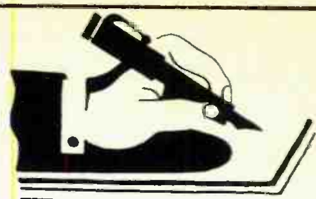

Letters

NEW WORLD'S DISTANCE RECORD

A new uhf communication record for distance was made between W6YFK and K4RJ on November 22, 1972 between 0619 and 0646 GMT. The terrestrial distance between W6YFK in California and K4RJ in North Carolina of 2080 miles (3347 km) was bridged on 2304 MHz CW via moon reflection. This breaks the record of 750 miles set in October 1970 by W4HHK and W3GKP.

WILLIAM L. SMITH, K4RJ
Franklin, N.C.

MASKING TAPE IS BETTER THAN CLIPS

In J. Gordon Holt's "A Galaxy of Gadgetry" (Stereo Scene, December 1972), mention is made of using tape reel clips to prevent unravelling. I would like to point out that masking tape is somewhat better to use for this job than is cellophane tape. Most clips tend to warp plastic reels when the latter are stored in boxes. I have not met a broadcaster yet who uses clips.

R.S. LEEK
U.S. Naval Base
Guantanamo Bay, Cuba

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Interested readers, please write directly to Mr. Seidler.

A 'LUMINATING RESPONSE

In "What's in a Color TV Signal?" (December 1972), Mr. Belt states: "Line 18 of field 1 carries the unfarmiliar pattern at the top left (Fig. 3) . . . The purpose of this signal was not explained to either AT&T or the network's station engineers." The signal in question is a subcarrier-modulated luminance pedestal. As the enclosed application note states, this signal is for measuring luminance cross-modulation, which is a shift in the luminance level due to rectification of the color subcarrier and is a function of the average picture level.

Other than neglecting an explanation of this useful signal, the article was very informative and concise. I would like to see more articles of this caliber in future issues.

JAMES D. BRAY
Service Center Supervisor
Tektronix, Inc.
Rockville, Md.

INFORMATION WANTED

Do you know where I can obtain an up-to-date roll chart for a Precise Model 111 tube tester?

ROBERT T. GOLEC
34123 Dryden Dr.
Sterling Heights, MI 48077

I recently acquired a USM-50 oscilloscope through the MARS Program (it was made by Sentinel Electronics, Inc.). Now I find that I need a technical manual to make full use of the scope. Can you help me?

H.F. HOOVER
4227 S. Dorset Rd.
Spokane, WA 99204

I am in dire need of a wiring diagram and instruction manual for a Precision Model 912 tube tester. Can you or any of your readers help me?

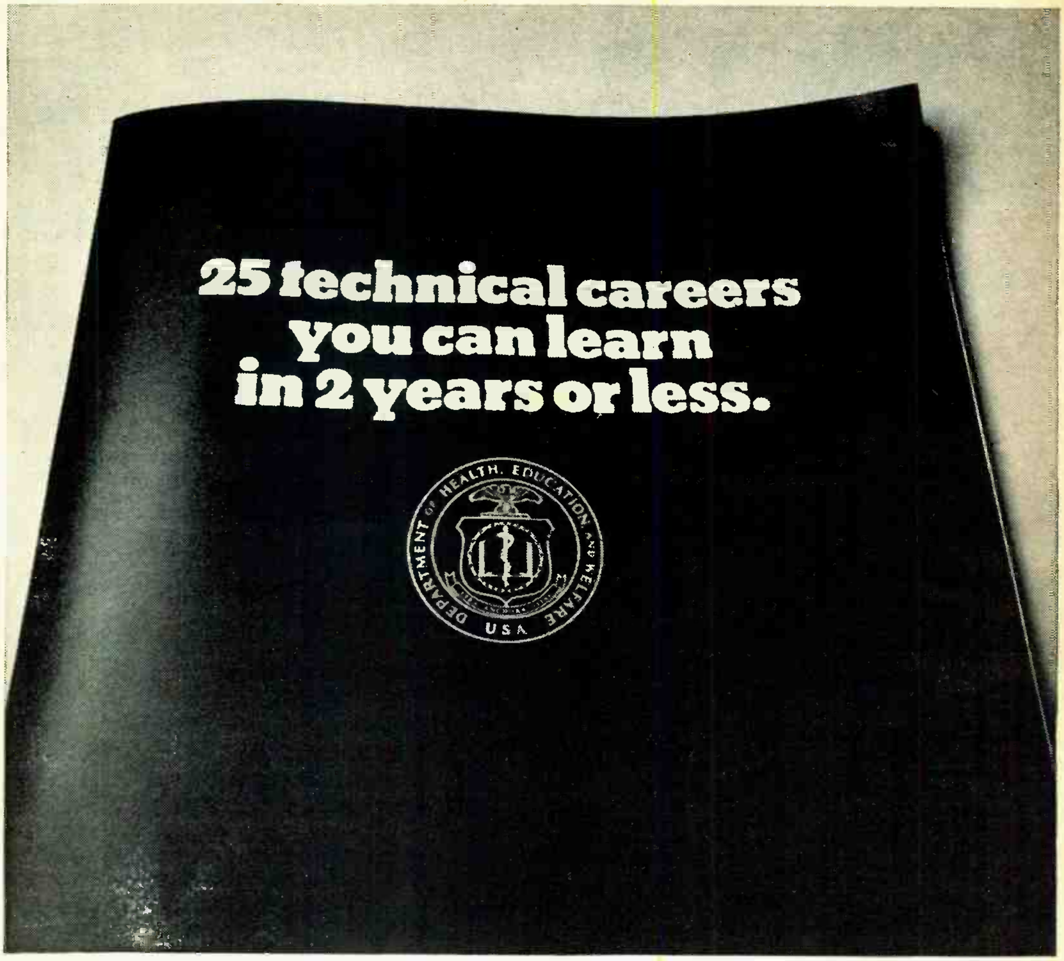
F.M. TAYLOR
72 Anthony St.
East Providence, RI 02914

We cannot help, but perhaps our readers can; if so, please write directly to the above.

A NOTE OF CAUTION

Whenever you work with an unfamiliar apparatus or substance, especially chemicals, maximum precautions should at all times be exercised. This is particularly true when handling the nematic liquid crystal material discussed in "Liquid Crystals for Electronics" (January 1973). At no time should you allow this material to contact your flesh or clothing, nor should you under any circumstances breathe in its fumes. Do as professional chemists do: wear surgical rubber or polyethylene (throw-away) gloves at all times and have an exhaust fan going to draw away the fumes. Should the liquid spill on a workbench or counter top, immediately clean it up and thoroughly scrub the area with paper towels. If you are a student, seek the aid of a qualified laboratory instructor when fabricating and assembling a nematic liquid crystal cell.

—The Editors



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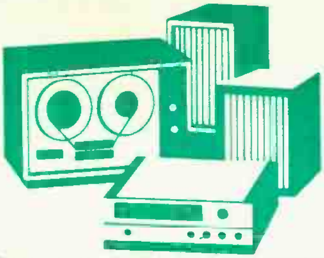

Stereo Scene

By J. Gordon Holt

Cassettes for Perfectionists

EVER SINCE the first hissing, fluttering, wowing cassettes appeared on the stereo scene, it has been an article of faith among serious audiophiles that the cassette medium was simply not worthy of consideration. Yes, they would admit, cassettes are getting better, and they probably have the *potential* of producing really good audio quality, but they'll never really compete with discs or open-reel tapes in terms of frequency range and freedom from noise, distortion and other audible bothers.

Well, times have changed and so have cassettes--so dramatically in fact that some critical audiophiles are even suggesting that today's cassette performance is the equal of or maybe even better than that of discs or open-reel tapes. Could this possibly be true? Well, let's see how the three media compare in performance.

Background Noise. Until fairly recently, a cassette recorder was considered to be doing exceedingly well if it could attain a signal/noise ratio of 45 dB, which means that hiss is quite audible at even moderately high listening levels. This compared with a little over 50 dB for a good 4-track open-reel machine, and 60 dB or more from a new disc recording. Then, two things happened to change the relative standing of the cassette, the Dolby B noise-reduction system, and chromium-dioxide tape.

Built-in Dolbys have allowed most cassette machines to achieve subjective signal-to-noise ratio figures of over 55 dB—better than 4-track open-reel tape (without its own Dolby), and almost the equal of a disc. And tapes will not accumulate noise with use, as will discs (unless the tape machine's heads are allowed to get magnetized). With a topnotch pickup and routine attention to cleaning, a disc will remain tolerably quiet for several hundred plays, but there is an inevitable gradual increase, not of hiss, but of ticks and pops due to dust particles.

DuPont's chromium-dioxide tape, although requiring higher bias current than iron-oxide tapes, has a much greater capacity for storing high frequencies, and even when used on a recorder that can provide (via a tape selector switch) the necessary higher bias, chromium dioxide will play back with a markedly rising high-frequency response. This suggested to designers a way of getting even lower hiss from cassettes: by reducing the treble during playback by the amount necessary to provide linear overall high-end response. The result was an additional subjective increase in S/N ratio of around 5 dB, making a Dolbyed chromium-dioxide tape very nearly as hiss-free as a disc. (Note that *all* of the figures cited here for the tape media are for recordings that you make yourself, from program material that is *quieter* than your own recorder's capability. Commercially pre-recorded tapes are typically about 5 dB hissier than your own tapes can be.)

Chromium-dioxide tape would of course improve the S/N of an open-reel recorder too, but as of this writing, CrO_2 tape is not available on open reel except in the special widths and coating thicknesses needed for videotape recording.

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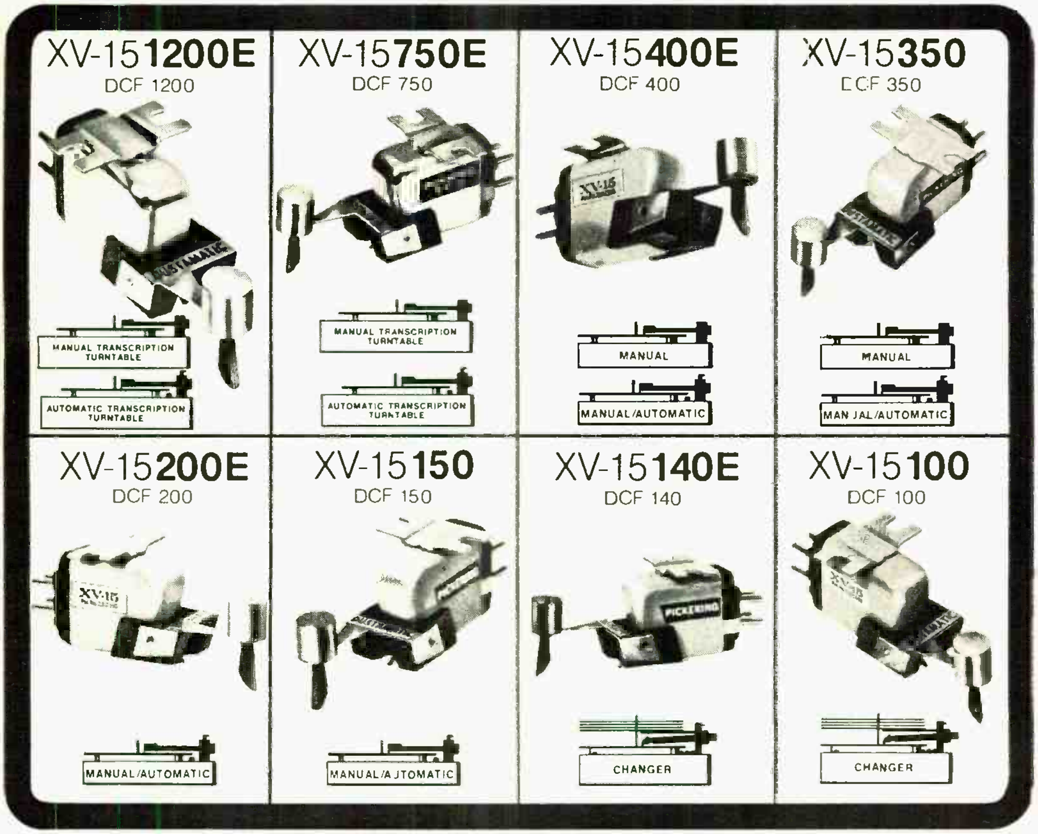

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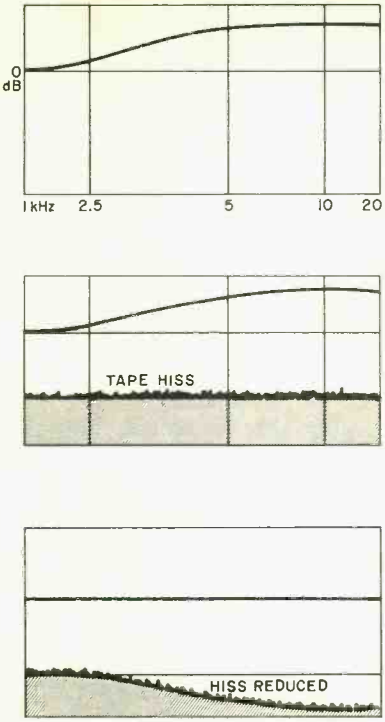

How noise reduction works in Dolby B and with chromium dioxide tape. Top: treble boost while recording; center: playback adds tape hiss; bottom: reducing treble restores the flat response and lessens the hiss in tape.

Frequency Response. While a stereo disc has the potential of yielding flat frequency response from below 30 to around 15,000 Hz, most commercial discs released in the US are purposely restricted to a range of 50 to 12,000 Hz, for reasons that make sense only to the record companies. The better open-reel recorders are essentially flat from 30 to beyond 18,000 Hz at 7½ ips, while the best cassette reproduction (via chromium-dioxide tape) is pretty flat out to beyond 14,000 Hz, which is still well beyond that on most discs. Thus, while open-reel has the potential for better high-end range than a cassette, either can more than do justice to a disc. Only when recording live, from very good microphones, is the open-reel tape likely to have audibly superior high end. (This is not however true of pre-recorded tapes, where the open-reel ones usually have conspicuously more-extended high ends than the cassettes.)

At the low-frequency end, cassettes and open-reel tapes have comparable ranges, but the response is usually smoother from open reel. The physical dimensions of a cassette recorder's head tend to cause partial cancellation of certain parts of the bass range, resulting in a rather bumpy response.

Speed Regulation. Although there are disc turntables available with a totally inaudible wow and flutter spec of 0.05% or better, the limiting factor on speed regulation from discs is usually the discs themselves. They are, after all, made from tape masters, and the best open-reel tape machines rarely have less than 0.08% wow and flutter, which is still inaudible. Actually, most of the speed variation from discs is slow-speed wow, due to eccentricity of the pressing, and figures of 0.5% wow are not uncommon. Fortunately, our ears are much more forgiving of slow wow than of flutter.

Only during the last year or so have cassettes and cassette machines been able to compete with the other media in this respect. The most stable machines, the majority of which use dual-capstan drive, can deliver less than 0.15% speed variation (assuming the cassette is good), and it takes a very good ear indeed to hear this in music. Most cassete reproduction, though, does well to stay below a definitely audible 0.3% variation.

Much of the really gross speed variation that is often blamed on the cassette medium is due to a dirty capstan drive or fatigued batteries (in portables).

Distortion. Any comparison between the recording media on this basis requires a definition of terms. To the person who has never been able to afford an excellent tone arm, cartridge and preamp, there is no doubt that discs have the most distortion of any home-music medium. This is because the particular kind of distortion that comes from mistracking discs is perhaps the most offensive kind to our ears, and it is aggravated to the point of torture by any distortion in the associated electronics, particularly by the earliest stages of the preamp. But given very good, although not necessarily ideal, conditions, disc mistracking distortion can be so low, even from a worn disc, as to be virtually inaudible, in which case the disc's superiority in other respects comes through. Tape duplicating, particularly at high speeds (used in production of commercial pre-recorded tapes), introduces its own particular varieties of distortion—

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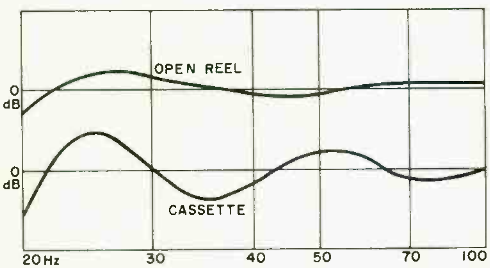
CIRCLE NO. 30 ON READER SERVICE CARD

usually audible as a muddying of bass and a fuzzing of treble. Thus, no tape copy of a previous recording, on tape or disc, can be as free from these distortions as the original.

Generally, the higher the tape speed, the lower are both of these kinds of distortion, and this holds right down the line when it comes to comparisons between open-reel recordings without a Dolby and cassette recordings also without having a Dolby. Dolbyization has no effect on a cassette's (or open-reel tape's) low-end, but it works wonders with the top. A Dolbyed cassette, as long as it isn't actually being overloaded by treble material, has less high-end fuzz than a non-Dolbyed open-reel recording, and that plus the lower noise makes it sound generally clearer and cleaner than the non-Dolbyed open-reel tape. With a Dolby on both, the cassette will tend to have somewhat muddier bass, but the high-end differences are relatively slight and not likely to be picked up by any but the most educated ears.



Low-end response of typical 4-track open reel and of cassette recorders.

Consistency and Dependability. This hardly applies to discs at all. You don't make 'em, you just play 'em, and it all depends on your playback equipment. With tapes, you have the advantage of a separate play head to allow you to monitor from an open-reel machine, and thus tell while you're recording what is going on the tape. With most cassette recorders (exceptions are appearing now), the record head is the play head, and you don't know what's gone on the tape until you play it back. With a good cassette machine and good cassettes, this is rarely a shortcoming (except insofar as it makes adjusting the machine for a particular tape more tedious). But, because of the cassette's slow speed and narrow tracks, tiny surface irregularities on the tape, that would have no perceptible effect on an open-reel tape, can cause monstrous dropouts (momentary signal losses); and you never know it until you play back the tape. This is why, if you value a cassette recording, you should use nothing but the very best cassette tape you can get. Ideally, cassettes give little such trouble. But open-reel machines give virtually no such trouble, even with cheap tapes.

Life Expectancy. As far as discs are concerned, this is obviously a matter of what you play them with and how well you care for them. With very good equipment and excellent care, you can expect upwards of several hundred plays from a disc before surface noise or mistracking distortion become annoying. There is no known limit on open-reel tapes, unless you have been recording an acetate-backed tapes, which tend to dry out and become brittle with age. But there are definite limits to the life of a cassette.

Recent studies have shown that the high-end response of most cassettes falls off progressively with each play. Researchers at Memorex Corporation (among others) found that ordinary iron-oxide cassette coatings lose more than 2 dB of output at 15 kHz after only 5 plays, although this tends to stabilize at 2½ dB after 15 plays. (Iron oxide, remember, is what is used for all pre-recorded cassettes.) The cobalt-doped iron-oxide coatings, which are advertised as high-potency or high-output tapes, may lose 5½ dB of 15-kHz output after 5 plays and as much as 8 dB after 25 plays! At 10,000 Hz, which is well within the audible range, this translates into 2½ dB of loss after 5 plays and 4½ dB after 25 plays, and indications are that the loss increases with each play of the cobalt-doped tape.

Chromium dioxide, however, was found to lose only 1 dB of 15-kHz output after 5 plays, and less than 1½ dB after 30 plays.

The physical phenomena that cause these high-end losses actually occur to some extent in all tapes, but because they are wavelength-related, they are most pronounced at the slow cassette speed. Thus, although the same tendencies will be observable from open-reel tapes at higher speeds, the extent of the losses will be concomitantly less. At 7½ ips, even with cobalt-doped tape, the effects are so gradual as to be imperceptible unless direct comparisons are made between the originals and the frequently played copies. ◈

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* Copies of the Audio Engineering Society paper, 'ON THE DESIGN, MEASUREMENT AND EVALUATION OF LOUDSPEAKERS', by Dr. A. G. Bose, are available from the Bose Corp. for fifty cents.

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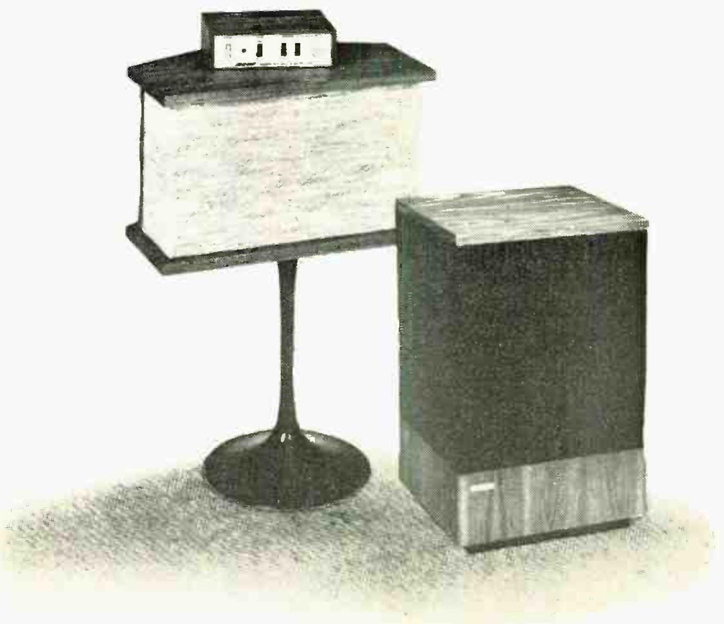

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CIRCLE NO. 1 ON READER SERVICE CARD

CIE graduate builds two-way radio service business into $1,000,000 electronics company!

How about YOU? Growth of two-way transmitters creates demand for new servicemen, field and system troubleshooters. Licensed experts can make big money. Be your own boss, build your own company. And you don't need a college education.

Edward J. Dulaney, Scottsbluff, Nebraska, (above and at right) earned his CIE Diploma in 1961, got his FCC License and moved from TV repairman to lab technician to radio station Chief Engineer. He then founded his own two-way radio business. Now, Mr. Dulaney is also President of D & A Manufacturing, Inc., a $1,000,000 company building and distributing two-way radio equipment of his own design. Several of his 25 employees are taking CIE courses. He says: "While studying with CIE, I learned the electronics theories that made my present business possible."

Two-way radio is booming. There are already nearly seven million two-way transmitters for police cars, fire department vehicles, taxis, trucks, boats, planes, etc., and Citizens Band uses. And the number keeps growing by the thousands every month. Who is going to service them? You can – if you've got the know-how!

Why You'll Earn Top Pay

One reason is that the United States Government doesn't permit anyone to service two-way radio systems unless he's *licensed* by the FCC (Federal Communications Commission).

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As a licensed man, working by the hour, you would usually charge at least $5.00 per hour, $7.50 on evenings and Sundays, plus travel expenses.

Or you could set up a regular monthly retainer fee with each customer. Your fixed charge might be $20 a month for the base station and $7.50 for each mobile station. Studies show that one man can easily maintain at least 135 stations – averaging 15 base stations with 120 mobiles! This would add up to at least $12,000 a year.

Be Your Own Boss

There are other advantages, too. You can become your own boss – work entirely by yourself or gradually build your own fully staffed service company. Of course, we can't promise that you will be as successful as Ed Dulaney, or guarantee that you'll establish a successful two-way radio business of your own, but the opportunities for success are available to qualified, licensed men in this expanding field.

How To Get Started

How do you break in? This is probably the best way:

1. Without quitting your present job, learn enough about electronics fundamentals to pass the Government FCC exam and get your Commercial FCC License.
2. Then get a job in a two-way radio service shop and "learn the ropes" of the business.
3. As soon as you've earned a reputation as an expert, there are several ways you can go. You can move *out* and start signing up and servicing your own customers. You might become a franchised service representative of a big manufacturer and then start getting into two-way radio sales.

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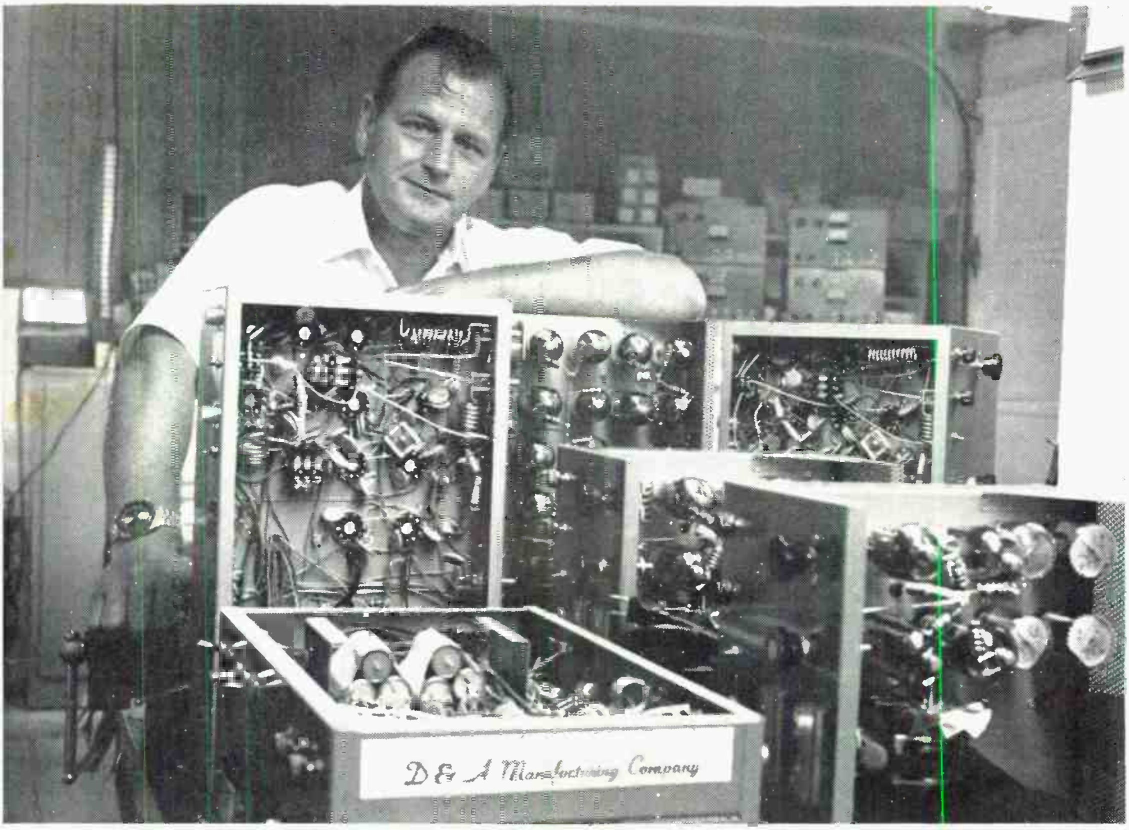

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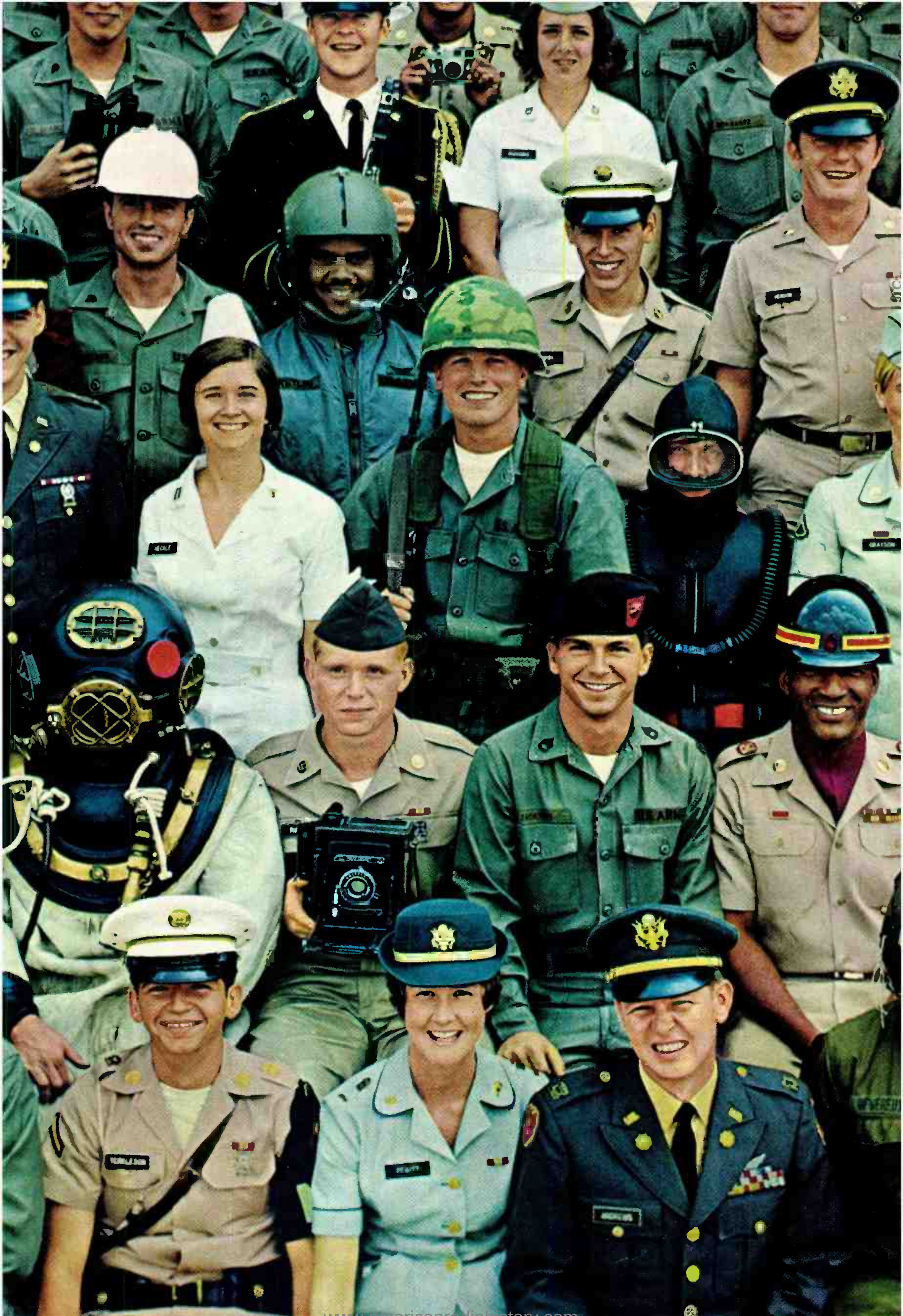

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They'll know by listening. Because you'll send with all the power allowed—15 watts P.E.P. input. Plus the extra authority of 100% modulation with Dynaboost speech compression.

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CIRCLE NO. 2 ON READER SERVICE CARD

News Highlights

Supreme Court Denies Patent for Computer Programs

In a 6 to 0 ruling, the Supreme Court recently ruled that computer programs are basically ideas rather than "things" and hence cannot be protected by patents. There had been a dispute between "hardware" companies, led by IBM, and smaller companies that provide the "software" or programs and routines without which the computer cannot be used. The ruling represents a victory for the hardware manufacturers who maintained that patents issued for programs would impede the development of future technology.

Video Tape Market Shows Signs of a Boom

Several straws in the wind are indicating a possible boom in the video tape field. One of these is the recent announcement by Sony of plans to produce 100,000 U-matic Videocassette machines during 1973 to meet world-wide demand for the equipment. Last year the company made 40,000 units for international marketing. In all, Sony has sold 181,000 video tape recorders. Along these same lines, Cartridge Television Inc. (maker of Cartrivision video tape system) has announced an order for immediate delivery of 5500 additional units by Warwick Electronics, manufacturer of equipment for Sears, Roebuck and by Teledyne Packard Bell. Such equipment is entirely for in-home use.

Cable TV Manpower Study

The cable television industry may need up to 50,000 additional technicians and engineers in the next five years. These figures come from a survey released by the U.S. Department of Commerce Office of Telecommunications. The prediction is based on DOC's analysis of a manpower requirement survey distributed by the National Cable TV Association in cooperation with DOC, IEEE, EIA, and others. DOC estimates that there are more than 2000 technical jobs now open in the CATV industry and that 7000 more positions will open up in the next 15 months.

More Engineering Graduates

The number of engineer graduates in a single school year has reached the highest level since 1950. However, freshman enrollments dropped again, according to data just compiled by the Engineers Joint Council. Those who graduated last June included 44,190 with bachelor's degrees, 17,356 with master's, and 3774 with doctor's degrees. These figures are marginally higher than the comparable figures for 1971. Note that the above figures include all engineering students and not just electronics engineers.

New Electro-optic Pen Reads Price Tags

A pen that "reads" price tags, then automatically totals the bill for a department store customer's purchases may make the present cash register obsolete. Instead of ringing up the price on a cash register of each item being purchased, the check-out clerk merely passes the tip of the instrument across a printed code placed on the item. An optical image pickup in the tip "reads" the code which is transmitted to a miniature computer that records the amount, keeps a total of the purchases and updates the store's inventory records. Developed by Bendix, the instrument resembles a ball point pen or pencil and will operate with any type of black and white bar code printed either on a tag attached to the purchased product or on the product itself.

Forecast of Government Markets Indicates Growth for Electronics

Moderate growth in the Department of Defense budget is foreseen over the next eight years as well as a proportional increase in the electronics content. This prediction was made by the Electronic Industries Association. An outlook study predicts that DOD areas which will see the most growth will be surveillance, electronic warfare, communications, command and control equipment. Currently running at about $74 billion, the EIA study sees the DOD budget growing to $94.7 billion by fiscal 1980. The electronic content of this budget, now about 15 percent, will increase to about 16.6 percent by 1980, the forecasters believe.

Four-channel Disc System Patented

A U.S. patent has just recently been issued to the Victor Co. of Japan for the invention and development of the CD-4 discrete 4-channel disc system. The CD-4 system provides four independent audio channels for the recording and playback of four-channel program material on records. Note that the CD-4 is not a matrix system but employs four discrete channels on a multiplexed subcarrier. Sidebands of this subcarrier extend out to 45 kHz so that a special phono pickup cartridge is required with this sort of response. This announcement was made by JVC America which handles sales and distribution of the parent company's products in the U.S. RCA has released a few records employing the Victor Co. of Japan's system.

NATESA and NEA are Working Toward Merger

The two national associations of TV service dealers and technicians, NATESA (National Alliance of TV and Electronics Service Associations) and NEA (National Electronics Associations, Inc.) are continuing to work toward an eventual merger. Presidents of both groups met recently along with their merger committees and boards in order to iron out some of the problems that would occur as a result of the merger. Although the actual merger may not take place for many months, the two groups are working together on a number of mutual projects.

TV Receiver Ads Held Misleading

The Federal Trade Commission has been examining advertising claims made by the various TV set manufacturers and has found that nearly 70 percent of these have been misleading or false. Some of these were from the larger TV set manufacturers. On the other hand, there were substantiated advertisements of uniqueness from Sony for its Trinitron picture tube, from RCA for its solid-state modules and computer-designed picture tube, and from Motorola for its solid-state receivers. Copies of the report are available from the Institute for Public Interest Representation (which had the study made for the government), 600 New Jersey Ave. NW, Washington, D.C. 20001.

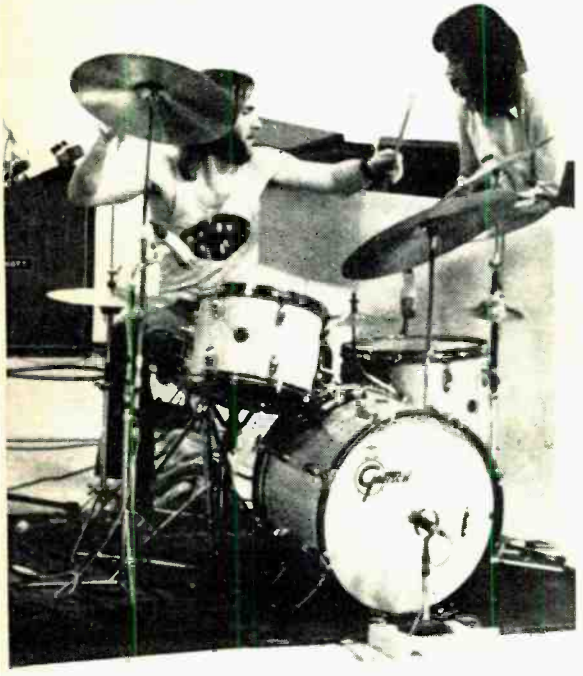
By Sidney L. Silver

THERE is a growing awareness of the problem of hearing loss among young people whose ears are constantly being subjected to more loud music than they can safely tolerate. Part of the difficulty comes from frequent attendance at live rock concerts where the intense sounds of electronically amplified musical instruments assault the ears of the audience. In addition there is the tendency of many youngsters to listen to recorded rock music at unreasonably high sound levels over long periods of time (especially on earphones) which can also contribute to impairment of the hearing mechanism. Members of rock groups experience still higher sound levels in both practice and performance sessions so they can be expected to face more significant hearing loss hazards.

It is now recognized that prolonged exposure to high-intensity sounds is a serious form of noise pollution which can lead to irreversible hearing damage. Unfortunately, there is a still widely held and erroneous belief that hearing loss sustained by exposure to excessively loud music is insignificant, or at worst only temporary. The facts tell a different tale: the temporary hearing loss suffered by individuals exposed to intense sounds may become permanent after repeated exposure. Gradually, the noise-induced hearing loss accumulates over the years and usually goes unnoticed until it becomes great enough to offset the ability to understand speech. When this happens, the loss is permanent and cannot be corrected by any treatment known to medical science.

The fear exists that as more and more young people are exposed to intense sound levels, many of them will eventually suffer sufficient hearing damage to jeopardize their occupational potential. In addition to the problem of accelerated deafness, there is mounting evidence that excessive noise exposure can cause severe psychological and physiological damage as well.

Nature of the Problem. The term "noise" is usually applied to unwanted or undesir-



ROCK MUSIC & Noise Pollution

Prolonged exposure to high-intensity sounds can lead to irreversible hearing damage

able sound. But this definition must allow for a very wide reaction by different people to the same sound. Depending upon the degree of pitch distribution, intensity, and persistence, certain sounds may be objectionable to some individuals but a source of pleasure to others. For example, the sound of modern pop music may be agony to some adults but ecstasy to most teenagers, the difference reflecting a conflict in musical tastes. In the case of hard rock, loudness is one of its identifying characteristics, and the acoustic noise produced is an element designed to heighten the aesthetic experience for the listener.

For many rock music fans, the ultimate listening pleasure is one in which sound intensity becomes so penetrating that it assumes complete control over mind and body. This demands a kind of total audience involvement in which the sensual impact of the ambient sound pressure levels is primarily intended to be felt rather than heard.

Unfortunately, repeated exposure to these intense sounds has proven disastrous to sensitive ear drums and damaging to the nerve cells of the inner ear. At the present time, however, there is still no general agreement as to exactly how much noise and what duration of exposure constitute a health hazard.

Super-Amplified World of Rock. Imagine being exposed continuously to the sound pressure levels created by a 100-piece military band playing fortissimo passages at close quarters, or the crescendo of street noises produced by a team of jack hammers operating simultaneously, or even the incessant roar of jet airplanes at a busy airport. The acoustic power generated by any of these sources roughly corresponds to the ultra-high levels associated with live rock groups aided by powerful amplification systems. In Fig. 1 is shown how other environmental noises compare with the high-intensity sound of a typical electrified rock band.

One important aspect of noise pollution

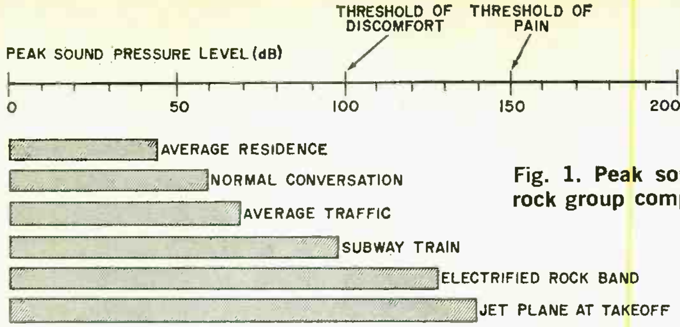


Fig. 1. Peak sound pressure level of typical rock group compared with other noise levels.

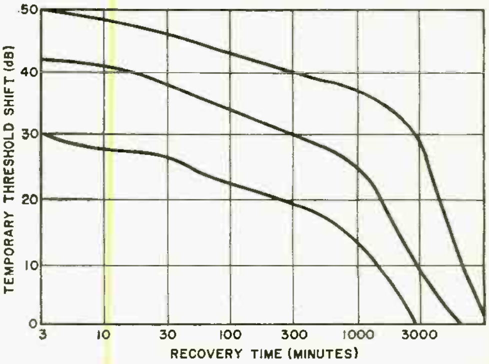
is the increase in rock music activity at leading concert halls which are primarily identified with classical music. Many of these halls were designed to provide programs of "natural" music without benefit of amplification, or in other cases, some degree of electronic enhancement to optimize the sound quality. These techniques range from simple sound reinforcement systems for providing uniform coverage throughout the hall to highly sophisticated systems for electronically controlling the total acoustical environment. But even a properly controlled system cannot compensate for the disturbing ringing and howling of hard rock music, so dominant that the sound level of a moderately loud rock band would be comparable with the screech of a jet fighter plane. With rock music, the delicate balance of hall size, reflecting surfaces, and instrument volume become grossly distorted by the crescendo of escalating decibels emitted by the high-powered electronic gear associated with rock groups.

Today, almost any musical instrument, from the drum to the sitar, can be enhanced electronically either through new instrument design or by adding internal pickups to each instrument and feeding the audio signals to separate high-power amplifiers and speakers. The amplifying systems then become part of the program source, not only emphasizing the volume but also contributing an array of effects such as tremolo, vibrato, reverberation, etc., to modify the tonal color. In many cases, the individual instrument competes for the decibel by feeding its own amplifier system, each amplifier ranging up to 100 or even 300 watts output.

For live performances, these instrument amplifiers are usually reamplified by a public address system, thus pumping into the combined speaker systems totals of more than 1000 watts of electrical power. Not to be left out, vocalists work close to their microphones and override the amplified instrument sounds with separate amplifiers. At outdoor concerts, it is not uncommon for rock groups to use huge amplifier systems that push more than 2000 watts through massive theater-type horn speakers.

Equipment produced for amplifying musical instruments should not be confused with entertainment hi-fi systems that are designed to faithfully reproduce sound from various program sources with an absolute minimum of distortion. Instrument amplifiers are noted primarily for their sophisticated electronic gadgetry which rock groups use to create an endless stream of controlled-distortion effects. The output power generated by these devices is considered unsafe for prolonged exposure. Manufacturers of this high-powered gear are well aware of the hearing hazards involved, else they would not put on their equipment such warnings as: "*Caution: Repeated exposure to high sound levels (more than 80 dB) may cause permanent impairment of hearing.*"

Fig. 2. Recovery times from temporary threshold shift for three listeners exposed to pressure level of 105 dB.



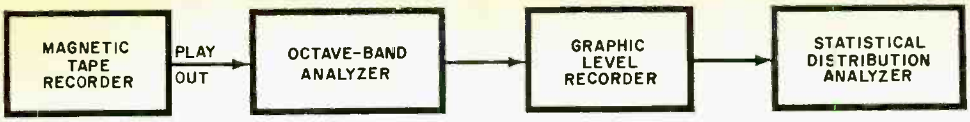


Fig. 3. Measurement system uses statistical approach for evaluation of musical sounds.

One of the effects in the rock music repertoire, known as "fuzz-tone," deliberately distorts the music by shunting the audio signal with a full-wave rectifier at a high-level stage in the amplifier. This eliminates the positive or negative portions of the audio waveform and completely "muddies" the original sound. Then there are the electric guitar "wah-wahs" used to synthesize tones similar to those of the trombone or trumpet. Cross-product distortion is also deliberately introduced by holding the instrument so that certain notes go toward the speaker system and regulating the feedback with a special gain control on the instrument so that several notes can be produced simultaneously, plus the sum and difference frequencies. Still another addition to the sonic boom consists of a pickup microphone attached to any wind instrument, with the amplifier adjusted for a number of tonal variations. Thus, one musician can produce up to four tones at the same time; one octave higher, one or two octaves lower, or any combination with the original tone at any relative sound level.

It must be emphasized at this point that it is not the electronically enhanced instruments themselves that pose the risk of hearing damage. The culprit is the excessive sound pressure levels produced by the electronic systems. At the other end of the scale, electronic modification of musical instruments can provide an almost unlimited variety and combination of effects to enhance the beauty of music. Creative musicians, both pop and progressive, are constantly searching for new sounds and are more concerned with exploring changes in harmonic overtone structures than the production of ear-splitting volume.

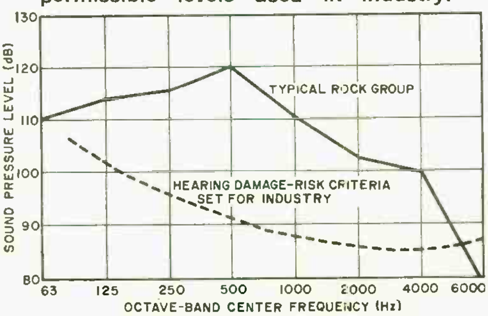
Human Response to Intense Sound. High-intensity sound like that produced by rock groups may affect hearing in a number of ways that are broadly classified as temporary threshold shift (TTS), permanent threshold shift (PTS), and acoustic trauma, the order indicating the general degree of severity of the noise exposure.

TTS is a relatively short-term effect in which exposure to loud sounds raises the threshold of hearing. It temporarily reduces the ear's ability to hear faint sounds. The higher the level of sound and the longer the exposure, the greater the shift in threshold. For example, when individuals are continuously exposed to live rock music, the most common symptom is a prolonged dullness in hearing or in some cases a maddening "ring" in the ears (tinnitus). This is somewhat analogous to the temporary impairment in visual acuity following the triggering of a flashbulb.

Sound components with maximum energy concentrated in the low-frequency range produce less TTS than those sounds concentrated in the high frequencies. So, a loud rumbling sound is less dangerous to the ears than is a screeching sound. If the exposure to intense musical sound is brief, the TTS will gradually diminish until some of the acoustical fatigue disappears. But complete recovery may take hours or even days. As a general rule, sound levels below 80 dBA (80 dB on the A-weighted scale of a sound-level meter) do not produce significant TTS; higher levels may produce shifts as great as 50 dB.

The recovery patterns of several individuals exposed to mid-band noise at a 105-dB sound pressure level for a period of 90 minutes are shown in Fig. 2. Here 0 dB represents the normal hearing thresholds established by audiometric measurement prior to exposure. In each case, the hearing response after exposure was taken at 4000 Hz where the human ear is par-

Fig. 4. Octave-band levels of typical rock group compared to 8-hr maximum permissible levels used in industry.



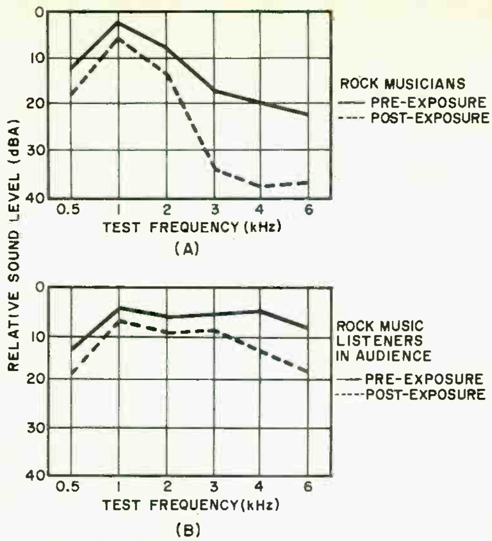


Fig. 5. Hearing levels after a 3-hr session; average sound level 112 dBA.

ticularly vulnerable to TTS. It can be seen that the initial hearing loss as well as complete recovery time varies widely among the listeners.

A point to consider is that, when intense musical sounds are interrupted, the ear can rest and partially recover from the effects of the noise. Due to the intermittent nature of most live rock music performances, the risk of hearing damage is somewhat reduced. These periodic interruptions, including intermission time, permit the ear to tolerate the sound for a longer duration and, hence, result in partial recovery from auditory fatigue. Nevertheless, repeated exposure to sound levels greater than 80 dBA over a prolonged time, not followed by adequate recovery time between exposures, will eventually lead to partial deafness or permanent threshold shift.

The onset of permanent damage is characterized by a fairly predictable sequence of events. Musicians, audiophiles, and other critical music enthusiasts would probably be the first to note a loss of hearing acuity for high-pitched sounds like the overtones produced by a violin or piccolo. The presence of these overtones gives character and quality to music and enables the listener to distinguish between instruments in the higher frequency range.

If the damaging exposure continues, permanent hearing loss will eventually be extended to the mid-frequency range that is most important for understanding speech. At this stage, when the hearing loss affects the ability to conduct verbal conversations under everyday conditions, nothing can be done to reverse the condition. Profound deafness or total loss of hearing due to continuous exposure over many years must be regarded as unusual, but there is no reliable way to predict which musicians or listeners might suffer impairment.

Measurement Procedure. In measuring musical sound levels, instrumentation tape recorders provide a means of obtaining a large amount of data that can be analyzed in an acoustic laboratory. These recorders are usually provided with two input channels, one accepting the output of a sound level meter and the other feeding a separate voice track for marking and identification purposes. Included in the measuring system is a sound level meter calibrator that supplies a frequency of precisely known sound pressure level to the pickup microphone and makes possible the recording of a reference signal. To handle the wide range of signal levels encountered in noise measurement, an accurate step attenuator is incorporated in the tape recorder to shift the recorded calibration signal to any convenient level so that any differences in the setting of the attenuator can be related to various playback level adjustments.

In the lab, a sample of recorded music is played through an octave-band analyzer that electronically separates the acoustic energy into identifiable frequency bands. As shown in Fig. 3, the analyzed output is fed to a graphic level recorder to provide a continuous written record of the data as a function of time. It is often convenient to extend the graphic recording of the sound level by statistical techniques to evaluate the music sounds automatically in terms of duration of sound energy. For this purpose, a statistical distribution analyzer presents a numerical display of the recorded information simultaneously with the writing process in the level recorder.

A plot of the octave-band analysis of sound pressure levels produced by a typical live rock music group is shown in Fig. 4. For comparison, the octave-band levels are given for the maximum permissible exposure limit, equivalent to 90 dBA, specified by federal regulations for industrial noise exposure during an eight-hour workday.

Accordingly, the interval of exposure can be increased by 5 dB for each halving of the duration of exposure without increasing the risk of noise-induced hearing loss. Thus, for a sound level of 95 dBA, the exposure must not exceed four hours per day, and for a level of 115 dBA, it must not exceed more than 15 minutes per day. Clearly, the sound levels generated at live rock concerts are well above the hearing conservation limits set for industry.

Noise Exposure Tests. Unfortunately, the relationship between temporary and permanent hearing loss cannot be determined directly in humans because the inner ear is a delicate area that is almost totally inaccessible for examination. It is necessary, therefore, to use experimental animals. In a recent experiment, researchers at the University of Tennessee exposed guinea pigs to recorded rock music at the approximate peak sound pressure level of 120 dB likely to be encountered in a rock music hall. Listening sessions were spread over a period of three months at intervals designed to match the listening habits of the average rock music buff. At the end of this period, the inner ear cells were exposed to microscopic examination where they clearly revealed the effects of cell destruction in the cochlea which translates sound waves into nerve impulses.

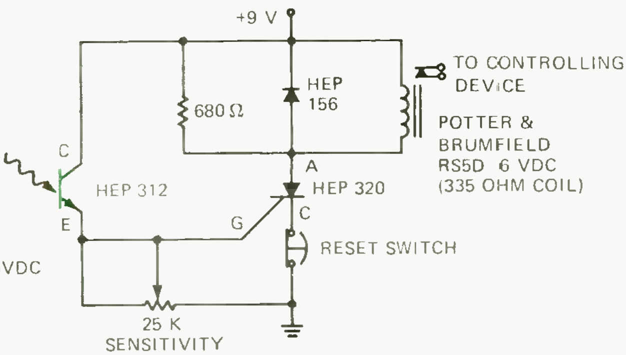
The Public Health Service has been collecting data from sample observations of rock music levels in order to determine the effects on the hearing of rock group members and individuals attending rock sessions. In a typical sample taken during a teenage rock session (see Fig. 5), the sound levels averaged 112 dBA and were fairly uniform throughout the hall. The hearing levels of the musicians and a group of audience listeners were determined by audiometric measurements just before and immediately after the three-hour rock concert. According to Fig. 5A the pre-exposure levels of the rock group members show a greater average hearing loss as compared to the listeners as shown in Fig. 5B, due no doubt to their more frequent exposure to high-level sound. Both cases, however, show significant temporary threshold shifts as indicated by marked differences between pre- and post-exposure hearing levels.

Repeated exposure to live rock music is only one aspect of over-stimulation of the human ear experienced by those people engaged in recreational activities. In assessing the risk of hearing damage, due consideration must be given to the accumulation of numerous other sources of noise pollution encountered in everyday modern living in both social and industrial environments. ◈

HEADLIGHT OPERATED GARAGE DOOR OR LIGHT SWITCH

FEATURES:
- Relay contact will close when light hits photodiode.
- Sensitivity adjustment to prevent false triggering.
- Low battery drain

PARTS LIST:
1 HEP 312
1 HEP 320
1 HEP 156
1 Resistor, 680 ohms, 1/2 Watt
1 Potentiometer, 25K
1 Push Switch, Normally Closed
1 Relay, Potter-Brumfield RS5D, 6VDC
1 Battery, 9VDC



LOW-COST IC SIGNAL GENERATOR

AUDIO AND 455-kHz R-F FROM A SINGLE IC

BY EMERSON M. HOYT

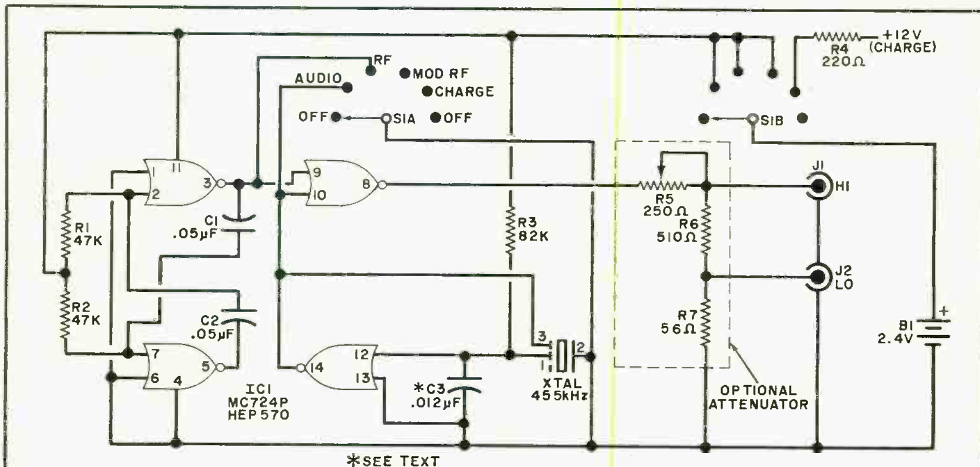
THE CIRCUIT shown below, using a readily available quad dual-input NOR gate IC and a ceramic "transfilter," makes an ideal tester of audio, r-f, and i-f stages in BCB receivers.

Two sections of the IC are cross-coupled through *C1* and *C2*, and, with *R1* and *R2*, they form an astable multivibrator operating at about 500 Hz. The third IC section (with *C3* and *R3*) operates as a "crystal" oscillator using the 455-kHz transfilter (*XTAL*). Some trimming of *C3* may be required to bring the output frequency to exactly 455 kHz. (A random selection of IC's and transfilters showed a capacitor range of 0.01 to 0.022 microfarads.) The two oscillator outputs (audio and r-f) are fed to the fourth section of the IC. This gate functions as a chopper or modulator—and as a buffer amplifier to isolate both oscillators from the output load.

Switch *S1* selects a 500-Hz square wave for audio testing, a 455-kHz continuous pulse train, or a 455-kHz pulse train chopped at a 500-Hz rate. This switch can also be used to recharge the nickel-cadmium batteries through *R4*. Output impedance without the attenuator is about 600 ohms.

Power is furnished by a pair of AA nickel-cadmium cells that provide about 2.4 volts over their useful life. The current drain of about 10 mA should yield a continuous operating life of 50 hours per charge. The batteries are charged from a +12-volt dc line through *R4* which limits current to about 50 mA.

The simple output attenuator uses *R5* to calibrate the output to 1 volt at *J1*. The two resistors associated with *J2* form a 10:1 divider and produce 0.1 volt at *J2*. If any other power source is preferred, any dc potential from 1.5 to 4 volts can be used. ◈



PARTS LIST

B1—Two AA nickle-cadmium rechargeable cells
C1,C2—0.05-μF capacitor
C3—0.012-μF capacitor (see text)
IC1—MC724 or HEP570 quad two-input NOR gate
J1,J2—Phono jacks
R1,R2—47,000-ohm, ½-watt resistor
R3—82,000-ohm, ½-watt resistor
R4—220-ohm, 1-watt resistor
R5—250-ohm linear potentiometer
R6—510-ohm, 5% resistor
R7—56-ohm, 5% resistor
S1—6-position, 2-pole rotary switch
XTAL—Transfilter, 455 kHz (Clevite TO-01A)
Misc.—Suitable chassis, battery clips, mounting hardware, etc.

BY STEVEN E. MARGISON

Stage Lighting for the Amateur

CONTROLS 1500 WATTS PER CHANNEL WITH PRESET STORAGE, CROSS FADING, AND SUBGROUPING

WHETHER it's the graveyard scene in "Our Town" or "June Is Busting Out All Over" in "Carrousel," one of the main concerns of the amateur (community, off-off-Broadway, etc.) producer is the lighting effects. Fortunately for everyone, the days of the cumbersome, creaky rheostats are gone—replaced by the era of silicon controlled rectifiers, Triacs, and other semiconductor devices.

Many little theatre groups now use the General Electric Triac modules, which are available in capacities of 6, 10 or 15 amperes. As in all things, however, there are improvements and circuit variations that can be made to enhance the overall effect. Here are some of the modifications that can be made.

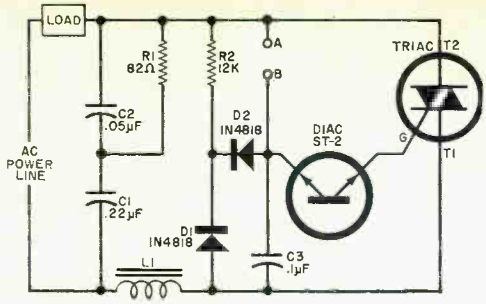
The circuit in Fig. 1 shows the basic wiring of the GE Triac assembly (except that *R2*, *D1*, and *D2* have been added). The added components prevent the "snap on" effect which usually occurs when the dimmer is first energized.

In Fig. 1, the usual potentiometer control has been removed from the circuit, and the circuit shown in Fig. 2 is connected to the terminals marked A and B. The use of the circuit in Fig. 2 provides a master control function and permits safe remote operation since the controls are powered by low-voltage dc.

Master Control System. The heart of the control circuit is a photocell-lamp combination. When the lamp is illuminated, the resistance of the photocell goes down, and vice versa. Transistor *Q1* can handle up to 3 amperes so that it can control as many as 25 dimmers. Potentiometer *R4* is the master control while *R3* and *R6* are trimmers for initial setup. Switch *S1* is used to turn the control off and to select either independent or master control.

Potentiometer *R7* is the actual dimmer control, while *R8* and *R9* are trimmers. Potentiometers *R4* and *R7* are mounted on the front panel; other controls are within the cabinet. Transistor *Q2*, preset by *R1*, is used to set the voltage on the independent line to the same value as the voltage on the master line.

To insure long life, transformer *T1* and *RECT1* should be selected to give more power than required. For instance, a 10-dimmer system requires a 1-ampere transformer; but a 1.5-ampere unit is better. The current rating of the transformer (at 10 volts) can be found by multiplying the number of dimmers by 0.1.



PARTS LIST

C1—0.22-µF, 200-volt capacitor
C2—0.05-µF, 200-volt capacitor
C3—0.1-µF, 200-volt capacitor
D1,D2—1N4818 diode
DIAC—ST-2 (General Electric)
L1—2" x ¼" ferrite core wound with double layer of #14 heavy Formvar magnet wire.
R1—82-ohm, ½-watt resistor
R2—12,000-ohm, ½-watt resistor
TRIAC—To suit load current
Note—All parts mounted on ⅛" thick aluminum, minimum area 12 sq in.

Fig. 1. Schematic of 1500-watt commercial dimmer module (except for R2, D1, and D2).

Construction. Most circuit breakers are not fast enough to protect the Triacs, so fast-acting fuses should be used. A good choice is the 3AB type, which is the ceramic version of the conventional 3AG. A better, though more expensive fuse, is the KAA rectifier fuse.

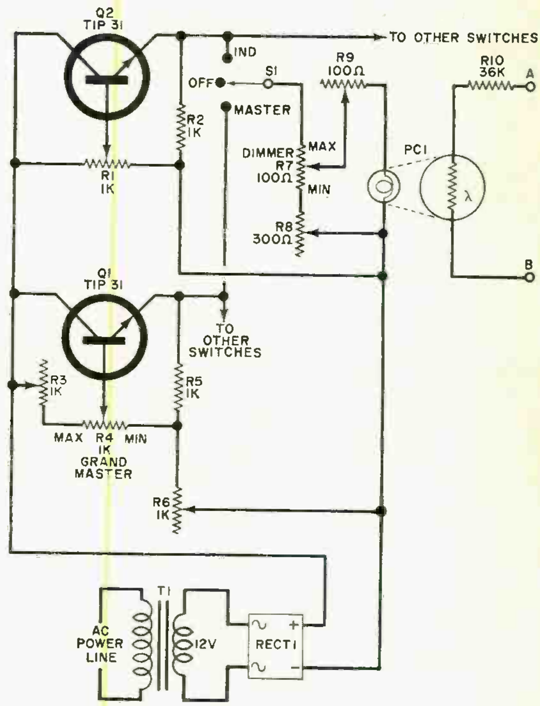
The two transistors must be mounted on heat sinks using mounting insulation. The photocell/lamp assembly should be mounted within the control cabinet with the long leads connected through *R10* to points A and B on the Triac module.

To avoid switching transients and radio frequency interference, use appropriate shielding and grounding in the modules and the associated wiring. Switching transients affect other dimmers in a manner called "tracking", which occurs only when several dimmers are operated at very low intensities. A slight change in the setting of one or more dimmers will correct the problem.

If there are problems with mechanical noise emanating from the dimmers, do not shock mount them to reduce the noise. This increases their internal heat and may result in early failure.

If the dimmers are not overloaded or short-circuited, the only damage they can suffer is from excessive heat. Make sure that the dimmer cabinet is well ventilated and that the modules are mounted on a heavy aluminum plate. The addition of a small, quiet fan will also help. The fan should be mounted to exhaust air from the cabinet and should be connected so that it goes on as soon as *T1* receives power.

If desired, a set of panel lights, operating on the 10-volt dc line and controlled by a 100-ohm potentiometer can be used. Treat each lamp as if it were a dimmer in determining transformer and rectifier capacity.



PARTS LIST

PC1—Vactrol VT10150 photocell lamp module (do not substitute)
Q1,Q2—Transistor (TIP31 or TIP31A)
R1,R3,R6—1000-ohm, ¼-watt trimmer potentiometer (Mallory MTC13L1)
R2,R5—1000-ohm, ½-watt resistor
R4—1000-ohm, linear taper, ½-watt potentiometer (Mallory U4)
R7,R9—100-ohm, 5-watt potentiometer (Mallory VW-100)
R8—300-ohm, 5-watt potentiometer (Mallory VW-300)
R10—36,000-ohm, ½-watt resistor
RECT1—50-100-volt rectifier module, current to match T1
S1—Spdt switch (Switchcraft 3034L)
T1—12-volt filament transformer (see text for current ratings)
Misc.—Heat sinks (Wakefield NC-633-3B), knobs (National HRS-3), suitable chassis, line cord, mounting hardware, etc.

Fig. 2. Remote control circuit to operate the phase-shift network in the Triac module.

Initial Adjustment. Adjustment is not critical, but it does require some patience to get the best results. Always adjust one trimmer at a time, and use a lamp load equal to about 60% of the dimmer's rated capacity. Use the following procedure:

1. Turn off all *S1*'s and set all controls to zero.

2. Set *R3* and *R6* for maximum resistance and *R4* for full intensity.

3. Connect the positive lead of a dc voltmeter to the emitter of *Q1* and negative lead to ground. Apply power.

4. Adjust *R3* to get a voltage indication of 5.5.

5. Set *R4* to minimum and adjust *R6* to get a 2.5-volt indication. Repeat steps 4 and 5 until *R4* varies the voltage between 2.5 and 5.5.

6. Set *R4* for full intensity. Set *R9* for maximum resistance and *R8* at 50%. Connect load to dimmer under adjustment and *S1* to MASTER position.

7. Set *R7* to maximum and adjust *R9* until the lamp no longer increases in intensity.

8. Set *R7* slightly off zero and adjust *R8* until the dimmer just begins to hum. Leave this setting for about 30 seconds. If the dimmer drifts either up or down, readjust *R8* until the humming is sustained, but as low as possible.

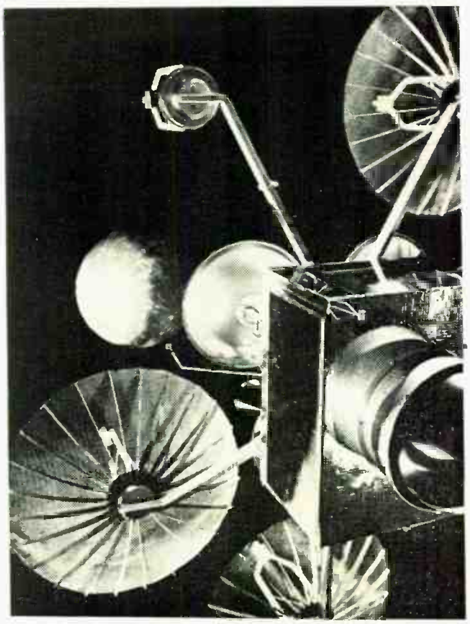
9. Repeat steps 7 and 8 for each of the other dimmers. Make sure that dimmers not being adjusted are off.

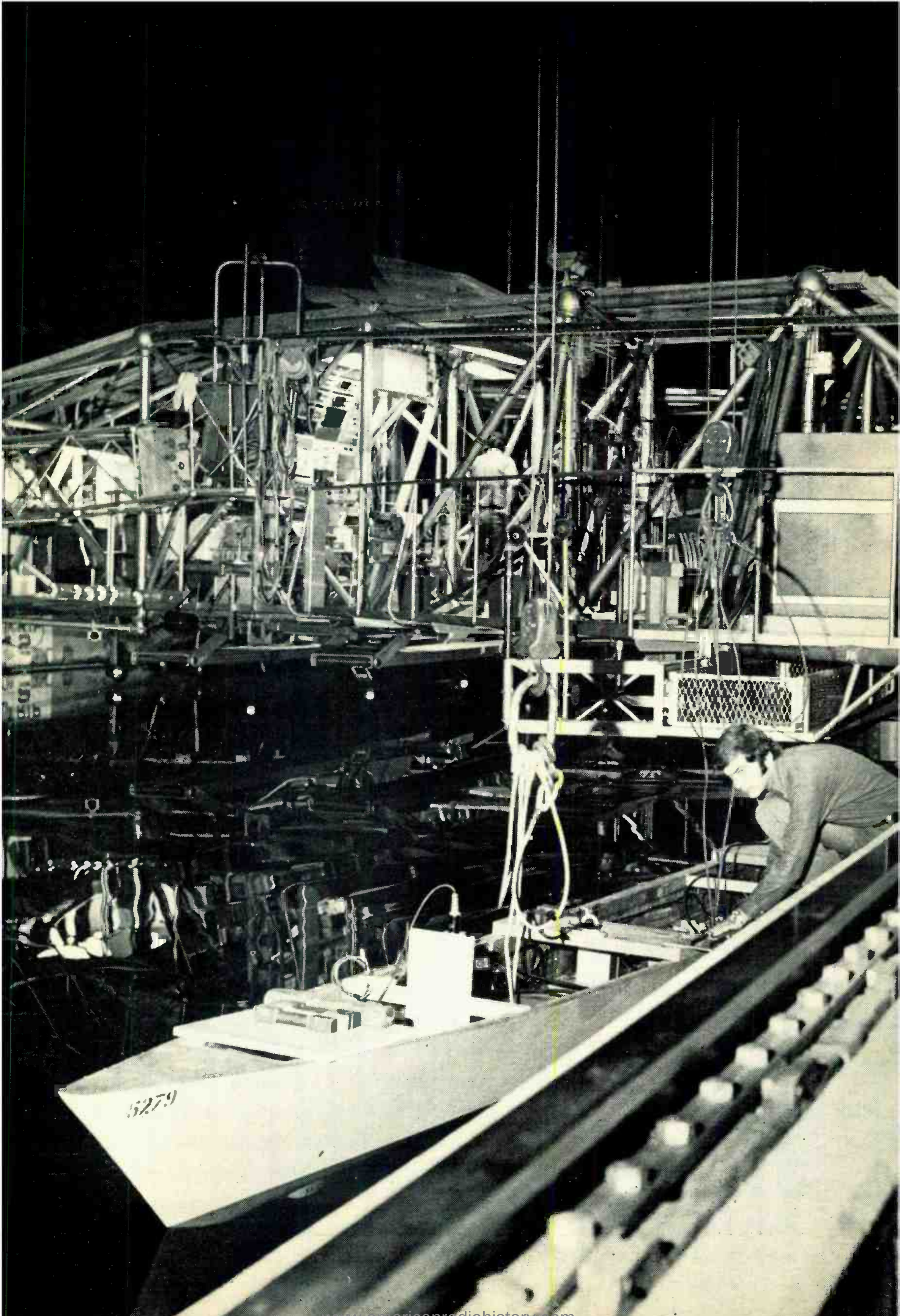
10. Set *R4* for maximum and any other dimmer to maximum (*S1* on MASTER) and read the voltage as in step 3. Move the positive voltmeter lead to the emitter of *Q2* and adjust *R1* for the same reading. Be sure to have one dimmer set to INDEPENDENT when making this adjustment.

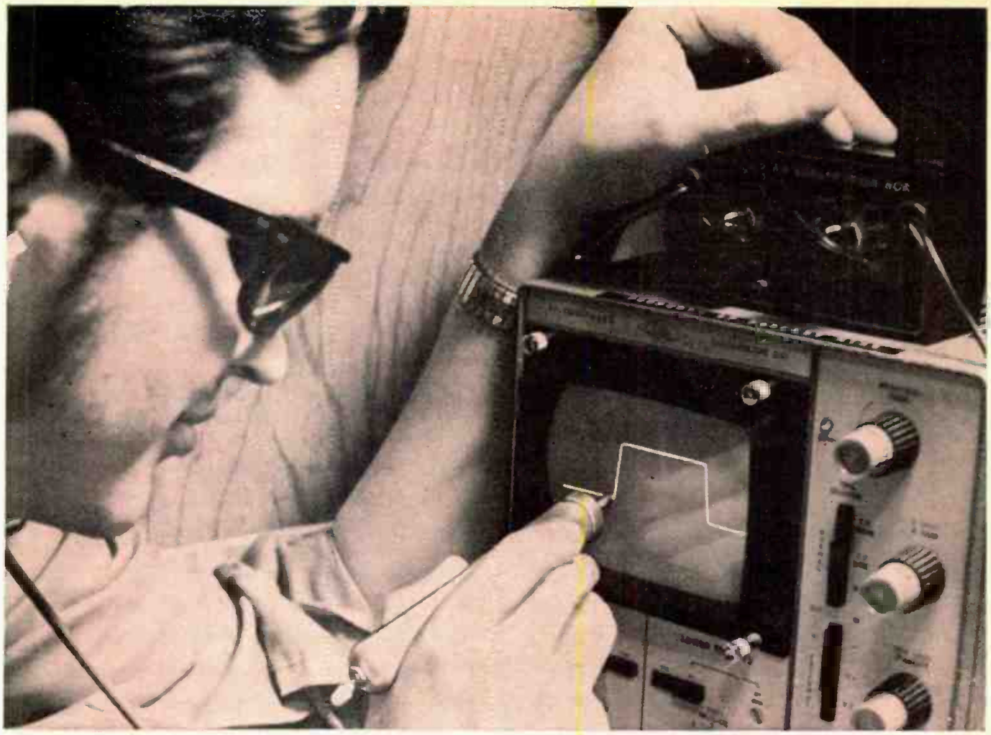
Readjustments should not be necessary unless parts are replaced. However, if the unit receives a great deal of use, readjustment after the first 100 hours may be necessary to correct for component aging. On rare occasions, *R8* may not have enough resistance to bring the blackout point of the dimmer below 1 or 2 on the knob scale. If this happens, insert a 150-ohm, 1-watt resistor in series with *R8* and proceed with the adjustment. Since *PC1* never operates above 50% of its rated voltage, it should last many years, but a few spares should be kept on hand. The *R7* controls may get slightly warm during use, but this is normal. ◈

THE NEXT COMMUNICATIONS SATELLITE?

Next generation of international communications satellites may look like this one proposed by Lockheed Missiles & Space Co. Large flex-rib antennas, horn antennas and telemetry antennas flank a model of the earth (background) on this model. In the foreground is the apogee kick motor to put the spacecraft into circular geosynchronous orbit at 22,300 miles altitude. The rectangular box contains batteries, communication relay systems and station-keeping hardware. Lockheed has been studying the satellite configuration for the Communications Satellite Corp. (COMSAT) and the Interim Communications Satellite Committee of the International Telecommunication Satellite Consortium (INTELSAT).







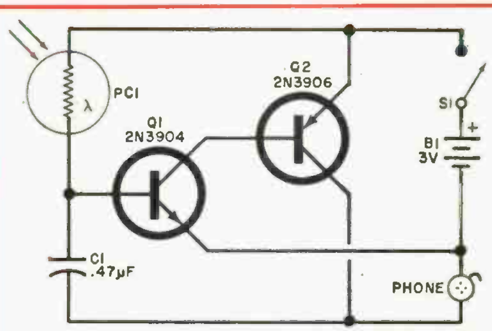
Build a LIGHT PROBE

ELECTRONIC HELP FOR THE BLIND

BY FORREST MIMS

IF YOU have a blind relative or friend, here is a chance to provide him with a simple-to-use light probe that will enable rapid location of pilot lights on a panel, switchboard, or multi-extension telephone; orient his position with respect to the sun; or even "read" the hands on a conventional clock. A blind person can use the probe to detect the presence or absence of artificial illumination within a room; and it could even be employed to read the waveforms on a scope.

The circuit (Fig. 1) consists of a simple two-transistor audio oscillator whose output frequency is dependent on the amount of



PARTS LIST

B1—3-volt alkaline battery (Eveready 532 or Mallory PX-24)
C1—0.47-μF, 6-volt capacitor
PC1—Cadmium sulphide photoresistor (Calectro J4-805, RCA SQ2429, Clairex CL5M AL)
Q1—Transistor (2N3904, HEP736)
Q2—Transistor (2N3906, HEP715)
S1—Spst miniature toggle switch
SPKR—Miniature earpiece
Misc.—1¾" by ½" perforated board, aluminum cigar tube, battery clip, hook-up wire, collimator tube.

Fig. 1. Output frequency of oscillator circuit is determined by light striking PC1.

light striking the sensitive surface of a photoresistor (*PC1*). The prototype has a frequency range of up to 5500 Hz, depending on the amount of light striking *PC1*.

Construction. As shown in the photograph, all components except for the battery and on-off switch are mounted on a 1¾" by ½" piece of perf board. The photoresistor is mounted at one end, at right angles to the board. Before mounting the miniature earphone which is to act as the speaker, remove the plastic sound guide (the part that goes in the ear), cut the leads to about one inch, and remove a small portion of the insulation. Push the leads through a hole in the board, press the earpiece close to the board and solder the two leads in place to secure the earpiece. A drop of cement may be used to form a secure mount.

The final assembly is best made in an aluminum cigar tube measuring 5¼" by ¾". Lay the finished perf board assembly beside the tube and mount a battery clip (for the 3-volt alkaline battery) and switch *S1* so that *S1* will protrude through the round end of the cigar tube (see photograph). Use heavy wire for this installation so that the entire assembly can be easily inserted or removed from the tube.

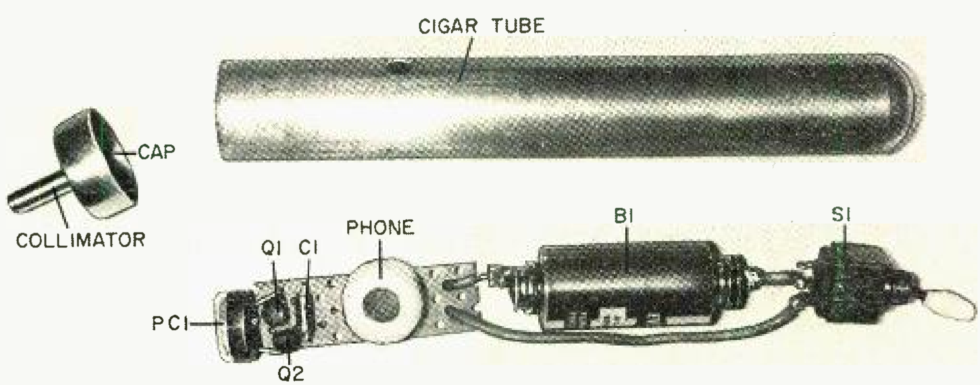
Use a sharp punch and miniature file to form the mounting hole for *S1* at the round end of the tube. Do not use a drill for this hole, unless you have a small hobby-type drill, as the aluminum tube is very thin and can distort very easily. Another hole, this one about ¼" in diameter, should be made in the wall of the tube, directly opposite where the speaker will be located when the assembly is in the tube.

The assembly must be made so that the sensitive surface of the photoresistor is close to the open end of the tube. You can either make a small hole in the cigar tube cap to allow the outside light to strike the photoresistor, or you can use a discarded clock gear wheel having a hollow axle as a light guide. The axle can be inserted from the inside of the cap and the gear wheel cemented to the cap as the support.

Operation and Use. To test the probe, turn on *S1* and aim the probe at different light sources around the room. There will be many different tones heard as the probe sweeps the room. If you find that the probe is too sensitive and cuts off at relatively low light levels, use a small piece of polarizing material on the interior of the light hole in the cap and another small piece covering the photoresistor. (Be sure that the cement does not cover the sensitive surface.) The light input can then be controlled by rotating the cap to cross the polarizers.

The light probe can be modified for special applications. For example, a miniature lamp mounted near the cap can be used to illuminate dark areas to improve the probe's ability to "read" clock hands or meter pointer positions. A blind electrical engineering student has successfully used the prototype with a narrow-bore light collimator (tube) to read the waveforms displayed on a CRT and the panel lights on a computer board. ◈

Components, except for battery and switch, are mounted on a small piece of perf board and entire assembly is inserted in aluminum cigar tube with light collimator in cap.



LOW-COST MILLIVOLTER

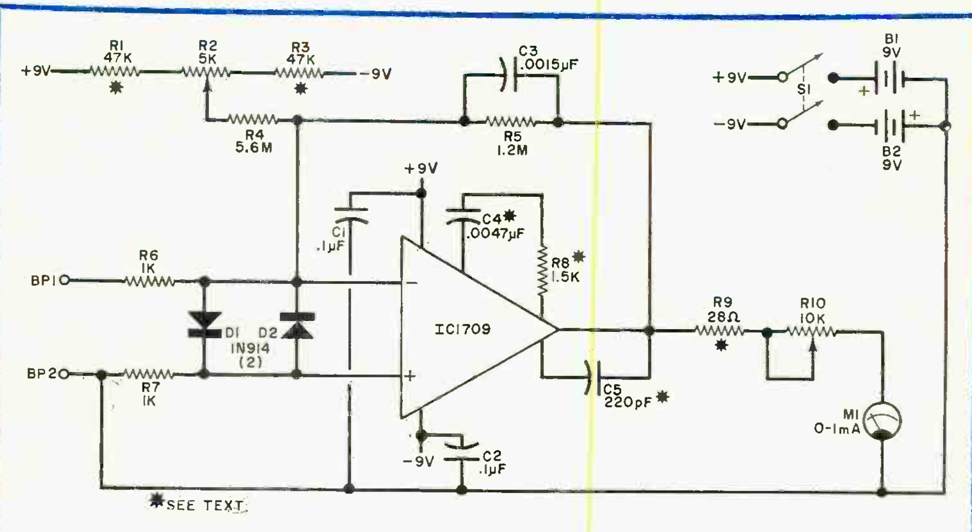
MEASURES BETWEEN 1 mV AND 1 VOLT FULL SCALE, AND CAN BE USED AS AC VOLTMETER

BY RALPH TENNY

WITH the increasing trend toward the use of semiconductors and the necessity for measuring voltage in the range of 1 mV, it is apparent that the trusty old VOM has about reached its limit. However, if your VOM has a low-current range (preferably 1 mA full scale) or if you have a 1-mA meter, all you need are a few low-cost components to make a dc voltmeter having a range of 1 mV to 1 volt full scale with an input resistance of 10,000 ohms/mV.

Using the meter with a zero-center scale, accurate voltage settings, independent of the voltage level can be made. Or, if desired, the circuit can easily be converted into a handy ac voltmeter.

As shown in Fig. 1, op amp *IC1* is connected as a current amplifier; that is, a change in current at the input causes a change in voltage at the output. The combination of *R9* and *R10* regulates the circuit sensitivity. The network consisting of *R1*,



PARTS LIST

B1,B2—9-volt battery
BP1,BP2—5-way binding post
C1,C2—0.1-µF, 25-volt ceramic capacitor
C3—0.0015-µF ceramic capacitor
*C4—0.0047-µF ceramic capacitor**
*C5—220-pF capacitor**
D1,D2—1N914 or 1N662 diode
IC1—709 or 741 op amp
M1—0-1-mA meter
R1,R3—47,000-ohm resistor (see text)
R2—5000-ohm potentiometer
R4—5.6-megohm resistor
R5—1.2-megohm resistor
R6,R7—1000-ohm resistor
*R8—1500-ohm resistor**
R9—(see text)
R10—10,000-ohm potentiometer
S1—Dpdt switch
**Use for 709 op amp only.*
Misc.—Suitable case, battery holders, mounting hardware, etc.

Fig. 1. Integrated circuit is connected as a current amplifier to drive 1-mA meter.

R2, R3, and R4 furnishes an offset bias to balance out any static differential voltage in the input. This insures that the meter will indicate zero with no signal input. As an added feature, this network has sufficient range to set the meter for a zero indication at center scale. The final values of R1 and R3 can be between 18,000 and 68,000 ohms, depending on the op amp used.

Capacitors C1 and C2 are power supply filters and should be mounted as close to the op amp as possible. Resistor R8 and capacitors C4 and C5 are used to compensate the 709 op amp used. If you use a 741 op amp, these three components are not required since the 741 is internally compensated.

Construction. The circuit can be assembled on perf board or on a small etched PC board. Do not use the chassis for a ground; the entire circuit should be "floating" with BP2 as the common. Mount D1 and D2 as close to their op amp pins as you can. Check to make sure that you are using the correct pins on the IC and that both diodes are installed properly.

Checking. Set R10 at its maximum resistance. Then set R2 to its electrical center. With the power turned on, the meter should deflect very little from zero. This can be compensated for by adjusting R2. If the meter should deflect very much in either direction, shut off the power and recheck the circuit.

If the meter behaves correctly, slowly reduce the value of R10 and adjust R2 for meter zero. Repeat this procedure until R10 is at its minimum and the meter is set for zero.

Calibration. Connect the meter as shown in Fig. 2A. With the values shown, the meter should deflect just about full scale. Trim the value of R9 for an exact indication.

Sensitivity is set by changing R11 as follows: 10,000 ohms produces 1 mV full scale; 100,000 ohms, 10 mV full scale; 1 megohm, 100 mV full scale; and 10 megohms, 1 volt. The meter scale can be calibrated accordingly.

Uses. To use the meter as a null indicator for setting a precise voltage, use the circuit shown in Fig. 2B. Set the meter for zero using R2. Then start with R12 at maximum resistance and adjust R13 for zero indication. Keep reducing the value of R12, resetting R13 for zero each time, until R12 is at minimum resistance. The voltage at the rotor of R13 will now be within a few microvolts of the standard voltage.

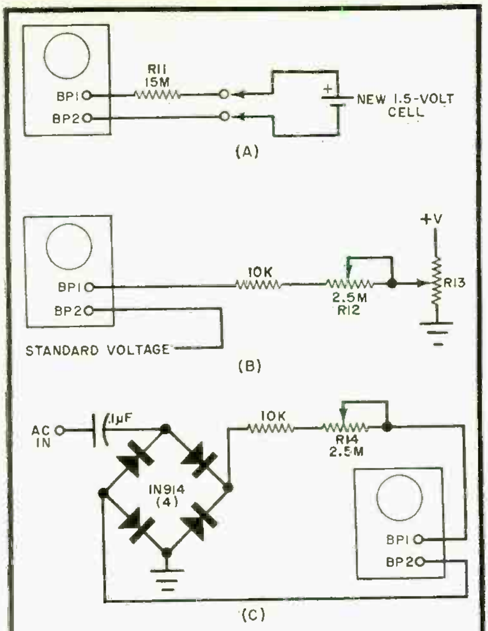
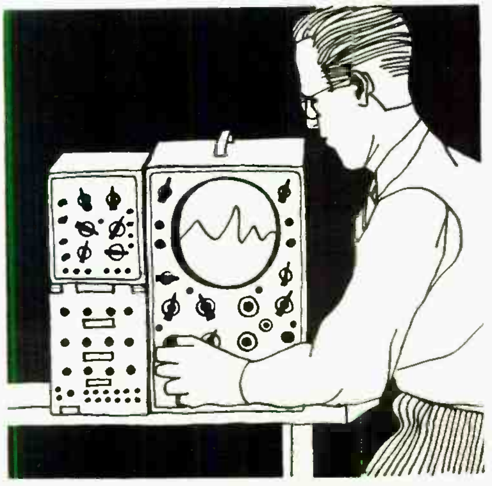


Fig. 2. Circuits for calibration (A), null indicator (B), and ac meter (C).

To make the meter function as an ac voltmeter, use the circuit in Fig. 2C. Apply the ac voltage and, starting with R14 at a high resistance, reduce it to get a more sensitive indication. Using an accurate source of ac, R14 can be calibrated in range. ◈



Make a Squawk Box Toy for $3

IT WILL ENTERTAIN AND EDUCATE YOUR CHILDREN

BY BENNETT A. LOFTSGAARD

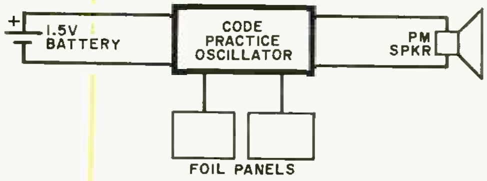
TOYS are the best aids for keeping children occupied and out from under foot. The Squawk Box circuit shown in the diagram, when assembled, will emit squealing, squawking, and other strange sounds which should keep any child of eight years old and less absorbed for hours. It even has a built-in secret which the small fry will soon discover.

The parts needed for the Squawk Box are readily available. They include a cigar box, aluminum foil, a battery with holder, a code practice oscillator kit (available from most electronics outlets), and a small PM speaker. The whole thing should not cost you more than about $3.

The first thing to do is cut a piece of aluminum foil to a size so that it covers the entire cigar box lid and overlaps the front and both sides by about 1½". Rubber cement the foil to the lid, neatly tucking the foil around the edges of the lid and cementing it to the lid's inside surface. Use a sharp knife to remove a ¼"-wide strip of the foil down the center of the lid, ending up with two electrically insulated foil panels. Insert a straight pin on a slant through each foil panel on the inside of the box lid. Solder an 8" length of hookup wire to each pin.

Using the circuit diagram which accompanies the code practice oscillator, locate and remove the feedback capacitor. Then wire the speaker and battery holder to the appropriate wires on the oscillator and the two wires coming from the straight pins to the points from which the feedback capacitor was removed. Mount the CPO, battery holder, and speaker to the floor of the cigar box. (Note: Before mounting the speaker, punch or drill a few holes through the bottom of the box so that the sound can get out.)

Insert a battery into the battery holder and close the cigar box, using a length of transparent or masking tape to keep the lid down. To test the Squawk Box, simply place one hand on each of the foil panels. In so doing, your body should complete the circuit and you should hear a "squawking" sound.

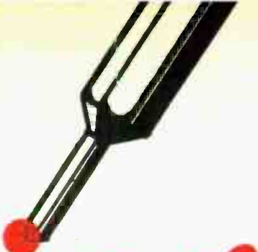


Parts necessary for the Squawk Box are a cigar box, aluminum foil, battery with holder, code practice kit, and small permanent magnet speaker. To assemble the Squawk Box, use the diagram that is provided with the CPO kit. The aluminum foil panels are substitutes for feedback capacitor.

Now, give the Squawk Box to the kids and let them figure out how it works. In a little while, they will learn that several of their friends can form a hand-holding chain to make it work. They will also find that the better the contact, the lower the tone. As a result, the toy tends to respond to the emotions of the person or persons playing with it.

The secret? Some ingenious child is sooner or later going to touch one panel with his hand and the other panel to a good earth ground (such as a water pipe), and—lo and behold—he is going to hear music or announcements. He will find that his Squawk Box is also an AM receiver capable of picking up nearby signals. ◈

Solder & Soldering



WHAT GOES INTO A GOOD ELECTRICAL CONNECTION

BY CLIFFORD L. BARBER

Research Director, Kester Solder Co., Div. of Litton Industries

SOLDER is one of civilization's oldest and most widely used alloys. Its many uses and applications readily lend themselves to relatively simple techniques and processes. Yet, this alloy is one whose properties are traditionally a subject of wide technical and scientific misunderstanding.

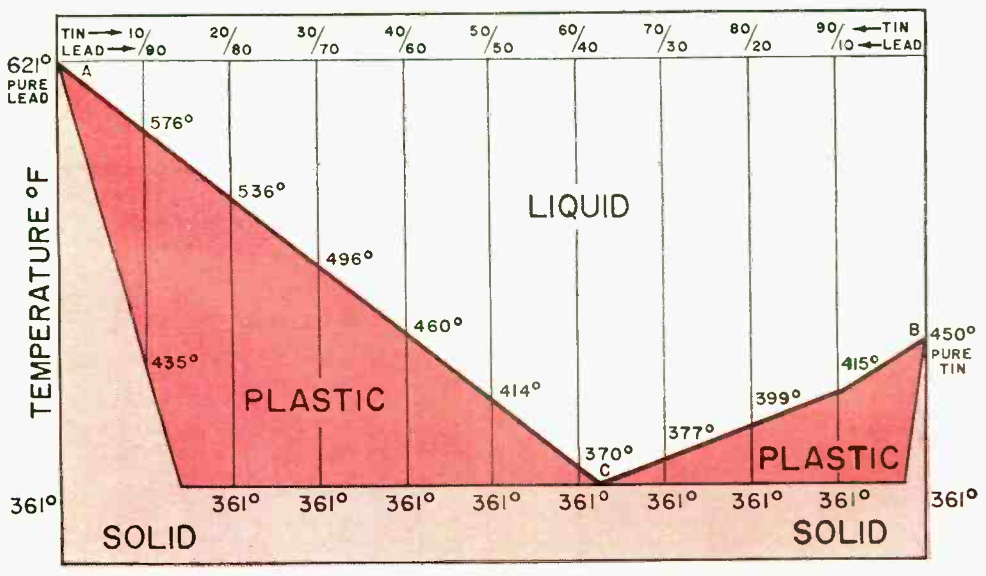
The somewhat limited technical knowledge many people have with reference to solder is even more pronounced in the case of soldering fluxes. In view of the fact that solder and its fluxes are fundamental to electronics, whether in industry or in the pursuit of a home hobby, it is not surprising to learn that a great deal of the difficulties found in electronic equipment can be traced to poor soldering and/or poor solders and fluxes. And that poor soldering can, in turn, be traced back to the operator's lack of knowledge about the principles and practices required for good soldering.

Soft solder is a fusible alloy whose basic components are tin and lead. Occasionally, small amounts of such metals as silver, antimony, or bismuth are added to the tin and lead for one reason or another.

Solder is used to join two metals, in a metallic union, at temperatures well below the melting points of the metals being joined. Since soldering is exclusively an intermetallic proposition that takes place between metals only, it is important that the metals be free from all nonmetallic material. Chief among these materials are oxides which form to a greater or a lesser extent on the surfaces of all ordinary metals.

Oxides form an insulating barrier that prevents metal-to-metal contact. Such ox-

Fig. 1. Tin-lead fusion diagram shows eutectic point with alloy of 63% tin, 37% lead.



ides or any other inert or nonmetallic material on the surface of the metal to be soldered will foil any soldering attempt.

Metal "Solderability." When soldering, the first consideration to take into account is the "solderability" of the metal to be soldered. Solderability is a function of the natural chemical affinity of the metal for solder, the cleanliness of the soldering surface, and any applicable soldering aid, such as hot tinning or electroplating.

It should be understood that some metals are not solderable in their natural states. They simply do not have a metallurgical affinity for solder. Some examples are aluminum, silicon, magnesium, chromium, and tantalum. To solder such metals it is necessary first to plate their surfaces with metals that will readily take to solder. Plating metals to obtain solderability, it is interesting to note, is not confined to the unsolderable or difficult-to-solder metals only. It is also widely used on virtually all easily solderable metals to increase their solderability and prolong their shelf lives.

Nonmetals, too, such as glass or ceramics, can be made solderable by a process known as "firing." Here, powdered silver is mixed with a borate and heated to a point of incipient fusion with the base substance. The result is a physical entrapment of metallic silver on the surface of the nonmetal.

Soldering Problems. One of the most common faults in soldering is the application of insufficient heat. The solution or alloying action in soldering just cannot be achieved without a uniform distribution of heat between the solder and the metal being soldered. If hot solder, for example, is applied to cold metal, or cold solder is applied to a hot metal, there can be no soldering action. Proper soldering can take place only when the metal being soldered is hot enough to maintain the solder in a liquid state. Anything less results in a "cold" soldered joint.

It is important to recognize that soldering depends on the amount of heat absorbed by the metal being soldered. A common source of frustration is the attempt to solder a heavy piece of metal with a low-wattage soldering iron that has insufficient capacity to deliver the required amount of heat.

For most jobs, the ordinary soldering iron or pencil is most widely used and very effective. But care should be taken to select an iron with a wattage capacity that is adequate for the job. The tip, usually a solid bulk of pure copper, should first be cleaned and tinned with solder before any attempt is made to use it in actual soldering. (Wear on soldering tips is not due to erosion or to the soldering flux. It results from the molten solder. Wear is often dealt with by plating the copper tip with iron, but such tips are less effective in transferring heat to the metal to be soldered.) Most important is that the applied heat be adequate to bring the metal being soldered to the alloying temperature.

Flux-core solder combines solder and flux, substances whose properties are physically and chemically very different. Taking into account this dissimilarity, flux-core solder is applied according to a technique that provides for the simultaneous liberation of both substances at a single point where the action of both is required. This application technique can be stated as follows: "Apply the flat surface of the adequately heated soldering iron directly against the assembly and simultaneously apply the cored solder strand at the exact point of iron contact."

Soldering Flux. Soldering is a solvent action that takes place between metals. This action does not take place if the metals are insulated from each other by any type of nonmetallic barrier. It is the function of the soldering flux to remove any such oxide film or barrier and to keep it away during the soldering operation so that the respective metals can make metallic contact and alloy with each other.

A soldering flux, then, is something that causes the liquid solder to make contact with the metal being soldered, or, in technical jargon, to "wet" the metal. Let it be understood, however, that the flux does not enter into chemical reaction with the metal and constitutes no part of the resultant alloy. After soldering, the flux residue and captured oxides, lie harmlessly and inertly on the surface of the solder.

There are three basic types of soldering fluxes: chloride, or acid; organic; and resin or rosin. Of the three, only the last is appropriate for use in electronic circuits and assemblies. The others are too corrosive, leading to difficulties shortly after soldering.

The rosin fluxes, although much less active than either the acid or organic types, possess two features that completely differentiate them from all other types: they

Fig. 2. Graph shows change in joining quality of tin-lead solders with increase in tin content, based on resistance of soldered joint to stress.

are non-corrosive and non-conductive. These two characteristics make the rosin fluxes very adaptable to electrical and electronic assembly.

Most active in the rosin group are the activated rosins, or resins. They are the same as the pure rosins except that they contain small amounts of a dissolved catalyzing substance that causes the rosin to be more active. Although considerably more active than straight rosin, the non-corrosive and non-conductive properties are comparable with those of pure rosin.

In more than 20 years of worldwide use, there has never been an authentic instance of corrosion attributable to the rosin flux residue.

The Solder Alloy. Solder secures attachment by virtue of a solvent or metallurgical action. But this alloy action will not take place unless the solder is of adequate quality with respect to composition and purity.

When tin is added to lead, the melting point of the lead decreases along a composition-temperature line. Similarily, when lead is added to tin, the melting point of tin is lowered along another composition-temperature line. The intersection of these two lines is the eutectic point (see Fig. 1). The composition is the eutectic alloy made up of 63 percent tin to 37 percent lead, and the temperature is the eutectic temperature of 361°F. It will be observed that solder compositions other than the eutectic alloy do not have a sharp "melting point." Rather, they have a plastic range extending from the eutectic temperature of 361°F to the melting point of pure lead or of pure tin (621°F or 450°F, respectively).

The eutectic has a laminated microstructure characteristic of a single constituent. Other solders have a multicomponent microstructure showing high tin or high lead crystals imbedded in the eutectic.

Since tin possesses a higher metal solvent action than does lead, the alloy quality of solder is very closely related to its tin content. As can be seen in Fig. 2, solders containing 30 percent tin are markedly inferior in joining quality. There is an extremely abrupt decrease in alloy quality beginning at about 20 perent tin; solders in this alloy range are sluggish, immobile, and difficult to use.

Complicating the quality of these low-tin solders is a tendency to incorporate soldering fluxes that are inadequate from the standpoints of flux content and flux stability. When attempting to use a low-tin solder, it is particularly important to employ an adequate volume of good flux.

The alloy quality curve reaches its maximum at about 63 percent tin, corresponding to the composition of the eutectic alloy. These eutectic solders are the most mobile and free-flowing of all solder alloys. They are also used almost exclusively for such exacting requirements as printed circuit soldering.

It has been noted that the quality of solder is related to its purity as well as its composition. However, much confusion exists about solder impurities. This is due in part to a lack of definition. For instance, in tin-antimony solder, silver would be an impurity, whereas in tin-silver solder, antimony would be an impurity.

In estimating the quality of solder on the basis of a chemical analysis, it is important to consider not the total amount of the impurity, but the relative significance of each element instead.

Finally, it should be understood that having solder analyzed does not have any effect in solving a solder problem. If solder is causing a difficulty for any reason, the best way to solve the problem is *replace the solder!* ◈

Stopping Engine Run-On

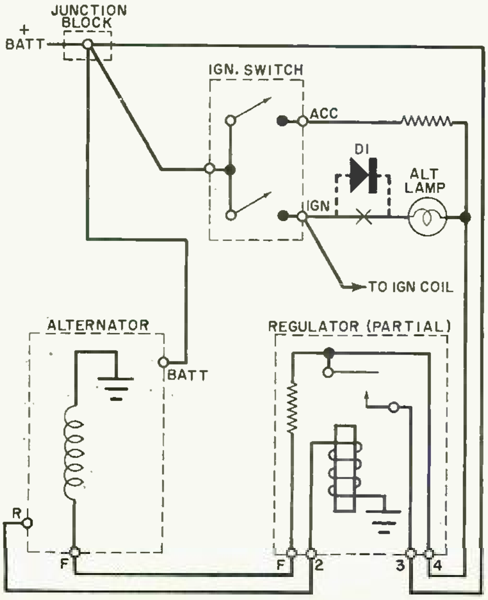
DOES YOUR CAR ENGINE KEEP RUNNING AFTER YOU TURN THE IGNITION OFF?

BY KARL O. AND RICHARD K. JOHNSSON

ONE cause of run-on, or what is sometimes called "dieseling," in many modern cars may be the feeding of electrical power from the voltage regulator to the ignition coil after the ignition switch is turned off.

A portion of the charging circuit for many recent General Motors cars is shown in the diagram. When the ignition switch is turned on, 12 volts from the battery is applied to the ignition coil as well as to the alternator field through the alternator lamp (mounted on the dashboard) and a resistor located in the voltage regulator housing. This energizes the alternator field winding just enough for the alternator to start generating power when the engine runs. This initial flow of current also turns on the alternator lamp to provide a check on the lamp's condition and to indicate that the alternator is not producing power.

Addition of silicon diode to basic circuit (GM shown here) prevents the engine from running when key is off.



When the engine starts, the alternator produces enough power to energize the field relay in the voltage regulator to apply battery voltage directly to the field coil. With 12 volts on both sides of the lamp, it goes out, indicating that the alternator is operating.

When the ignition switch is turned off, inertia keeps the engine turning over for a couple of revolutions so that the alternator is still generating enough power to keep the field relay closed. Now, current (conventional) can flow from the battery through the closed field relay contacts and through the alternator lamp to the ignition coil. This current is limited by the resistance of the lamp (about ¼ ampere), and while it is not enough to produce a good spark from the coil, it may be sufficient to cause the engine to run roughly for some time after the ignition switch is off. With a transistor type of ignition system, this small current may be enough to keep the engine running for a considerable time.

One indication of this type of power feed-through is that the alternator lamp glows during the run-on. A simple way to determine if this is your problem is to remove the lamp from its socket. If the engine stops normally, with no run-on, then the cure is simple.

Locate the wire from the alternator lamp to the ignition switch and connect a 3-ampere, 50-PIV silicon rectifier diode (HEP-161 or similar) as shown in the diagram. Of course, you can connect the diode on the other side of the lamp if that lead is easier to get to.

Since you want current (conventional) to flow from the ignition switch to the regulator, but not backwards, the cathode end of the diode should be toward the voltage regulator. After cutting the correct wire, solder the diode in series and tape all exposed leads. This installation does not affect the normal operation of the ignition system, or the alternator lamp. ◈

BUILD A

LOW-COST DIGITAL CLOCK

PUTTING SURPLUS PARTS TO WORK

BY EARL LARSEN

NUMERIC readout devices and their associated digital IC's have dropped in price and increased in availability (from a number of suppliers and mail-order houses). You can put some of these modern TTL "chips" to work by building a digital clock having either a 12- or 24-hour display at a total price under $40. (See Fig. 1.)

How It Works. The basic timing for the clock is derived from the 60-Hz power line. This signal is taken from the transformer secondary through *D5* and voltage divider *R4* and *R5*. After going through *S2*, *S3*, and *S4*, the signal is conditioned by Schmitt trigger *IC9* to produce a train of square waves to drive the countdown logic. When either *S3* or *S4* is operated, the 60-Hz signal is removed from *IC9*, which then oscillates at a frequency determined by the feedback resistor and capacitor. Two fast forward speeds are provided to permit setting the time.

The 60-Hz input is divided by 10 in *IC12* to produce 6 Hz which is fed to *IC15*. There it is divided by 6, resulting in one pulse per second. The latter drives *IC14*, a conventional decade counter that produces a BCD output to drive *IC13*, a BCD-to-seven-segment decoder. The output of *IC13* drives the appropriate segments of a low-power incandescent seven-segment digital display device. When the count at the D output of *IC14* changes from 9 to 0, a carry pulse is generated to toggle another counter —*IC11*, which is connected as a modulo-6 (counts to 5 and, at the next pulse, drops back to zero). Unit *IC11* drives *IC10*, a seven-segment decoder and lamp driver. This accounts for the unit seconds and tens-of-seconds counters.

The unit minutes counter and readout (*IC8* and *IC7*) is another decade stage, while the tens-of-minutes counter and readout (*IC6* and *IC5*) form a modulo-6 stage. The unit hours stage (*IC4* and *IC3*) is a decade counter and, in conjunction with *IC1*, *IC2*, and *IC16*, determines whether a 12- or 24-hour display is made. Dual flip-flop *IC2* is connected in a divide-by-three configuration and its outputs are decoded by *IC1* to drive the tens-of-hours display. Unit *IC16* monitors the hours output and provides a reset pulse at either 12 or 24 hours, depending on the setting of *S1*.

The power supply uses an IC voltage regulator whose cost is offset by the elimination of additional filtering and isolation that would be necessary with a simpler supply.

Construction. The clock has two PC boards as shown in Figs. 2 and 3. Although parts layout is not critical, the use of the boards will simplify construction and keep the size down. In constructing the boards, be sure to observe the polarities and pin numbers. Be sure all 18 jumpers are correctly placed and are not contacting any IC pins. The IC's can be installed using Molex, Solder-Cons, or sockets. They can be installed directly but take care not to overheat them when soldering. Use a low-power iron and fine solder.

On the display board, the readouts are

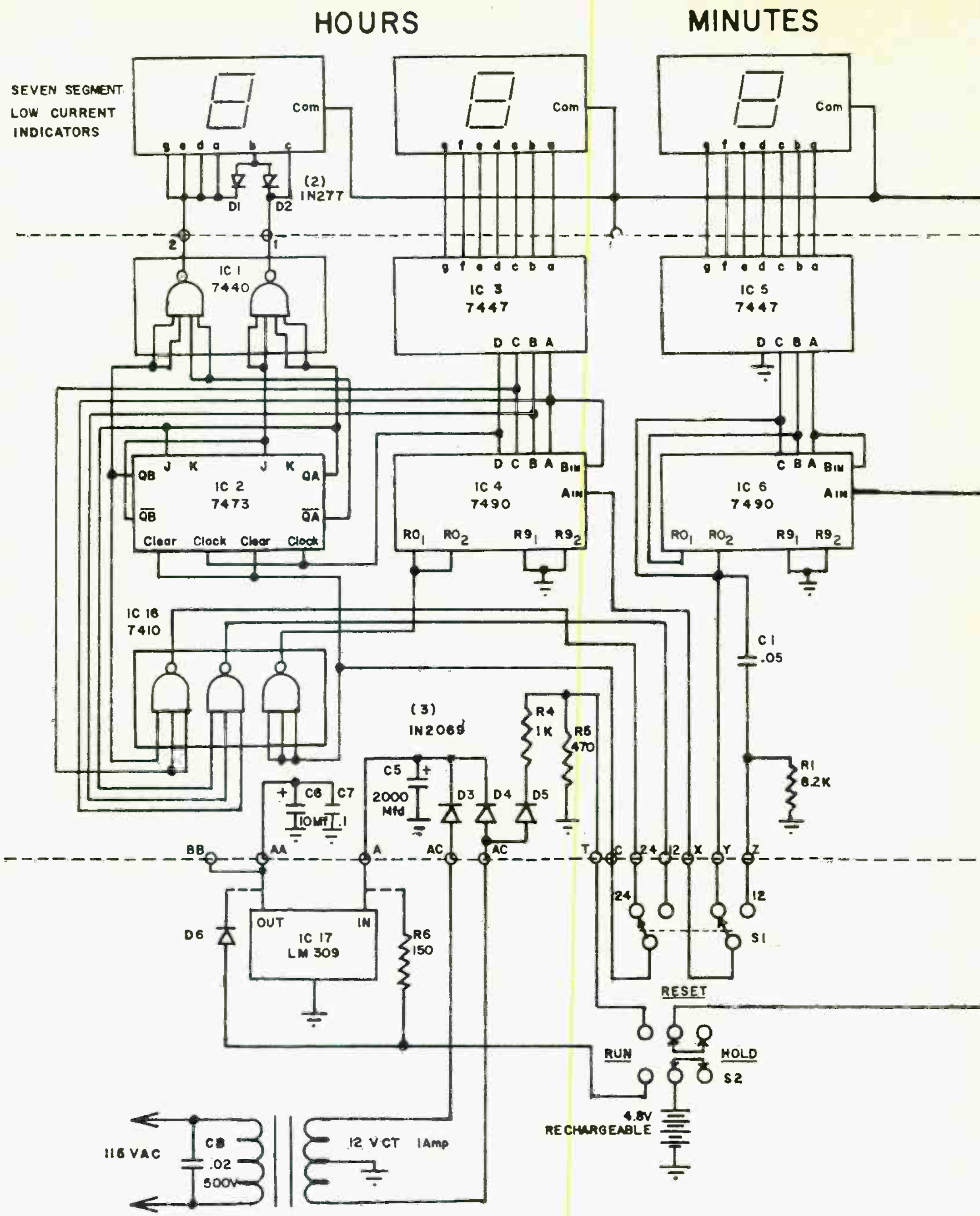
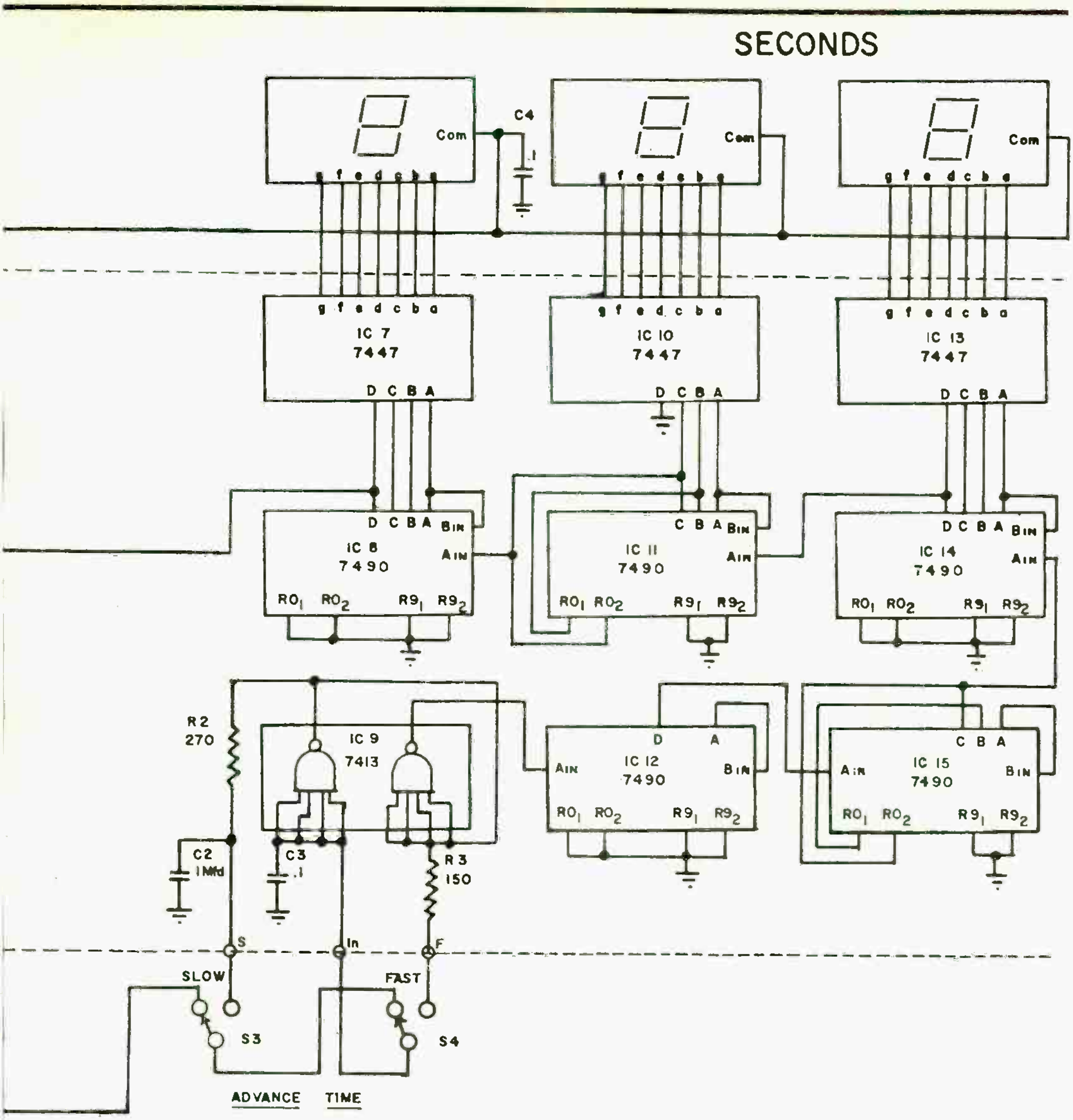


Fig. 1. The 60-Hz input is conditioned by IC9 and used to drive a set of TTL decade and mudulo-6 counters. Besides voltage regulation (IC17), the circuit has 12- or 24-hour operation, optional battery, fast/slow setting.



PARTS LIST

C1—0.05-μF, 10-volt disc capacitor
C2—1-μF, 10-volt disc or electrolytic capacitor
C3,C4,C7—0.1-μF, 10-volt disc capacitor
C5—2000-μF, 15-volt electrolytic capacitor
C6—10-μF, 15-volt electrolytic capacitor
C8—0.02-μF, 500-volt capacitor
D1,D2—1N277 or 1N281 diode
D3-D5—1N2069 diode
IC1—7440 integrated circuit
IC2—7473 integrated circuit
IC3,IC5,IC7,IC10,IC13—7447 integrated circuit
IC4,IC6,IC8,IC11,IC12,IC14,IC15—7490 IC
IC9—7413 integrated circuit
IC16—7410 integrated circuit
IC17—LM309 or SI3050E IC
R1—8200-ohm, ¼-watt resistor
R2—270-ohm ¼-watt resistor
R3,R6—150-ohm, ¼-watt resistor
R4—1000-ohm, ¼-watt resistor
R5—470-ohm, ¼-watt resistor
S1,S2—Dpdt slide or toggle switch
S3,S4—Spdt pushbutton switch
Misc.—Seven-segment incandescent display; 4.8-volt rechargeable battery; power transformer (12VCT, 1A secondary); suitable cabinet; transparent plastic for windows; line cord, mounting hardware, standoffs; L brackets; etc.

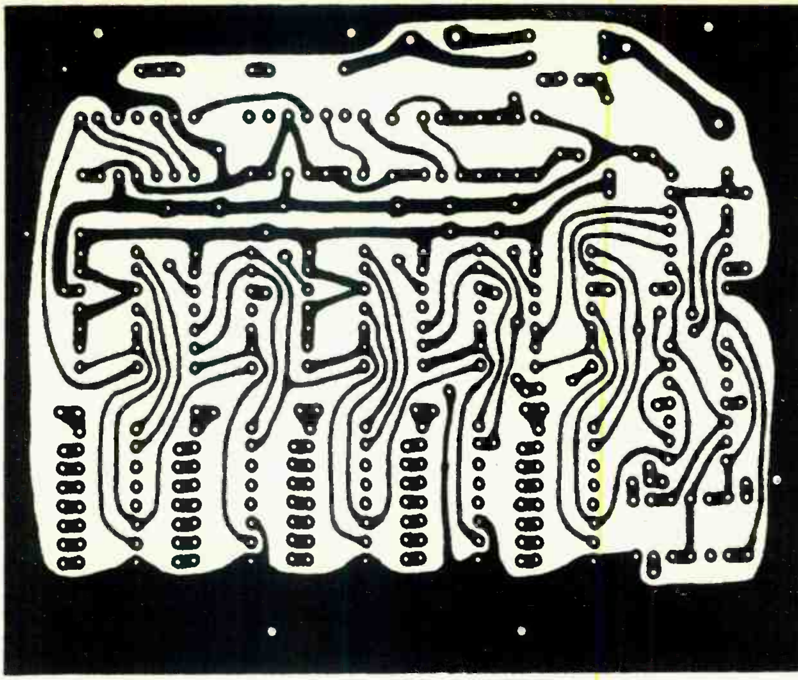
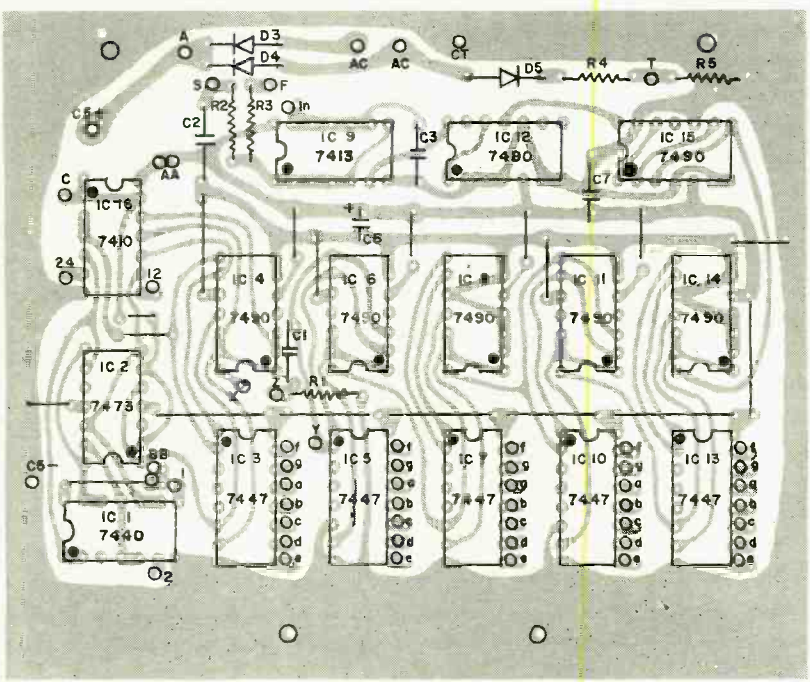


Fig. 2. Actual size foil pattern is shown above, component layout below.



installed in the same manner as IC's. This board is mounted using small L brackets attached to the two holes provided on the front of the larger board.

Wire decoder outputs to their associated terminals on the display board using the coding shown in Fig. 1. Use short lengths of fine insulated wire (#22 or #26). Then

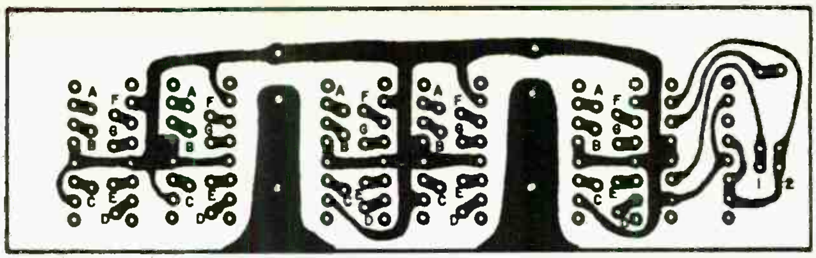
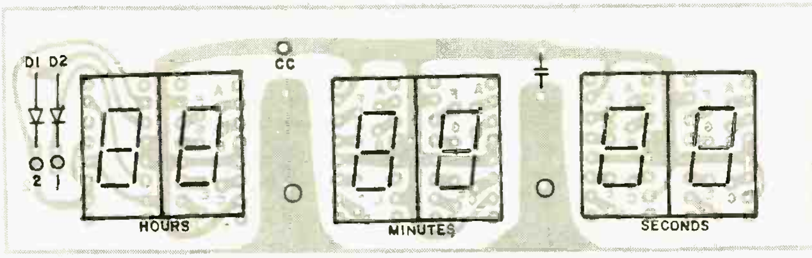


Fig. 3. The actual size foil pattern for the display board is shown above. Use the diagram shown below to position components on board.



connect an insulated jumper between point BB on the large board and point CC on the display board. Capacitor *C4* is mounted on the foil side of the display board. Connect an insulated jumper between AA and BB on the foil side of the large board.

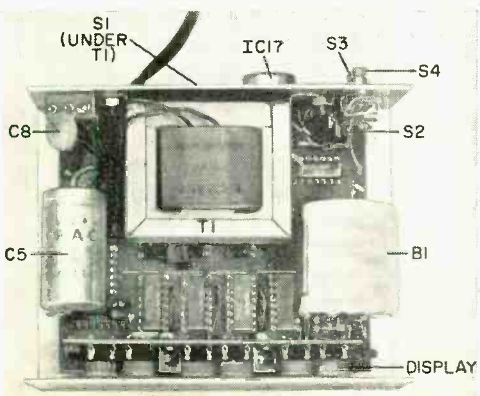
Almost any type of chassis can be used for the clock. The prototype was built in an LMB422 chassis for maximum compactness, though the LMB452 might allow for a bit more freedom in mounting components. Assuming ⅜" standoffs, measure and mark rectangular cutouts on the front panel of the chassis so that the digital display can be seen. The author used separate cutouts for seconds, minutes, and hours, though a single, large window will suffice. Back the window with colored plastic to produce the color display desired.

The power transformer, switches *S1* through *S4* and voltage regulator *IC17* are mounted on the rear apron. When mounting *IC17*, be sure both pins are clear within their holes. It is not necessary to insulate the case of the IC from the chassis.

Capacitor *C5* is mounted using its leads as standoffs, between points C5− and C5+. Use a piece of spaghetti on the positive lead.

The 4.8-volt battery shown in Fig. 1 is optional. Momentary power outages will cause the logic to reset to some state other than the correct time. The battery will hold the logic (but not the display) for a few moments during an outage. Then, only a small correction is needed to reset the time. If the battery is not used, *D6*, *R6*, and the lower half of *S2* can be eliminated. If the battery is used, mount it on a capacitor clamp on the right side of the board.

Photo below shows compact arrangement of prototype. Battery optional.



Operation. Plug the clock into a 117-volt, 60-Hz supply and note that the display produces some numbers. Set *S1* for either 12 or 24 hours, and operate *S4* so that the display runs completely through one period. Operate S3 to check the slow rate.

Use *S4* to set the display to the correct hours and minutes and S3 for the correct seconds. Place S2 on RUN. ◈

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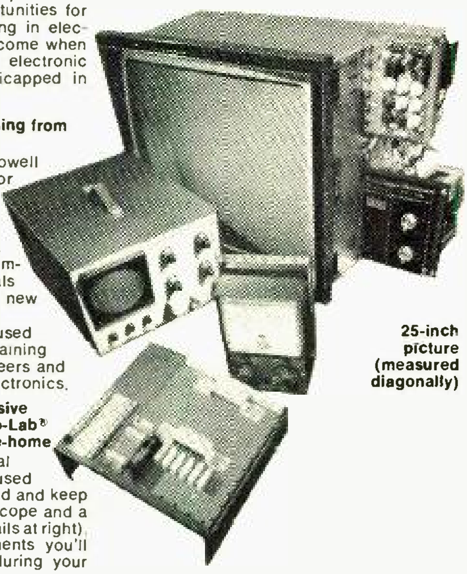

25-inch picture (measured diagonally)

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ANATOMY OF A LIGHTNING BOLT

The world's spectacular electrical show produces a staggering amount of energy

BY DAVID L. HEISERMAN

YOU probably witness the world's largest and most spectacular electrical show several times a year. Under a curtain of black clouds and in the company of heavy rain and high winds, nature winds up her giant electrical dynamo, releasing bolts of blue-white electrical energy that have terrified, mystified, thrilled, and troubled mankind.

Nature puts on her world-wide lightning show about 1800 times a day. The output of electrical energy is staggering—about 350 kW-hr per bolt, which amounts to 10^{15} kW-hr annually. If there were some way to harness all this power, it could supply the world's growing demand for electrical power for at least the next 300 years. In comparing lightning to manmade electricity, it is interesting to note that the average going rates for electrical power would put a price tag of $10 on each bolt. All told, the annual operating budget for nature's giant electrical show would be on the order of $25-trillion.

Lightning has no sympathy for the feeble electrical schemes of civilized man. It is especially troublesome to highly developed nations that rely heavily on long-distance power transmission and electronic communications. Lightning has a way of immobilizing and blacking out communications for whole communities. Although modern lightning protection techniques have reduced the number and duration of total power outages due to lightning, the outages that do occur have more disastrous effects than ever before.

Engineers and scientists have developed lightning rods, arrestor schemes, and fast-acting bypass switches to reduce the ways lightning can destroy outdoor structures and sensitive electrical equipment. Frequency- and pulse-modulation techniques are partial answers to the problem of carrying on radio communicaton through the world's constant thunder-storm activity. But lightning still manages to pull off some surprises. NASA engineers, for example, thought they had a good lightning protection system for spacecraft until a bolt struck Apollo 13 seconds after takeoff.

So scientists and engineers still have much to learn about lightning in general. By studying the behavior of devastating cloud-to-ground discharges, they hope to find improved ways of eliminating the destructive effects. By studying the atmospheric mechanisms responsible for generating the charges in the first place, they may find ways to dissipate thunderstorms before they reach maturity.

Cloud-To-Earth Damage. Only a small fraction of electrical equipment disabled or destroyed by lightning is the victim of a direct "hit." In most cases, the damage is due to currents and voltages induced by a nearby lightning stroke. The intense magnetic and static fields set up by a bolt can crush steel conduit, fuse long wires, and send surges of electrical energy through conductors to sensitive electrical equipment. In one case, a stereo buff had strung long wires to a pair of speakers mounted near a backyard patio. A nearby lightning stroke induced currents into the wires, blowing the speakers out of their enclosures and burning out the components in the output stages of his amplifier. The amplifier was inside the house; so, it was fortunate that the interconnecting wires disintegrated before setting the house afire. The moral? Use grounded shielded cable for outdoor speakers.

What makes indirect lightning effects even more perplexing is the fact that electrical equipment sometimes burns out even when there has been no lightning in the immediate vicinity. Thunderclouds carry extremely large electrical charges and can act as one plate of a giant capacitor. The air directly below the cloud serves as a good dielectric, while the earth and objects attached to it act as the opposite plate. A highly charged thundercloud moves along, dragging a "shadow" of charges along the earth below. The moving charges gather around ungrounded objects and produce field strengths that can run as high as 10,000 volts/meter in a vertical direction. This accounts for the eerie corona discharge, or "St. Elmo's Fire," sometimes visible on tall masts and antennas just before a storm arrives. When a lightning bolt suddenly discharges this giant capacitor, the charges surge along the earth for several kilometers (1 km = ⅝ mile) toward the point of discharge. Any ungrounded conductor lying perpendicular to the path of these moving charges can serve as the armature in a giant electrical generator; and it is often possible to see a continuous arc across gap-type lightning arrestors when a storm is as much as 5 km away.

Low-impedance grounding cables can eliminate most of the effects of St. Elmo's Fire. But in the case of antennas and power lines that cannot be directly grounded, the gap-type lightning protectors allow some voltage build-up to occur. The only way to suppress this kind of gap potential is by adding special bypass circuits to the input or output stages of equipment attached to the towers.

Modern grounding techniques have all but eliminated serious damage by direct hits to towers and tall buildings. No grounding system is perfect, however, and the small impedance that remains between the tip of a tower and the earth still invites a direct lightning hit during a very heavy storm. Even though the grounding scheme permits the full blast of lightning current to flow to ground without doing serious damage, the IR drop along the current path can produce some devastating and unpredictable high-voltage flashover effects. High-voltage flashover does not pack the punch of a direct hit, but it often originates near the ground—far below the lightning rods and arrestors intended to protect the system from overhead sources of high voltage.

Creating a Lightning Bolt. About 200 years ago, Benjamin Franklin demonstrated that lightning is a form of electrical energy. The mechanism for generating the electrical charges, however, is still imperfectly understood since it involves moving air currents, temperature and air pressure changes, and formation of all kinds of precipitation. So, the following generalized theories apply to about 90 percent of lightning events studied; the remaining 10 percent represents what is not yet understood, accounting for most of the surprises.

Lightning forms in a vast atmospheric thunderstorm "cell." Unless at least one cell exists, there can be no lightning. It is possible for a single thunderstorm to have as many as five cells at one time. An infant cell begins to form whenever a localized up-draft of warm, moist air moves faster than 8 meters/second. When this air reaches an altitude of 10-12 km, it expands and cools to form supercooled water droplets (water that still exists in a liquid state between −20° C and −40° C). The heavier droplets of supercooled water remain at this altitude, while the lighter ones move up to about 15 km where they freeze at −50° C and form the "anvil head" that typifies a fresh thundercloud.

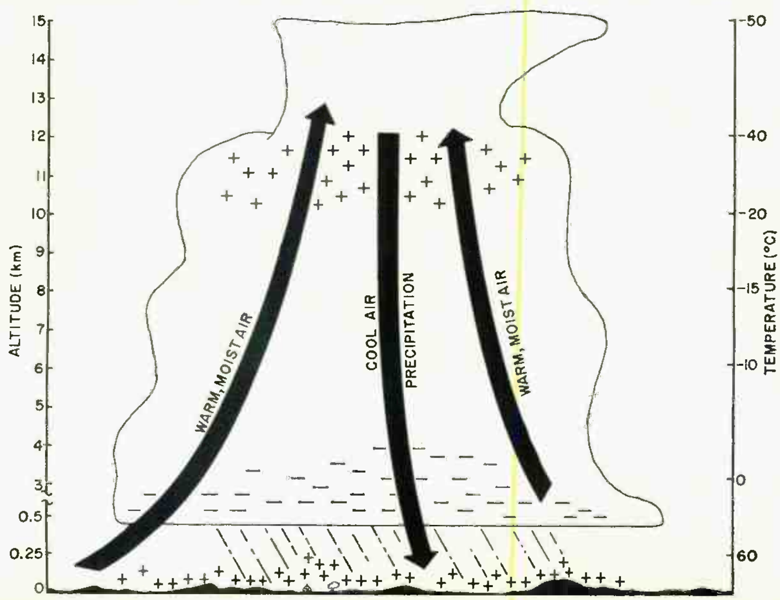
As the droplets of supercooled water merge and form heavier drops, they freeze into hailstones and begin falling against the updraft. The falling precipitation sets up weak downdrafts of cool air that force even more hailstones, sleet, and snow to form. If prevailing weather conditions are just right, the cool precipitation and downdraft avalanche into a tunnel of air moving earthward at about 8 m/s. The tunnel of cool air pinches the warmer updrafts into a smaller space, increasing the updraft velocity to about 20 m/s and creating a cycle of violent air flow that typifies a mature thunderstorm cell.

The cell exists only as long as there is an adequate supply of warm air from the earth below. When the supply is exhausted, the cell dies away, and the anvil-head cloud breaks up. A typical cell lasts about 30 minutes.

The most widely accepted theory of how electrical charges form in a thunderstorm cell depends upon the peculiar electrical behavior of violent collisions between droplets of supercooled water and hailstones. Scientists have shown in laboratory experiments that supercooled water droplets colliding with somewhat warmer and larger chunks of ice tend to splatter into even smaller particles that almost instantly freeze. More important is the fact that these tiny freezing particles take on positive electrical charges, leaving the ice with a somewhat negative charge. In an actual thunderstorm cell, the positively charged ice particles are so light that updrafts keep them suspended near the top of the cloud. The heavier hailstones fall earthward, carrying their negative charges with them. As these hailstones pass through the 0° C point, they begin to melt, leaving a trail of negatively charged water droplets behind. Most thunderclouds, then, accumulate positive charges near their tops and negative charges near the bottom (see Fig. 1).

On a normal clear day, the surface of the earth has a negative electrical charge with respect to the air above. Tests show that clear-day fields increase with altitude at about 120 V/meter. However, whenever a thundercloud passes over the earth, the negative charge on the cloud reverses the polarity on the earth's surface below it. Consequently, the earth takes on a positive potential that can rise as high as 10,000

Fig. 1. Diagram of electrical and mechanical structure of a typical thunderstorm cell shows positive charges at top, negative at bottom.



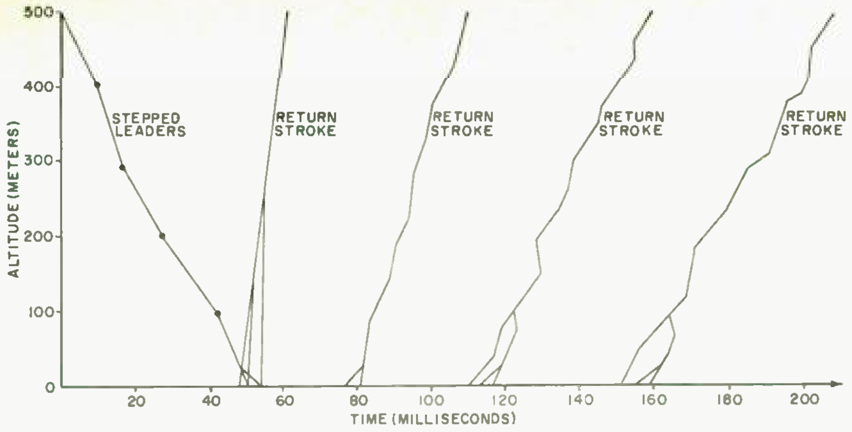


Fig. 2. Sequence of electrical events that occur for a typical lightning bolt shows downward stepped leaders and the bright return strokes.

V/meter under the middle of the cell for a radius of about 10 km. Since the bottom of the cloud has the opposite charge, it sets the stage for a mammoth electrical discharge.

A lightning discharge between cloud and earth is not caused by an instantaneous electrical breakdown of the intervening air. The breakdown potential of air is on the order of 10 kV/cm, whereas the charge between a thundercloud and the earth seldom exceeds 100 V/cm. The ultimate breakdown actually takes place in a series of steps that begin at a point near the bottom of the cloud.

When the potential difference between a cloud and the earth reaches a critical point, a dense corona discharge appears at a spot on the bottom of the cloud. Since in the corona the charges are negative, the positive potential on the earth pulls it downward to form a long "tunnel" of highly conductive plasma (ionized gases). This tunnel, called a "leader," can be 10-200 meters long and about 12 cm in diameter. After an interval of 10-100 μs, the leader stabilizes and another develops from its bottom tip, channeling negative charges another 100 meters or so toward the earth. This process repeats until the chain of leaders reaches to within 5-50 meters of positively charged objects on the earth, at which point the positive coronas on the earthbound objects rush up to meet the lowest leader to complete the conductive path between cloud and earth.

Typical stepped leaders carry about 1000 amperes of current. The tunnel gives off very little light except at the very tip where it is pushing its way through freshly ionized air. Traveling downward at an average velocity of 10^5 meters/s the leaders touch ground within about 20 ms. Without the help of special cameras, it is practically impossible to see a stepped leader develop.

Once the plasma tunnel between the cloud and the earth is complete, the main discharge energy bursts upward at about a tenth the velocity of light. The plasma carries 10-100 kA of current, and light from the highly agitated ions in the tunnel is quite intense. This phase of the lightning discharge cycle is known as the "return stroke." For most of us, this pyrotechnic display is what lightning is all about. (See Fig. 2).

The dramatic return stroke lasts about 100 μs, or just long enough to neutralize the charges around the ends of the tunnel. However, the tunnel can remain highly conductive for several milliseconds after the return stroke is over and can move several meters to points on the cloud and surface of the earth where pockets of charges still exist. Hence, several return strokes can occur after a single stepped leader paves the way. On the average, a single plasma channel carries three return strokes, separated by about 30 ms so that an observer appears to see the lightning bolt flicker.

When there are no longer any return strokes, the winds destroy the tunnel by scattering the conductive ions. If weather conditions are right, though, nature's dynamo needs only about 20 seconds to recharge and get another leader started earthward. ◈

Electronics Crossword Puzzle

BY JOHN D. RICHARD

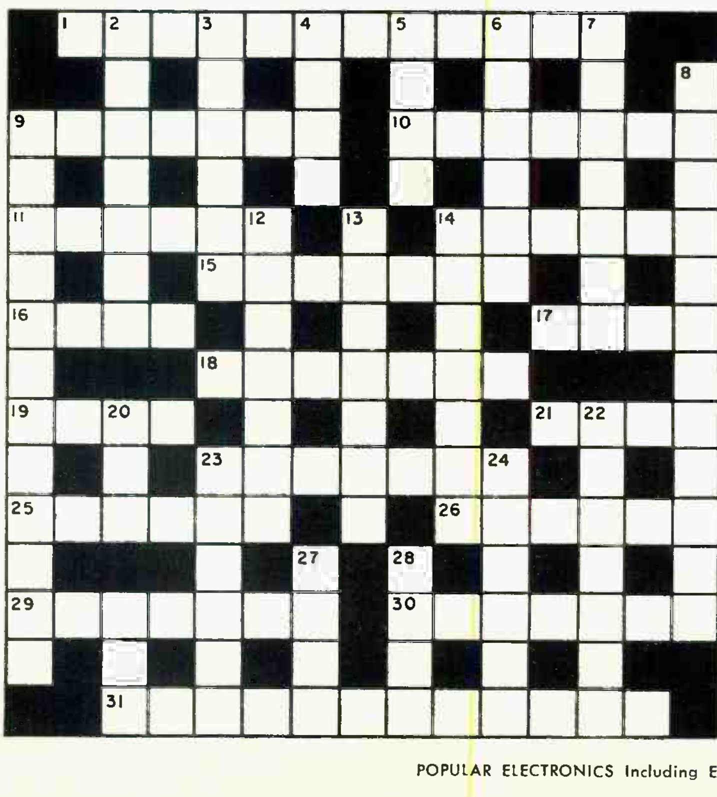
ACROSS

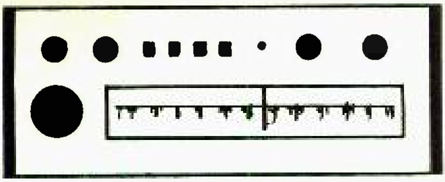
1. Used a lot with hi-fi tubes, but rarely with hi-fi transistors.
9. Cells in series.
10. Avoid this class of radiation.
11. Pre-radio astronomy apparatus which illustrated the planet positions.
14. What you may hear when the n.f.b. goes positive.
15. Condition of the overlong pot shaft.
16. 1000 cycles, this Hz!
17. It's a grabber.
18. Boozy sort of permanent magnet.
19. Diminutive devils.
21. Merely a component.
23. This gives the micrometer its final resolution.
25. Parish lands hidden in the dingle beside the church.
26. Minuet, polka, or bugaloo.
29. Sounds like Noah's nameplate, but is really the inverse of the sine.
30. Lags.
31. To put excessive audio into the final.

DOWN

2. Applies to mono disc recording.
3. What the yoke does to the beam.
4. Alcoholic radical and gets dopey with acetate.
5. A volt is one.
6. Scruffy appearance of the jack board?
7. Ten ions in stress.
8. A neon checker will perform these with capacitors.
9. Circuit presentation for squares?
12. A pair for vertical deflections.
13. Just a moment!
14. Fate of disc on badly adjusted auto-changer?
20. Loud passage faintly evident in preceding groove.
22. This mariner of old had a nice tan.
23. City of blinding TV interference?
24. The field in a d'Arsonval meter air-gap.
27. A very feminine sort of wave.
28. The board is this with copper.

(Solution on page 108)





If you know the meaning of the new specs, you'll be able to select the best tuner

UNDERSTANDING UPDATED FM TUNER SPECS

by Leonard Feldman

THE Institute of High Fidelity (IHF), an organization of hi-fi component manufacturers, last issued formal testing standards for basic FM tuners and those in receivers way back in 1958. Though vastly superior to the testing procedures used by manufacturers prior to their issuance, the standards are nevertheless somewhat archaic in terms of today's modern stereo FM tuner. After all, in 1958, all tuners employed vacuum tubes exclusively, and stereo FM broadcasting was three years in the future. Too, FM broadcasters numbered in the hundreds then, and there was generally a good deal of "dial space" between stations.

Recognizing that the old standards do not adequately cover or describe the performance of a modern FM tuner, many manufacturers have begun to list specifications not mentioned in the old standards—specs designed to augment the basic facts that were needed in 1958.

Happily, these "new" specs are fairly consistent from product to product, permitting the prospective buyer to compare competitive products once he understands the purposes of the new "numbers." In addition, some of the older specs, originally relegated to positions of secondary importance, take on primary status in light of modern tuner requirements. Our purpose here is to examine both the old and the new specs as they relate to a modern state-of-the-art FM tuner.

IHF Sensitivity. Sometimes known as the "least usable sensitivity," IHF sensitivity is usually the first in a long list of tuner specs. It is defined as the least number of microvolts (μV) of signal needed at the antenna terminals to produce an audio output 30 dB above the background noise and distortion. Now, with the output 30 dB above the distortion, the latter is about 3 percent, which is actually a lot of noise and distortion—an amount you would not tolerate in an amplifier or tape recorder where signal-to-noise specs easily reach 50 dB or more and where residual distortion is usually measured in tenths of a percent. What is worse is that residual noise and distortion when listening to stereo FM is invariably greater than when listening to mono stations. Hence, the 30-dB signal-to-noise ratio and distortion criterion may well turn out to be 20 dB or less when so few microvolts are applied to the tuner for stereo reception. Illustrated in Fig. 1 is how noise and distortion reduce as signal strength increases. Many manufacturers have begun to quote the input signal in μV required for a more realistic 50-dB signal-to-noise ratio which is more "listenable" than the old 30-dB reference. In Fig. 1, this occurs with an input signal of 5 μV, as opposed to an IHF sensitivity figure of only 1.8 μV.

Distortion. In general, distortion figures for stereo FM listening tend to be a bit higher than they are for mono. The composite stereo signal is much more complex than is a mono signal, and both i-f and detector circuitry must be carefully designed if low orders of audible distortion are to be maintained. In addition to the required total harmonic distortion (THD) figure stated for mono reception, many spec sheets now list

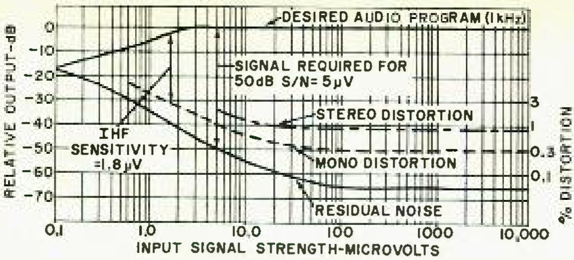


Fig. 1. Important FM characteristics are determined from plotted curves such as those shown here.

THD for stereo as well. Again referring to Fig. 1, you can see that at a 1000-μV input (the point at which most distortion measurements are made), 0.3-percent THD is shown for mono, while for stereo the THD is 0.8 percent.

It is not uncommon for THD to be somewhat higher at extremely low and high audio frequencies than at the mid-frequencies where distortion measurements are usually made. Some of the braver manufacturers have begun to quote figures for several frequencies, such as 100 Hz, 1000 Hz, 5000 Hz and 10,000 Hz, and the really daring ones have begun to quote these THD figures for stereo performance as well. A typical THD-versus-frequency curve is shown in Fig. 2, from which the four THD numbers for mono and stereo can be picked off for a representative tuner.

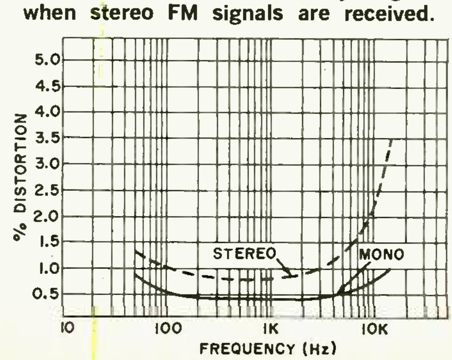
Stereo Separation. Most manufacturers have been quoting stereo separation figures taken at 1000 Hz since the inception of stereo FM broadcasting. Frankly, this spec is relatively unimportant unless the figure given is less than 20 dB. After all, even the best stereo phono cartridge seldom has a separation capability much beyond 25 dB, which at high frequencies tends to diminish rapidly. More important is the ability of the tuner to maintain adequate separation at the extreme high and low audio frequencies. Here, too, more quality-conscious manufacturers have begun to list separation figures for frequencies other than the nominal 1000 Hz, and some even publish a complete curve that gives a total picture of separation-versus frequency (see Fig. 3).

Selectivity & Capture Ratio. Of the two related terms, capture ratio is probably less understood (and more difficult to measure) than is selectivity. The Federal Communications Commission assigns FM frequencies so that no two stations in the same geographic vicinity are on the same or even adjacent channel frequency. Usually within a major metropolitan area, stations will be assigned frequencies as much as 800 kHz apart. Each channel occupies a total bandwidth of 200 kHz. Weaker suburban area stations in a region may be assigned frequencies that are only 400 kHz apart, while 200 kHz separation between stations in a region will be made only for stations deemed to be so far apart that no interference can take place between them. However, the fact is that tuners of late vintage have become more and more sensitive and what was once regarded as a sufficient geographical distance between transmitters may no longer be valid.

Capture ratio defines the ability of a tuner to "capture" a desired station while rejecting a more distant or weaker station broadcasting on the *same* frequency. While such a condition may at first seem remote, remember that the distant station may be many times more powerful than the "local" desired station—a condition that tends to offset, at least in part, the greater distance to the undesired station. Capture ratio is measured and quoted in dB; the lower the number, the better the characteristic.

Selectivity, as generally stated in spec sheets, is really an abbreviation for "alternate-channel selectivity," which means the ability of the tuner to reject signals 400 kHz (two channel widths) away from the desired signal frequency. Selectivity is determined

Fig. 2. Distortion is usually higher when stereo FM signals are received.



primarily by the design of the i-f section of an FM tuner (though the r-f or front-end also plays a part in this characteristic as well). When a manufacturer claims that his tuner is using multielement (or crystal or ceramic) filters in its i-f section, he is informing you that the tuner's selectivity has been improved. Older, more conventional, i-f transformers were not capable of providing the steep, carefully controlled "bandpass" characteristics required in modern FM tuners. A comparison of the bandpass characteristics of the older and newer forms of i-f circuits are superimposed in Fig. 4 to illustrate the difference between "good" and "not-so-good"

TYPICAL TUNER SPECIFICATIONS

Specification	Average	Good	Super
IHF Sensitivity	3.0 µV	2.2 µV	1.8 µV
Signal for 50 dB S/N	20.0 µV	10.0 µV	5.0 µV max.
Ultimate S/N	55 dB	65 dB	70 dB min.
THD, Mono:			
1 kHz	1.0%	0.6%	0.3% max.
100 Hz	2.0%	1.0%	0.6% max.
5 kHz	2.0%	1.0%	0.8% max.
10 kHz	2.5%	1.5%	1.0% max.
THD, Stereo			
1 kHz	1.5%	1.0%	0.7% max.
100 Hz	2.0%	1.5%	1.0% max.
5 kHz	3.0%	2.0%	1.5% max.
10 kHz	10.0%	4.0%	3.0% max.
Full Limiting	10 µV	4 µV	2.0 µV max.
Alternate Channel Selectivity	45 dB	60 dB	70 dB min.
Capture Ratio	3.0 dB	2.0 dB	1.5 dB max.
AM Rejection	40 dB	50 dB	55 dB min.
Image Rejection	50 dB	65 dB	70 dB min.
Spurious Response Rejection	60 dB	70 dB	80 dB min.
I-F Rejection[1]	60 dB	75 dB	80 dB min.
IM Distortion[2]	2.0%	1.0%	0.5% max.
19 kHz & 38 kHz Rejection[3]	45 dB	50 dB	55 dB min.
SCA Suppression[4]	45 dB	55 dB	60 dB min.
Stereo Separation:			
1 kHz	30 dB	35 dB	40 dB min.
100 Hz	20 dB	25 dB	30 dB min.
5 kHz	20 dB	25 dB	30 dB min.
10 kHz	15 dB	20 dB	25 dB min.

NOTES: 1. Ability to reject incoming signals at the i-f frequency of 10.7 MHz.
2. Intermodulation distortion—caused by beating of low and high frequency andio signals.
3. Ability to reject unwanted elements of the composite stereo signal.
4. Ability to reject "background music" hidden channel, sometimes transmitted simultaneously by stations for special subscribers.

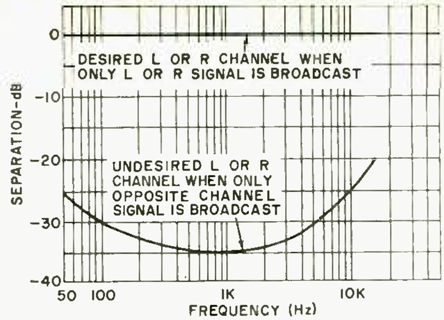


Fig. 3. Stereo FM separation often varies widely with audio frequency.

selectivity. As with capture ratio, selectivity is quoted in dB, with the higher number indicating the better tuner.

Full Limiting & AM Rejection. These two terms are also related to each other, with most manufacturers now providing a figure for the latter and some offering a figure for the former. "Full limiting" means that at the required signal level input, the unit works totally as an FM tuner. A further increase in signal level will not produce audio amplitude changes as was the case for signal levels below the full limiting threshold.

The primary virtue of any FM tuner is the fact that it *rejects* or does not respond to changes in incoming signal amplitude (AM). This accounts for its ability to be insensitive to man-made noise and electrical interference, such as ignition noise, lightning and the like, which are AM phenomena.

While rejection of these forms of interference has always been recognized as an important virtue of FM, the relationship between AM rejection and "multipath" problems has become more evident with the popularization of stereo FM broadcasting. Multipath in FM is akin to "ghosts" in TV reception. It is caused by reflections from adjacent man-made and natural structures. The primary signal arrives at the antenna at a given time, while reflected signals arrive fractions of a second later because of the greater distances they must travel.

Now, these reflected signals may be in-phase, phase-displaced, or even totally out-of-phase with the primary signal when they finally arrive at the antenna. If they are phase-displaced or out-of-phase, they will partly *cancel* the amplitude of the incoming signal. Varying intensity of an incoming signal is, in effect, AM reception, and if a

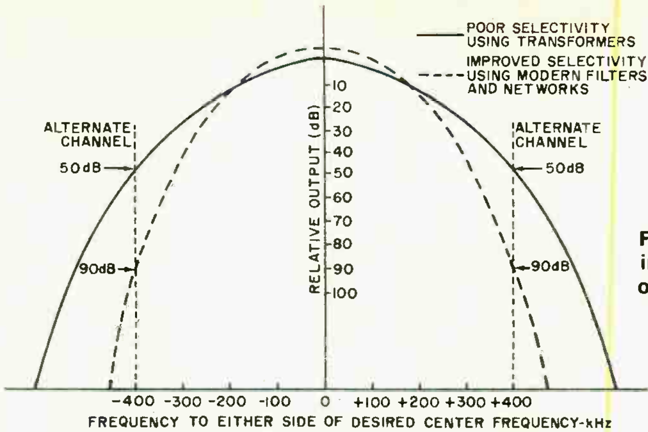


Fig. 4. Curves show improvement in selectivity through the use of modern filters and networks.

tuner is incapable of rejecting this form of "AM," you will hear a wavering, whooshing sound, often accompanied by severe distortion that is particularly noticeable when sibilant sounds are articulated or when musical high frequencies are reproduced. While good AM rejection is by no means a cure-all for multipath distortion, it certainly helps (proper orientation of a good directional outdoor antenna is a must). AM rejection is quoted in dB; the higher the number the better the tuner. Full limiting is given in microvolts where the *lower* the number, the better.

Spurious Response & Image Rejection. Ideally, when a tuner is set to a frequency of 100.1 MHz, the only signals you should receive are those broadcast on 100.1 MHz. If your listening experience goes back to the early days of FM, however, you have probably run into the problem of "spurious responses"—signals showing up at points on the dial where they just should not be. There are many causes for this problem. Often, close-by powerful transmitters emit signals that are powerful enough to "overload" the tuner and tuning becomes meaningless. At other times, the undesired frequency may be related to the dial setting in some mathematical way so that a signal appears where it should not be.

Image frequencies are a specific form of spurious response that is quite interesting. The band of frequencies just above the high end of the FM band (above 108 MHz) is used for, among other things, police and aviation communication. Most FM tuners operate on the "superheterodyne" principle with a built-in oscillator tuned to 10.7 MHz above the desired frequency. The beat or difference between the two frequencies becomes the i-f signal which is amplified and detected by the rest of the tuner's circuitry. Now, suppose the tuner were set for a dial frequency of 105.5 MHz, which means that the local oscillator is tuned to 116.2 MHz (105.5 + 10.7). Suppose, too, that a local aircraft transmitter was transmitting at 126.9 MHz. This incoming signal, if not adequately rejected by the "front end" of the tuner, would mix with the local oscillator to also produce a 10.7 MHz i-f (126.9−10.7). To all appearances, this beat signal is a valid i-f signal that will be amplified and detected by the tuner to produce an undesired output. Consequently, "image rejection" is determined by the design and quality of the r-f front end of the tuner and is quoted in dB where the higher the number, the better.

Judging FM Tuner Quality. The information given in the Table is this writer's opinion of the kinds of specs you might expect in an "average," a "good," and a "super" tuner these days. The tabulation is intended to be more a general guide than the last word from a great oracle. However, it does include just about every performance spec a manufacturer should include, omitting such entries as control features, "drift" (which should be minimal in *any* modern, well-designed tuner), and mechanical considerations. If you find that one or more of these specs is not given when you are shopping around, you can write to the manufacturer and ask for it. For one thing, you are very likely to receive an answer; for another, you might prompt the manufacturer (and the industry at large) to be more complete in his future listings. That can only lead toward the much-needed updating of uniform industry standards. ◈

Test Equipment Scene

By Leslie Solomon, Technical Editor

Multipath & Crystals

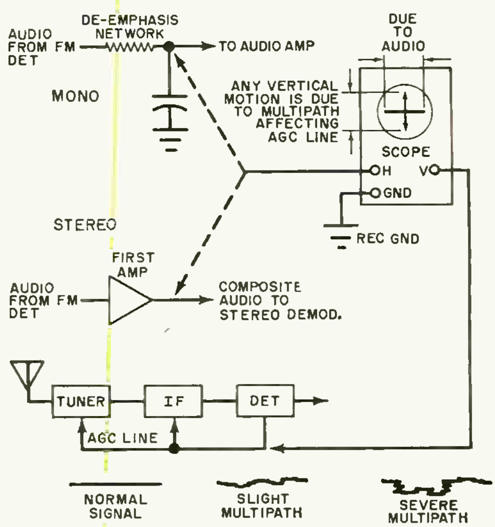
SOME of our recent mail has asked questions about test equipment that does not even exist! For instance, "How do I test for multipath?" or "How can I check a CB crystal?" There are, of course, no simple, plug-in black boxes for these situations; but the questions are interesting and such problems can be solved without too much difficulty.

Multipath Distortion on FM. Many hi-fi buffs and service technicians have equipment which is afflicted with distortion on FM reception, but operates perfectly well on either disc or tape inputs. The problem is caused by multipath reception, which means exactly what it says. When an r-f signal leaves the FM transmitting antenna, it can either take a direct path to the receiver antenna (the ideal case) or take a number of "bounces" off various reflectors before reaching the receiving antenna—or, the received signal can be an unhappy combination of both types.

Because of the time-of-arrival differences of the various signals due to the different path lengths, the combination of signals can either enhance or cancel each other in various ways. This produces both AM and FM components; and the end result is distortion on FM reception.

Although most likely to occur in strong signal zones, especially in large urban areas having a number of metallic reflectors (buildings), multipath can also occur in suburban areas when the receiver is surrounded by hills, power line towers, water tanks, large metal billboards, or substantial structures on distant hills.

Just how bad can multipath be? This depends on how far away the reflecting surface is and on the strength of the reflected signal compared to the main signal when they both arrive at the receiver. The mixing of the two (or more) signals results in a phase shift of the composite signal to be processed by the FM receiver.



In mono reception, it would be difficult to detect several degrees of phase shift audibly. However, in stereo reception, a phase shift of only 3° between the suppressed 38-kHz subcarrier originating at the studio (the reference from which the stereo is determined) and the restored 38-kHz subcarrier within the decoding matrix in the

All quadraphonic systems are not created equal...Sansui has created the Vario-Matrix

QRX-6500

Here at last is the development that once and for all will lay to rest the dispute over discrete vs. encoded recordings. The Sansui Vario-Matrix®—a technological extension of the QS Regular Matrix—provides unbelievable front-to-back separation, to a degree never before possible with matrix recordings—separation so great that engineers have hailed it as the "discrete matrix."

Two new units in the Sansui four-channel lineup—the QRX-6500 (Price: $699.95) and the QRX-4500 ($599.95) contain this outstanding new decoder. These full-featured four-channel receivers have high power output (280 watts anc 240 watts IHF), superb FM sensitivity, and are loaded with special features to make quad listening a totally trouble-free and fulfilling experience.

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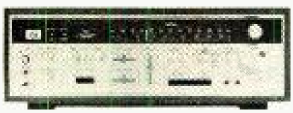

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receiver will limit the stereo separation to 30 dB. Obviously, the greater the level and phase shift of the multipath signal compared to the main signal, the greater the resulting phase shift and the less the stereo separation. With about 12 or 15 degrees of composite phase shift, the maximum stereo separation may amount to 18 dB; but, because the multipath signal may be fluctuating (similar to the effect an aircraft can have on a TV signal), the result is a complete mixup in the stereo positioning of the performers—producing the effect of "wandering minstrels" on the stereo stage.

The effect on synthesized four-channel reception may be even more disturbing. Because of the complex phase relationships necessary to derive each of the four channels properly, a varying phase signal coming in through the antenna can be enough to negate completely the use of four-channel operation at that particular reception point. The varying multipath signal may be the culprit that causes the four channels to form an acoustic "merry-go-round" at a rate determined by the instantaneous level of the multipath signal.

Of course, some expensive FM receivers are equipped with small CRT's to observe the presence of any multipath signals, but most of our mail usually says, "I have a relatively inexpensive FM receiver. How can I tell if there is a multipath problem, determine how bad it is, and then do something about it?"

First of all, you need an oscilloscope. Preferably, it should be dc-coupled, but you can get away with using an ac-coupled scope. In fact, if you are a real electronics enthusiast, you could build a small CRT unit to fit with your hi-fi gear.

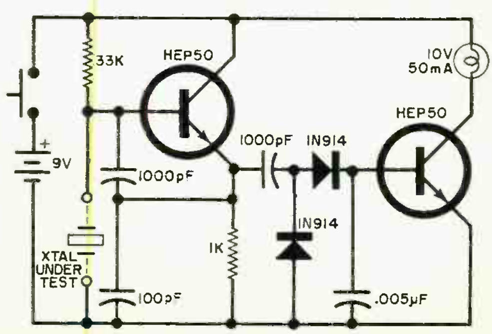
The connections are simple if you have the schematic of your FM set and possess some knowledge of audio electronics. First, connect the ground lead of the scope to the ground (usually the metal chassis) of the FM receiver. Then connect the horizontal input of the scope to the audio take-off point of the FM detector. The last connection is from the scope's vertical input to the receiver agc line. Set the scope for an external horizontal input. If you have a dc mode, use it.

Turn on both the scope and the FM receiver and allow both to warm up. As the scope warms up, you will probably see a horizontal wiggling line appear in step with the receiver audio. Set the scope controls for a clean signal 2 or 3 inches long at about the middle of the CRT. If you have a dc scope, you will note that, as the receiver is tuned, the line will move up or down (depending on the type of agc) and follow the motion of the FM tuning meter on the receiver's front panel. Tune the FM receiver for maximum vertical travel of the wiggling line. This should correspond to the maximum meter indication and insures that the receiver is properly tuned.

If you have a clean FM signal, all you should see on the CRT is the single wiggling, horizontal line, varying in length with the audio component and having no up or down component. If there is any multipath, the receiver agc line will know all about it and will cause the wiggling horizontal line to have a vertical component. Obviously, the greater the multipath, the more pronounced the vertical displacement.

Now, what can you do about multipath? With the scope still hooked up to the FM receiver, rotate the antenna until the vertical component displayed is minimum. Unfortunately, the multipath may be different for each station, so an antenna rotator will be required. Don't pay strict attention to the direction in which the antenna is pointing, since sometimes the best reception comes with the antenna pointing in a direction not necessarily toward the station. The use of a beam antenna will greatly reduce multipath. When you get right down to it, this procedure is exactly like that of aiming a TV antenna to reduce ghosts.

Crystals, Good or Bad? Many people have a chance to purchase surplus crystals and they need some way of telling whether or not the crystal is good or bad without having to take it home and test it in an operating rig. Well, here's a circuit that you may not want to carry around with you all the time but it's simple and small and will do the job.

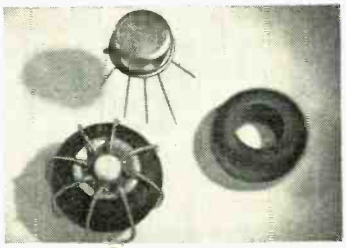


It is a crystal-controlled oscillator whose output frequency and amplitude are determined by the crystal. There are no tuned circuits to worry about.

If the crystal causes the circuit to oscillate, there will be an r-f signal across the emitter resistor. This signal is then rectified by the diodes, filtered, and applied to the base of a lamp driver. If the oscillator is working (signifying a good crystal), the lamp should glow. This circuit will work between approximately 3 and 90 MHz. All you do is stick the crystal in the socket, depress the power switch and note whether the lamp glows.

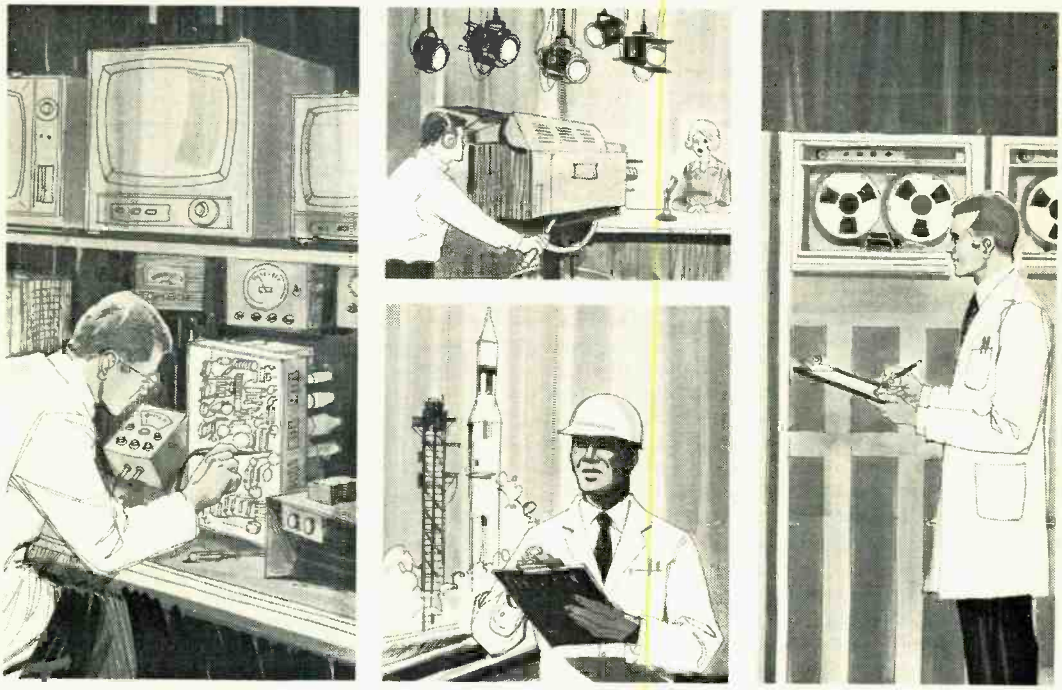
An Additional Note: This is to all you nice guys who wrote about how we said that a differentiated sine wave is still a sine wave ("Test Equipment Scene," November 1972). I was fully aware that it would be a cosine wave, but to most people using a single-beam scope, it still *looks* like a sine wave. I just didn't want to cloud the issue at that point by bringing in a new term that would cause readers to dash to engineering books to find out what was going on. Maybe I should have said, "sine-wave looking." ◈

IC MOUNTING TECHNIQUE



The mounting technique illustrated in the photo is ideal for experimenting with multi-lead IC's and other devices in TO-5 cans. This technique allows ready access to all leads for measuring and monitoring voltages and waveforms. The leads of the device are formed with the aid of a suitably sized rubber grommet that is fitted over the TO-5 can. With the grommet in place, it is easy to bend over the leads, after which the grommet is carefully removed. With the leads thus formed, the IC or other device can be mounted on perforated board by inserting the leads into small eyelets set into the board's holes. —*Royland Petterson*

Great careers



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Product Test Reports

DYNACO FM-5 STEREO FM TUNER
(A Hirsch-Houck Labs Report)

THE NEW Dynaco Model FM-5 stereo FM tuner, which measures 13½" wide by 4" high by 9" deep, matches the company's Model SCA-80 integrated amplifier in style and size. Its satin-finished, gold-colored front panel is dominated by a large rectangular dial window. Only two control knobs appear on this panel—a large tuning knob and a smaller volume control/power switch.

Three rocker switches located below the dial window betray a hint of some of the FM-5's unusual features. One is a MONO/STEREO switch with a center position that provides blending of the high frequencies in the two channels for stereo noise reduction, a common feature in FM tuners. Next is the AUX/FM switch which permits the user to connect the tuner's audio outputs and volume control to the two AUX inputs located on the rear of the tuner. This means that the FM-5 can be connected directly to a basic stereo power amplifier to form a usable stereo system, minus the tone controls and integrated amplifiers. Dyna also plans to offer as an accessory a magnetic phono preamplifier module (Model PPM-5) that can be installed in the FM-5 tuner. Connected to the AUX inputs, this will effectively convert the FM-5 into a simple high-quality preamplifier/FM tuner combo at minimum cost.

The third switch on the front panel controls the muting and DYNATUNE systems, both of which are disabled in the OFF position. DYNATUNE is a novel form of highly amplified afc in which an IC amplifier is used to insure that the tuner is locked onto the exact center, or minimum distortion point, of an FM channel over a 500-kHz tuning range.

Normally, such a strong afc system would invalidate the dial calibration and make it impossible to tune in stations with the 400-kHz alternate channel spacing. However, the DYNATUNE system can acquire a signal only when the tuning is within 50 kHz of the channel center, after which it holds onto the signal for an additional 250 kHz or so. The muting circuit, which works in conjunction with DYNATUNE, senses off-center tuning of more than 50 kHz or excessive ultrasonic noise over 150 kHz in the detector output; either condition would be sufficient to mute the receiver.

The FM-5 has a FET front end and an i-f amplifier that contains four IC's and seven ceramic filters. An IC handles most of the multiplex decoding functions, while another is used only for the DYNATUNE system. In addition to the variable audio outputs, there are fixed-level outputs for driving a tape recorder.

The construction of the tuner kit is greatly simplified by the fact that both of its circuit board assemblies and the front end are factory-assembled and aligned. Building the kit is essentially a matter of mechanical assembly and interconnection of the electronic modules. We assembled our kit in less than four hours. So, even a novice kit builder should not require more than five or six hours of assembly time.

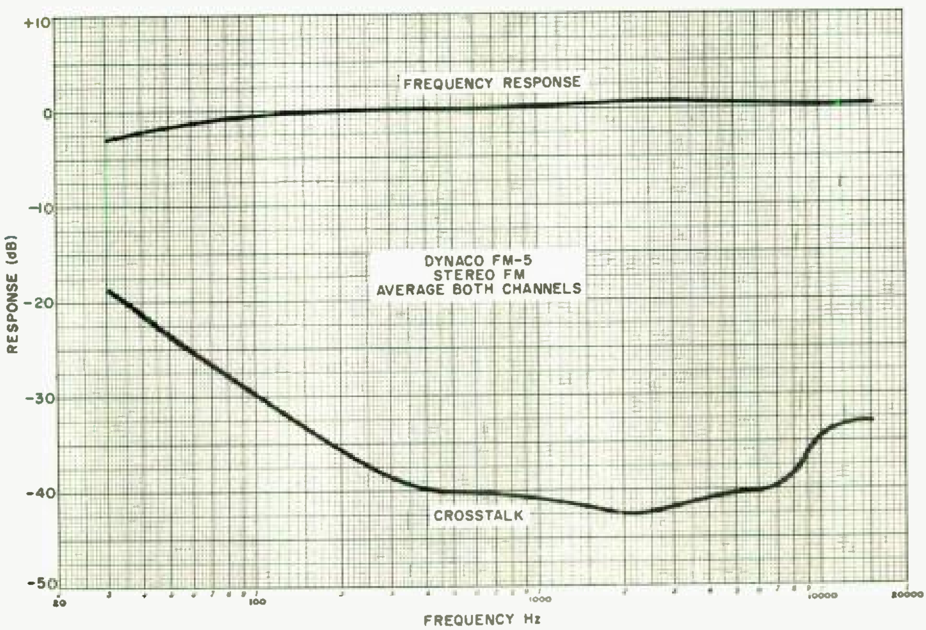
Once the kit is assembled, there is absolutely no electrical alignment required (or possible without the use of instruments not available to the average kit builder). Positioning the dial pointer is the only assembly step that affects the final calibration or performance of the tuner in any way. A note of caution is in order, however. Some of the potentiometers on the circuit boards are quite critical in their settings and can easily be disturbed if the modules are carelessly handled. When assembling the kit and connecting wires to the modules, care must be exercised to avoid changing any control settings.

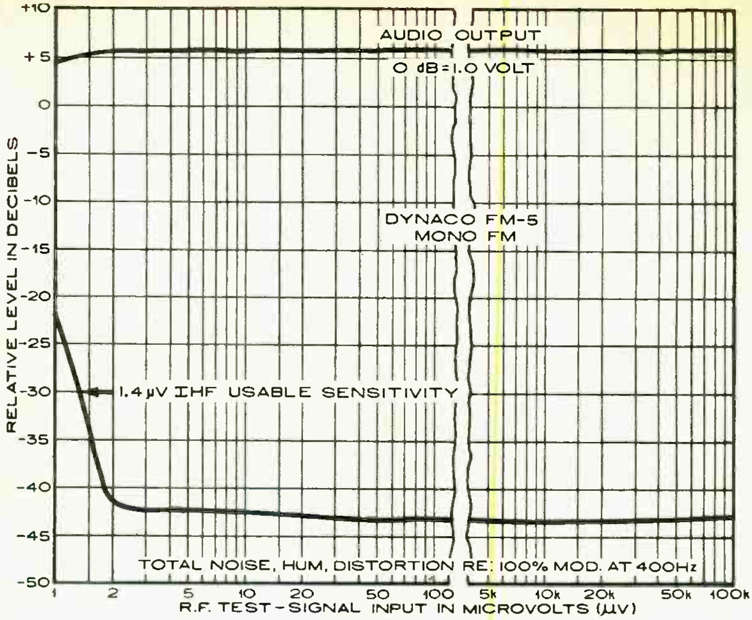
Laboratory Measurements. In spite of the ease with which the kit went together, the FM-5 tuner proved to be one of the most outstanding tuners we have put to the test. Its measured IHF usable sensitivity was 1.4 μV, which is close to the theoretical maximum and is in a range where measurement errors can become significant. In any event, it easily surpassed its rated 1.75-μV sensitivity. The limiting curve was steep, with a 50-dB (S + N)/N ratio occurring at 2 μV and an ultimate (S + N)/N ratio of almost 75 dB—among the best figures we have yet measured on an FM tuner. The measured distortion at 100 percent modulation was 0.75 percent, which includes the 0.5 percent residual distortion of our signal generator.

The capture ratio of 1 dB also surpassed the published specification of 1.5 dB. The AM rejection was 52 dB, and image rejection was 65 dB. Alternate channel selectivity was difficult to measure accurately because Dyna specifies it at 65 dB, while our measurement was nearer 90 dB! Doubtful as the latter figure may be, the tuner again surpassed its ratings in this important characteristic. The muting (and stereo switching) threshold was 4.5 μV. Maximum audio output from a 100 percent modulated signal was about 2 volts.

The stereo FM performance of the FM-5 was also quite extraordinary. Its frequency response dropped off slightly at the lower frequencies to −3 dB at 30 Hz. But is was flat within ±0.5 dB from 90 Hz to 15,000 Hz. Channel separation exceeded 40 dB from 450 Hz to 7000 Hz and exceeded 33 dB from 140 Hz to 15,000 Hz. At low frequencies, the separation fell to 18.5 dB at 30 Hz. Overall, the stereo separation of this tuner was among the greatest we have yet measured.

Use Tests. In use, the Dynaco FM-5 stereo FM tuner was delightfully smooth and easy to tune. The flywheel mechanism had a "feel" not usually associated with kit-built tuners (or even a great many factory-wired units). The muting action





was perfect, with absolutely no extraneous sounds such as thumps and noise bursts. We found that with DYNATUNE, any receivable station could be tuned simply by spinning the dial to the indicated frequency and stopping. In a fraction of a second, the TUNED light came on.

Although the dial calibrations are located at only 1-MHz intervals, they are so accurate that the pointer setting can easily be interpolated to 200 kHz or better.

A tuner with the performance of the Dynaco FM-5 would be a good value at almost any price. At its factory-wired price of $250, it is not exactly a steal, but it is worth every cent. Considering the ease of building the tuner, the kit price of only $150 is an unqualified bargain.

Circle No. 65 on Reader Service Card

SSI QUADRASIZER IV 4-CHANNEL ADAPTER
(A Hirsch-Houck Labs Report)

ALTHOUGH the last year or two has seen a proliferation of matrix systems for quadraphonic decoding, to say nothing of the advances in discrete 4-channel recording techniques, one should not lose sight of the fact that many of the advantages of 4-channel sound can be enjoyed with a minimum investment in equipment and without the addition of a new library of specially made recordings.

One of the earlier proposals for adding a "new dimension" to sound reproduction in the home was made by Dave Hafler, late of Dynaco, and several versions of his "decoder" have been sold under different names. The Hafler system takes advantage of the fact that most recordings contain considerable out-of-phase (L − R) information in addition to the L, R, and varying amounts of sum (L + R) program material. In a normal 2-channel stereo system, the L + R signals appear to be centered between the two speakers, adding to the stereo "spread" across the front of the listening room. The difference information does not appear to be in any specific location, but is merged with the other program material.

In many recordings, the room ambience (echoes within the concert hall) form a large part of the L–R program. The essence of the Hafler system is to drive two rear speakers with a signal derived from a mixture of the difference signal and some of the L or R signal, depending upon which rear speaker is being considered. This provides a small amount of separation, from front to rear or between the two rear speakers. But since the major effect of the separation is obtained in the front, this does not degrade the stereo effect (front separation is unaffected). The contribution of the rear speakers is largely a sense of "liveliness," or ambience, always present in the recording but not usually heard so effectively.

Best of all is the fact that this technique requires only the addition of two rear speaker systems, plus an inexpensive passive adapter. Although it can be used with any form of matrixed recording or radio program, it is frequently just as effective with ordinary 2-channel material. Of course, specific directional effects in matrixed quadraphonic recordings, whether using the Electro-Voice, Columbia's SQ, or Sansui's QS encoding methods, will not be heard with the intended directionality with the Hafler method, but the overall effect is nevertheless very satisfactory.

Decoder Configuration. A variation on the decoder configuration for this technique is now offered by SSI (Sound Systems International, Inc.). Their Quadrasizer IV, like the other decoders we have seen, drives the rear speakers with a mixture of L or R and the L–R signal. But unlike the other systems, it does not require that the amplifier outputs have a common ground, which in this case means that the grounds can be separate. The adapter's inputs go to the normal speaker outputs of an amplifier or receiver. The adapter has four outputs for the front speakers and four outputs for the rear speakers. All connectors are RCA phono jacks. On the front panel of the Quadrasizer IV are a rear level control and a switch that connects either the front or rear speakers or drives all four speakers in the usual manner.

Since the rear speakers are always driven at a lower level than are the front speakers, it is desirable that they be at least twice as efficient as the regular system speakers. SSI shows an alternate configuration in which the front speakers are driven directly by the amplifier and the adapter is used to drive a separate rear-channel amplifier from its outputs. This permits more effective level balancing, although it does require an additional amplifier.

We used the SSI Quadrasizer IV with several combinations of speakers and different program material and found the results very satisfactory. While the adapter does not produce some of the more spectacular effects possible with current decoders and correspondingly encoded discs, it enhances existing 2-channel material about as effectively as any of the decoders we have used for that purpose. This is an excellent way to begin a conversion to 4-channel sound with a minimum of equipment obsolescence.

The SSI Quadrasizer IV is relatively compact, measuring only 8¼" wide by 3" high by 6" deep. It retails for $29.95.

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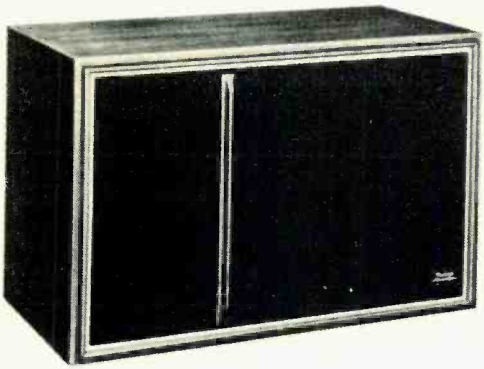
WHARFEDALE W60E SPEAKER SYSTEM
(A Hirsch-Houck Labs Report)



THE Wharfedale Model W60E is a three-way speaker system whose styling and compact dimensions (24" × 15" × 12") make it equally suitable for wall or floor mounting. The complete system, housed in an attractive oiled-walnut enclosure, weighs about 45 pounds.

The W60E's woofer is an acoustic-suspension design that is made to operate in a sealed enclosure. Its cone measures 12½" in diameter, while the massive magnetic structure weighs 9½ pounds. At 700 Hz, there is a crossover to a 5" cone-type midrange driver; at 3500 Hz, there is another crossover to the system's 1" dome-type tweeter. (These frequencies are not stated in the company's literature but were arrived at during our tests.)

Two continuously adjustable level controls on the rear of the enclosure permit separate adjustment for the middle and high frequencies. The W60E's nominal system impedance is 8 ohms.

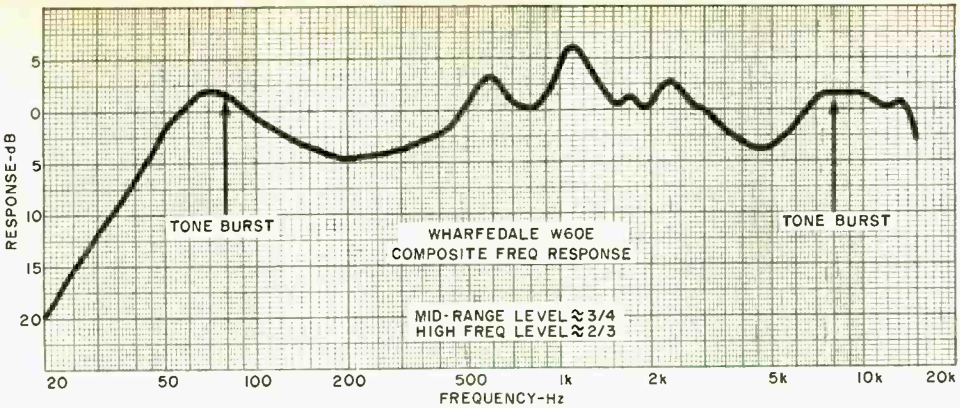
Laboratory Measurements. In the laboratory, our measurements showed that the Wharfedale W60E speaker system is relatively inefficient. In the 1000-Hz region, it required slightly more than 4 watts of power to produce a 90-dB sound-pressure level (SPL) at a 3' distance from the grille. However, any good amplifier capable of delivering at least 20 watts throughout the audio range should have no difficulty in driving the system at normal listening levels.

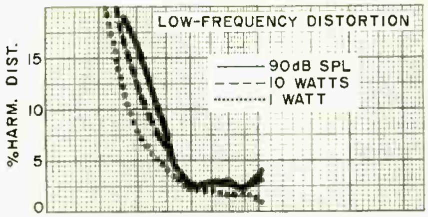
Since there are no indicated "normal" settings for the two speaker level controls, it is difficult to define a "frequency response" for the W60E. We experimented with various combinations of settings to obtain what seemed to be the best overall frequency balance using both our listening judgement and test measurements.

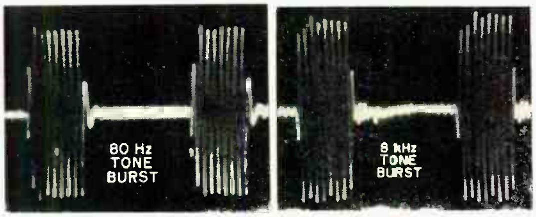
The "flattest" response was obtained in our listening room with the midrange level control set about three-quarters clockwise and the high-frequency level control at about two-thirds clockwise. The swept frequency measurement was made with a warble tone to minimize the effects of standing waves in the room, and a single microphone, located about 15' from the speaker, was used for the tests. At low frequencies, the response was measured by substitution against a calibrated speaker with close microphone spacing.

After being corrected for microphone response, the overall frequency response of the system was within ±5 dB from 45 Hz to 15,000 Hz. The midrange level was somewhat elevated, with slightly depressed regions centered at about 200 Hz and 4500 Hz. At the high frequencies, the response was very uniform, and dispersion was good. The midrange level control allowed the middle frequencies to be raised about 4 dB over our test level, or reduced by about 10 dB. It affected a frequency range of 700-4000 Hz, with the maximum effect at about 2000 Hz. However, it was not capable of modifying the general shape of the curve. The tweeter level could be adjusted over a range of 15-25 dB, depending upon frequency, with its action beginning at about 3500 Hz.

The low-frequency output was not only strong down to 45 or 50 Hz, it also had low harmonic distortion at these frequencies. The distortion was less than 5 percent at 50 Hz and above and rose to about







15-20 percent at 35 Hz, which we judge to be the lower limit for the system.

The tone-burst response was excellent throughout, with virtually identical and undistorted bursts being radiated by each of the system's three drivers within its operating range. The electrical impedance of the system was typically 4-5 ohms at the upper and middle frequencies, rising to about 20 ohms at 55 Hz and 450 Hz, and dropping to 6 ohms at 20 Hz, 100 Hz, and 1000 Hz.

Listening Tests. Our listening comparison test, in which the ability of the system to accurately simulate "live" music was judged, showed a slight midrange coloration that we would attribute to the measured response characteristics of the speaker. However, this effect was fairly subtle and not particularly evident until the speaker's sound was compared directly with the original. The highs were excellent in both smoothness and dispersion. Our listening room is on the "bright" side, but the range of adjustment available to the user makes the W60E adaptable to just about any room, if enough care is taken in its set-up.

Overall, the W60E is another fine speaker system in a rapidly growing and highly competitive price bracket, retailing for $130. While retaining many of the well-known virtues of acoustic suspension systems, such as extended low-distortion bass response in a moderate-sized enclosure, the W60E sounds different from most of its peers. It is well worth hearing, especially if you have any reservations about the sound of some of the other speaker systems in the W60E's size and price range.

COURIER "GLADIATOR" AM/SSB CB TRANSCEIVER

THE Courier "Gladiator" is a 23-channel AM/SSB CB transceiver designed to operate from a 12-14-volt dc, positive- or negative-ground, source. Although it carries the usual features of a rig of this type, the Gladiator's performance and appearance make it an outstanding unit.

A circuit diagram was not supplied with our unit; so, we are forced to limit our report to the transceiver's performance. The performance figures we cite below were determined with the aid of our own test gear in our own lab. However, they agree closely with the manufacturer's published specs where given.

Receiver Details. The dual-conversion receiver, employing 7800- and 455-kHz i-f's, had quite a hot front end that yielded an overall measured sensitivity of 0.1 μV for 10 dB (S + N)/N on SSB and 0.25 μV for 10 dB (S + N)/N on AM at 30 percent modulation and 1000 Hz. In either case, full rated a-f power output is obtainable at the rated sensitivity.

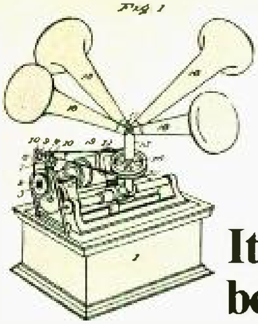
Selectivity on SSB is obtained by using a crystal-lattice filter that provides a 2.1-kHz bandpass with an unwanted-sideband suppression (at 1 kHz) and an adjacent-channel rejection of at least 60 dB. Selectivity on AM provides a 6-kHz bandpass through the use of a mechanical filter that has adjacent-channel rejection of 55 or more dB. Primary image rejection was 65 dB, with other spurious input signals at least 60 dB down, thus greatly minimizing the possibility of interference from other services.

The agc maintains a 3-dB a-f output increase with a 10-dB (1-10 μV) signal rise and 6 dB with a 60-dB (10-10,000 μV) range of signals. On SSB, the variations for the above respective signal changes were 9 and 11 dB. Where the agc is not adequate for minimizing overload on strong local signals (especially on SSB), an r-f gain control permits a decrease in sensitivity to cope with the situation.

A built-in meter indicates signal strength. It requires 1000 μV of input signal to register S-9. The squelch functions with either mode of operation and is adjustable for thresholds of 0.35-500 μV. Noise blanking can be switched in or out during either AM or SSB reception. It is highly effective and a must for mobile service.

Jacks on the rear of the transceiver allow external speakers to be used for receive or PA use. The a-f gain control is used to vary PA gain (microphone level), an unusual feature that enables optimum PA quality to be had without a-f feedback. With operation into an 8-ohm load, 4.5 watts of a-f output is obtainable at 5-percent distortion. Above this level, clipping tends to set in with 10 percent distortion at 6 watts (at 1000 Hz).

Transmitter Section. The transmitter functions at the legal inputs of 5 watts



It was 72 years before Frederick Myers' dream would become a reality.

Back in 1900, Frederick Myers dreamed that he could fill a room with dramatic music. But, he faced the same problem that plagued inventors for 70 years thereafter: the standing wave phenomena.

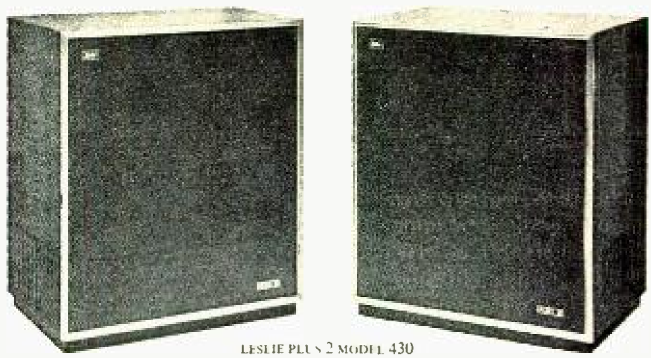
When placed in your home, every conventional speaker produces a fixed emission pattern of sound waves. These waves reflect from your walls to "add and subtract" from the true original signals. In this way, standing waves alter the true dynamics and reduce the "live qualities" of the music.

In 1971, the Leslie Speaker group of CBS applied for patents on special designs which—for the first time—effectively dealt with the standing waves. These patents are used exclusively in the Leslie Plus 2 Speaker system.

Here is what this breakthrough means to you. Now, you can hear music with a realism that is unmatched. You literally feel that you're in third row center of your favorite concert hall—no matter what part of the room you are sitting in.

Also, you can achieve this effect with either stereophonic or quadraphonic recordings!

For further information on this unique system, just send in the coupon below, or visit your authorized Leslie dealer. Sixty seconds of hearing the Leslie Plus 2 Speaker system will prove everything we say about it is true. Hear it for yourself ... soon!



LESLIE PLUS 2 MODEL 430

LESLIE PLUS 2 MODEL 450

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on AM and 15 watts PEP on SSB. It is designed to work into a 50-ohm load. However, an adjustable control on the rear panel permits maximum output to be had with slightly divergent loads. There is also an adjustable TVI trap built into this rig.

Operating from a 13.8-volt dc source, the AM carrier output was 3.8 watts with good upward modulation, exhibiting a clean waveform right up to the 100-percent level, at which point, slight clipping commences. Under this condition, the negative peaks break up the carrier. But a spectrum analysis revealed spurious responses therefrom during excessive modulation to be 50-60 dB down at the adjacent channel, thus avoiding the creation of adverse splatter.

On SSB, we measured 10 watts PEP during voice modulation, with an unwanted-sideband suppression the same as on receive and a carrier suppression of 45-55 dB, depending upon which sideband is in use. The results of a two-tone test indicated that the third- and fifth-order distortion was down 24 to 35 dB, respectively—among the best we have ever found.

Frequency control for the transceiver is obtained through a crystal-controlled synthesizer, the crystals for which have individual trimmers for bringing them right on frequency. A clarifier control enables the frequence for both the receiver and the transmitter to be shifted an average of ±550 Hz around the center frequency. On each channel, this was within 50 Hz of the channel assignment, thus holding the maximum possible deviation well within the legal tolerance of 0.005 percent. A mode switch that selects between AM, LSB, and USB changes crystals as needed. Switching between sidebands requires virtually no retuning inasmuch as the frequency remains within 50 Hz on most channels, although a difference of up to 200 Hz was noted.

General Comments. The Gladiator is a very ruggedly built CB transceiver. The black metal case measures 11¾" deep by 10⁹⁄₁₆" wide by 3" high. The weight of the basic rig, not including microphone, is 9½ pounds.

Current drain on receive is 300 mA. On AM transmit, it is 1.1 A with carrier only, and 1.7 A at full modulation. On SSB, the standby current is 600 mA, while during modulation it is 1.7 A.

The Courier "Gladiator" retails for $400 including microphone, mobile mounting bracket, and hardware.

Circle No. 68 on Reader Service Card

B&K MODEL 501A SEMICONDUCTOR CURVE TRACER

THERE are a number of approaches one can take when testing transistors. Those systems that employ audio tones or lamp readouts provide only a go/no-go indication of transistor operation. Other approaches that use meters show only the dc beta at one selected value of base current. However, when the exact beta of a transistor must be known, as when using the device in a twin- or bridged-T oscillator that demands a high beta to oscillate, at various collector voltages and base currents, or when matching a pair of transistors for a particular application, then an actual "family" of curves should be used.

The B&K Model 501A curve tracer ($130) that we have been using is an excellent example of a first-class semiconductor tester. We say "semiconductor" rather than transistor because besides being a conventional npn and pnp bipolar transistor checker for ac and dc gains (beta), breakdown, leakage, saturation voltage, output admittance, and the effects of temperature, the unit also checks transconductance (gain) and pinch-off voltages of FET's. Also, rectifier, signal, and zener diodes can be thoroughly checked, as can UJT's, SCR's, triacs, diacs, tunnel diodes, and some types of IC's. This list should suffice for many years of bench use.

Use With Scope. The 501A curve tracer is designed to be used in conjunction with almost any oscilloscope, although a dc scope with an external horizontal input is preferable. The curve tracer employs a testing voltage (collector sweep) that is variable from 0 to 100 volts dc peak, adjustable via a calibrated potentiometer on the control panel. Current limiting prevents catastrophic burnout of the device under test when performing breakdown tests. A built-in sweep generator employs a six-step waveform that has 11 ranges from 1 μA to 2 mA per step, depending on the setting of an appropriately marked switch, and five voltage ranges from 0.05 to 1.0 volt per step. Operating at 120 steps per second, the scope's CRT display is quite steady.

The display can be calibrated through the use of the 3-percent accuracy 0.05-to-5.0-volt peak-to-peak source. There is also a built-in scope vertical attenuator that has a 1-2-5-10-mA/division vertical range. A special scope graticule is provided for properly displaying the calibrated curves generated by the curve tracer.

The tracer measures 10" × 9" × 4" and weighs 6 pounds. It has a sloping-top control panel. A pair of TO-5 sockets, marked for both bipolar and field effect transistors, with each pin paralleled by a suitably marked banana jack for external cables, enables a rapid A-B slide switch comparison of two transistors.

Banana jacks are also used for providing a convenient means of interconnecting the tester and scope. A special "universal joint" three-tip probe equipped with needle-sharp points, is provided for simplified in-circuit testing of semiconductors or transistors that have other than the TO-5 configuration. The probe pins and connectors are color-coded to the three banana jacks.

The manual supplied with the curve tracer not only covers every aspect of semiconductor testing and the use of the instrument, but it also is a complete semiconductor course in itself.

We have been using this unit to check out transistors both in and out of circuits and have found it to be a very handy bench instrument. There were times we were shocked at the differences in the family of curves between two supposedly similar transistors. This could account for some strange results we have been encountering with "exact" replacements.

Circle No. 69 on Reader Service Card

MAC'S SERVICE SHOP

Zenith's 1973 Color Line

By John T. Frye, W9EGV, KHD4167

"LAY down your solder gun, Barney," Mac said to his assistant. "I want to up-date you on the Zenith 1973 color TV line we're going to be encountering before long. I bought these service manuals from the company and have been studying them. Now I'm ready to bestow my acquired wisdom on lucky you."

"No contest," Barney said. "I'd always rather listen than work. Blast off."

"First, Zenith has two complete color TV lines for 1973. Sets in one line are remote controlled; those in the other, manually controlled. If the customer goes for remote control he can have it in one 16" portable, or two 19", one 23" or one 25" table models. He can also get RC on ten 25" consoles or two 25" combinations. But he still must make up his mind how sophisticated a remote control he needs. The four-button 600-X turns the set on and off, switches vhf and uhf channels higher or lower, adjusts the volume to one of three levels, and mutes the sound. The three-button 500 system turns the set on and off, adjusts the volume to two levels or mutes the sound, and changes the vhf channels higher or lower. The 100 system turns the set on and off and changes vhf channels higher or lower with a single button. All three systems use Zenith's Space Command mechanically produced ultrasonic signal.

"Twenty-six sets in the manually operated line break down into two 16" portables; five 19", one 23" and one 25" table models; four 23" and twelve 25" consoles; and one 25" combination. All Zenith color sets are served by three basic chassis. The Titan 200 is 100% solid-state and features the Zenith Dura-Module concept of five good-sized plug-in modules. Incidentally, transistors and IC's on these modules are also plug-in and can be replaced when necessary without changing the entire module. The Titan 101 chassis is over 90% solid-state and also uses Dura-Modules. The High Performance Chassis used in the portables features Zenith's solid-state 3-stage i-f module with an amplification factor of 26,000. This module has been modified this year by incorporating a hot-carrier diode for detection and changing the biasing for the third i-f transistor to increase reliability.

"The sound module, employing an IC amplifier, has also been changed this year so the volume control varies a dc potential applied to the IC amplifier to control its gain instead of varying the audio signal directly. You'll also find a change in the black-and-white tracking adjustment procedure. Instead of using potentiometers to vary the red, green, and blue gains, Zenith does this with taps in the red and blue cathode circuits. Don't waist any time looking for knobs to twist. Just read the service procedure."

"What's the 'Chromatic Brain' that I hear Zenith yakking about?"

"That's their name for circuitry designed to detect and extract color information from the signal. It's built around a Zenith-developed IC containing two independent, double-balanced demodulator systems. But there's no point in our going into features you take for granted on a modern color set—such as automatic degaussing, afc, motor-driven touch tuning, etc. Instead I'd like to call your attention to such things as Zenith's solid-state electronic tuning, their voltage-regulating transformer, their chromatic one-button tuning system and their Super Chromacolor picture tube.

"The solid-state electronic tuning is standard in ten of the 25" color sets in the remote control line and provides for control of both the solid-state vhf and uhf tuners through a solid-state 'nerve center' mounted on its own Dura-Module. With this system, up to fourteen pre-tuned channels, locally available, can be set up through the front of the set in any combination or sequence desired for direct channel-to-channel tuning by the hand-held RC unit. When desired, new channels can be quickly added or substituted for one no longer watched, thus providing true 82-channel remote control."

The Voltage-Regulating Transformer. "The voltage-regulating transformer is used in their 25DC56 color TV chassis. (Incidentally, the '25' in the chassis number indicates a 25" diagonal picture tube; the 'D' indicates the year 1973; the 'C' stands for color, and the '56' is the individual chassis designation.) This transformer supplies all voltages required with reasonable regulation under power line variation from 95 V to 140 V. This is done by using a transformer with loose coupling between primary and secondary windings and by tuning the secondary winding to resonance at the 60-Hz line frequency by means of an externally mounted 3.5-μF oil-filled capacitor. Resonating the secondary causes the voltage to increase until the core material saturates, rendering any further increase in voltage impossible. The effect is much the same as if you had a double-ended zener across the secondary. Not only does this arrangement provide good regulation of the secondary voltage through wide swings of the line voltage or current demands, it also suppresses transient pulses on the incoming power line—transients that can wreck transistors and IC's. For example, the total B-plus change on the 128-V line is approximately only 5 V with brightness varied from minimum to maximum or with the line voltage changing from 100 V to 132 V; and a 30-V transient appearing in the primary for 2 seconds appears on the output side at less than 15 V in amplitude and lasts for only about 100 milliseconds.

Still another advantage to the loose coupling of the transformer windings is the limiting of short-circuit currents. Under conditions of a direct short circuit across the secondary, the current will increase only to about double the normal current, which will trip the circuit breaker with no damage to the transformer. But let me warn you of one thing: don't expect to get the rated 6 volts rms on the filament of the picture tube if you use a conventional D'Arsonval meter movement where the rms voltage is derived from a sine wave peak detector.

You're measuring a square wave produced by the limiting action of the transformer, and a true rms-reading meter or a dynamometer movement must be used. It would be a good idea if Zenith would provide a scope measurement of this filament voltage. Not many service technicians have dynamometers!"

One-Button Tuning. "Zenith's chromatic one-button tuning system features versatility, and is available on thirty-eight sets, spread over both color lines. With the CHROMATIC TUNING button off, the color-level, tint, contrast, and brightness are adjusted with the manual controls to taste. When the button is on, it lights with an orange glow and a 'second' set of controls pre-set at the factory for a normal picture, are switched in and override the manual controls.

"But the owner may prefer a different 'normal' picture than the factory set up. If so, with the CHROMATIC TUNING on, he or the service technician can readjust the brightness, contrast, color level, and tint with an insulated screwdriver provided. From then on, any time the CHROMATIC TUNING is on, the owner's custom-selected picture appears automatically on the screen.

"Finally, even if he does not change the factory settings, he still has a short range of adjustment with the manual controls when the CHROMATIC TUNING is on. He can make slight changes in flesh tones and color intensity to compensate for discrepancies that may occur with older color movies, certain taped programs, and occasional variations in transmission by TV stations."

Super Chromacolor Picture Tube.® "That brings us to Zenith's 1973 Super Chromacolor Picture Tube. I'm always astonished that a Rube Goldberg contraption such as the three-gun shadow mask color picture tube—with all the precise geometry and nanosecond timing its operation demands—can be made to work at all; yet Zenith seems to have brought that performance closer to perfection by achieving a significant increase in brightness by increasing the area of total active phosphor on the face of the tube.

"As you know, the shadow mask is used as a stencil in depositing the dots of the phosphors on the tube face. That means the size of the holes in the shadow mask—some 450,000 such holes in a 25" tube—determines the size of the phosphor dots. In a standard tube the dots are 17 thousandths of an inch in diameter at the center. The electron beam is 13 thousandths in diameter. Being smaller than the dot, the beam illuminates only 45% to 65% of each dot. The remaining dot-area is needed as a 'guard band' or tolerance allowance for the alignment of electron beams and phosphor dots. By allowing a larger target for the beam to hit, we avoid discoloration produced by slight beam misalignment. The aluminized area between dots in a standard tube reflects room light and causes washout and loss of picture contrast. To overcome this a low-light-transmission glass is used in the face of the standard tube to cut down on reflected light. Unfortunately it also absorbs about half of the actual screen brightness.

"The original Chromacolor tube, patented in 1964 and introduced in 1969, doubled the brightness of the then-standard tube by illuminating each dot completely and surrounding the dots with a jet-black light-absorbing material that soaked up reflected room light. Tubes employing this black-surround feature are called 'matrix' tubes and are used by several manufacturers because they permit the use of higher light-transmission glass in the face of the tube and consequently brighter pictures without increasing room light reflection.

"Zenith employs what they call the 'negative guard band' approach in which the electron beam is made larger than the phosphor dot, and it is done with their 'Iris Mask.' A mask is first prepared in normal fashion except the holes are smaller—9 thousandths of an inch in diameter at the center in the original Chromacolor tube—and it is used in depositing the phosphor dots. Then the mask is removed and the holes are acid-etched to 14.5 thousandths at the center of the tube. Now we have a beam larger than the dot; so the entire surface of the dot and part of the black area surrounding it are illuminated. Even if the larger beam is slightly misaligned, it will still illuminate the entire dot, instead of the 45% to 65% formerly illuminated by the smaller beam.

"There are other less important changes. In the original Chromacolor tube the dots grew progressively smaller moving from the center toward the edges. This provides additional guard band to assure alignment of the sharply-deflected beams at the edges. The decrease in size was in the form of concentric circles with the dots in each circle being the same size, but growing smaller as the circles grew larger. In the Super Chromacolor tube, the decrease in size is in the form of concentric rectangles instead of concentric circles. With this configuration, the *majority* of holes in the mask are larger than in the previous chromacolor tube, although some at the edge are actually smaller. Finally, the electron guns are made more precise to approach the ideal of a perfectly round electron beam. A beam slightly oval in shape produces a tiny amount of distortion."

"Zenith got a reputation of being kind of reactionary when they were so slow to switch over from hand-wiring to printed circuits," Barney offered.

"Probably *conservative* would be a better word," Mac suggested. "Maybe they follow Pope's advice: 'Be not the first by whom the new is tried, nor yet the last to lay the old aside.' Perhaps this comes from taking their advertising slogan seriously. 'The quality goes in before the name goes on.' Those first PC boards, with their plated-through holes and their flimsy construction, *were* pretty horrible. I know Zenith carries on an aggressive research program, and just last October they demonstrated a 0.63-inch thick TV display panel using a matrix and gas discharge principle. Their Robert Adler forecasts we shall have flat wide screen TV by 1985 at the latest, and he says a component failure in any part of a TV receiver should be a rare event by that time. He also speaks of their experiments with 3-D holographic TV, although he is not optimistic about this being perfected in the near future.

"Incidentally, their advanced color-TV research groups are housed in the new parts and service administrative headquarters at 5600 West Jarvis Avenue, Niles, Illinois. This is also the base for Zenith's customer relations service program in which P.J. Wood, Vice-President Customer Relations, says: 'Service is arranged for virtually 100 percent of all customer complaints as soon as we hear from a customer—within 48 hours at the latest.' I'll bet they are, too, for a follow-up letter from Zenith President, John J. Nevin, asks for customer reaction to the service performed!"

Barney rose from his stool and stretched until his muscles cracked. "It's refreshing to see a manufacturer backing his product like that," he said. "Let's hope the idea catches on." ◈

RCA Institutes introduces the CASSETTE SYSTEM

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Now, another breakthrough from the company that brought you AUTOTEXT, RCA's step-by-step home learning method! It's the new RCA Institutes' CASSETTE SYSTEM, an innovative learning-by-hearing approach designed to get you started more quickly and easily towards an electronics career. The CASSETTE SYSTEM adds an extra dimension to AUTOTEXT, RCA's step-by-step planned instruction which simplifies the mechanics of learning. As you play the cassette tapes, you'll have an instructor guiding you through your AUTOTEXT lessons. Explaining the material as you read it. Going over schematics with you, reinforcing the basic electricity and electronics study materials. All in an easy-to-understand conversational tone. And now the CASSETTE SYSTEM is available as an optional extra to all students enrolling in basic, fundamental, and career programs.

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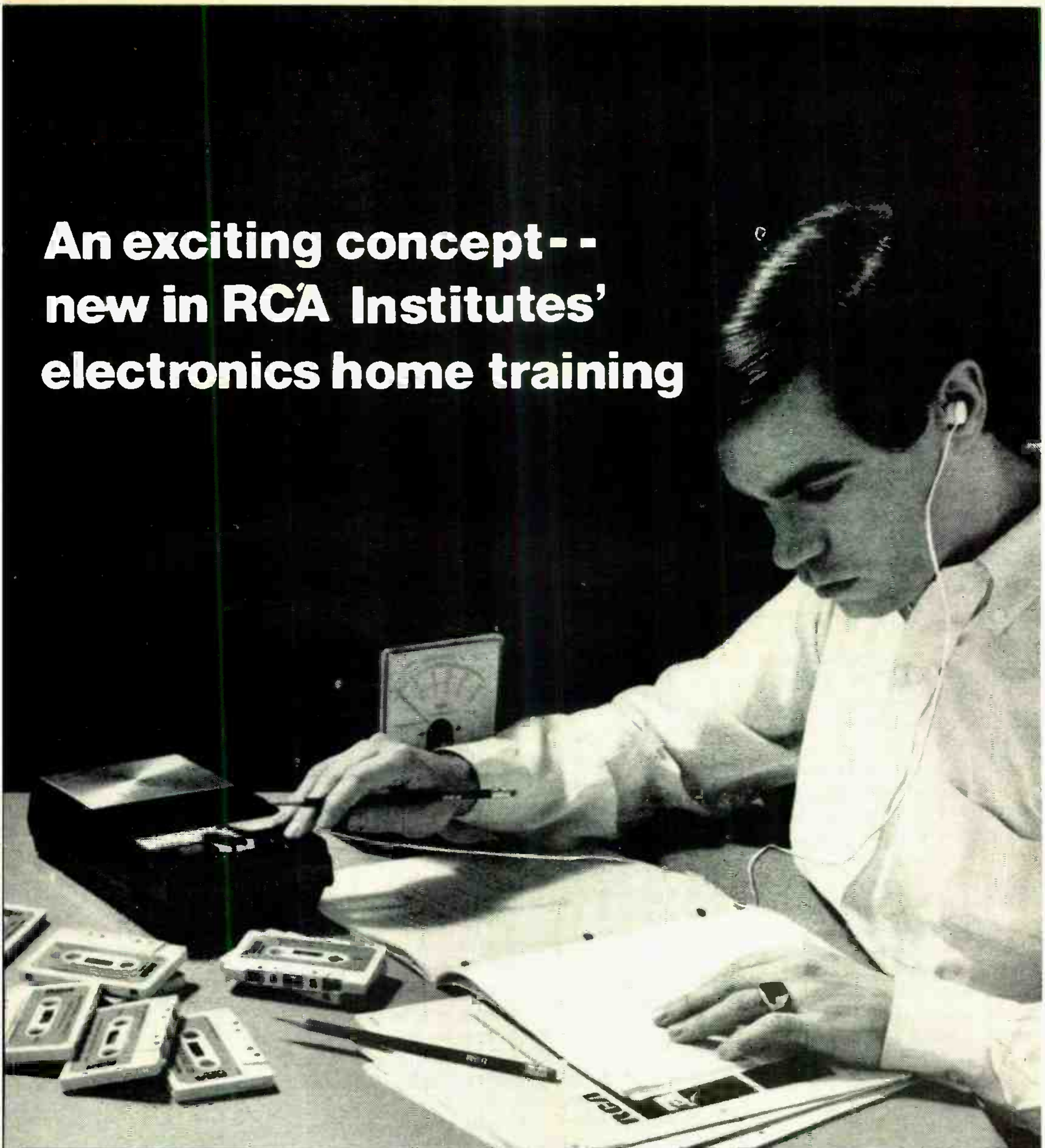

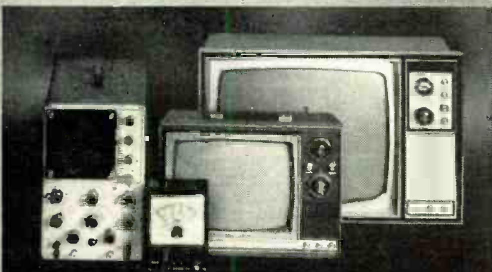

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CIRCLE NO. 23 ON READER SERVICE CARD

Solid-State Scene

By Walter G. Jung

More New Devices & Applications

THE HOTTEST item in the audio world right now is quadraphonic sound, and Motorola's just-introduced MC1312P and MC1313P IC chips should find use in many a 4-channel matrix system. They are designed for decoders of Columbia SQ encoded program material. The MC1312P and MC1313P are similar in operation, the former being for home-based equipment and the latter for automotive applications. The basic circuit for either use is shown in Fig. 1. Recommended V_{CC} is 20 V for the MC1312P and 12 V for the MC1313P. Both chips operate essentially as zero-gain signal processors with a typical signal-to-noise ratio of 80 dB, harmonic distortion of 0.1%, and high input and low output impedances.

Readers are reminded that the SQ process is covered by CBS patents, and the IC's will be available only through CBS licensees. The MC1312P and MC1313P are in 14-pin plastic DIP's with prices for 1 to 99 of $2.80 for the MC1312P and $3.10 for the MC1313P.

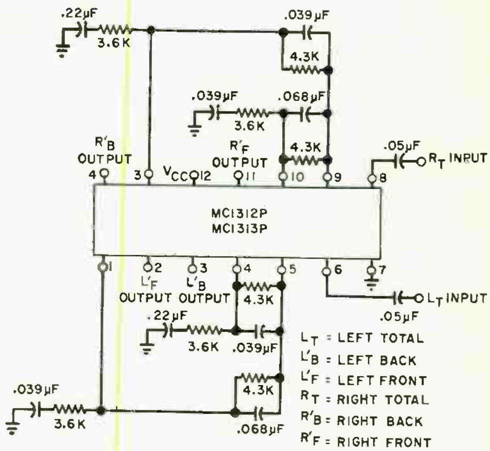

Fig. 1. Typical applications circuit for MC1312P or MC1313P decoder IC.

New Transistor Arrays from RCA. The popular RCA line of integrated circuit transistor arrays has been augmented with several useful new devices. The CA3096AE, for instance, has three general purpose npn transistors and two pnp's in a 16-pin DIP with two npn's and the two pnp's specified to match. The CA3096E is the same basic device without tight matching. With no interconnections, flexibility of the five devices is at a maximum. Try your hand at some of the applications which suit the matched complementary performance–differential amplifiers, timers, lamp or relay drivers, for instance. One very unique circuit is shown in Fig. 2. This is a 10-second timer which operates from a single 1.5-volt cell.

For more sophisticated applications of arrays, there is the new CA3095E, a super beta plus three-transistor array. What is super beta? Really it is just a single transistor (as opposed to a Darlington) processed for extremely high gain. The CA3095E units, for instance, have a typical beta of 2000, allowing operation with a base current of a few nanoamperes. This means they can work with much higher impedances (in the megohm region), providing timers for long periods and preamps with low input currents.

Of course, RCA has not neglected r-f and

Some of the reasons why other turntables don't perform quite like a Dual.

Because of the wide acceptance and acclaim Dual has earned over the years especially among audio experts, many Dual features inevitably appear on competitive turntables.

To copy a Dual feature is one thing: to achieve Dual performance and reliability is quite another matter. The true measure of a turntable's quality is not its features alone but how well the entire unit is designed and manufactured.

Following are just some of the ways in which Duals differ from other automatic turntables.

Gyroscopic gimbal suspension.

The gyroscope is the best known scientific means for supporting a precision instrument that must remain perfectly balanced in all planes of motion. That is why the tonearms of the 1218 and 1229 are suspended in true, twin-ring gimbals.

Every Dual gimbal is hand-assembled and individually checked with gauges especially developed by Dual for this purpose. This assures that the horizontal bearing friction of the 1229 for example, will be no greater than 0.015 gram, and vertical friction no greater than 0.007.

True single-play automatic tonearm.

A turntable of the 1229's caliber is used primarily in its single play mode, so the tonearm is designed to parallel a single record on the platter. For multiple-play, the entire tonearm base is moved up to parallel the tonearm to the center of the stack.

The 1218 tonearm provides the single-play adjustment within the cartridge housing, and the cartridge pivots around the stylus tip to maintain the correct overhang.

Stylus pressure around pivot.

Today's finest cartridges designed to track at around one gram have little margin for error. In the 1229, therefore the tracking pressure scale is calibrated within 0.10 gram from 0 to 1.5 grams.

To maintain perfect balance on every Dual tonearm, stylus pressure is applied internally and around the pivot. This is accomplished by a very long spring coiled around the pivot. Only a small portion of the spring's length is needed to apply the required pressure, thus contributing greatly to the accuracy of the calibrations.

Avoiding sounds that weren't recorded.

The rotor of every Dual motor is dynamically balanced in all planes of motion. Each motor pulley and drive wheel is also individually examined with special instruments to assure perfect concentricity.

Any residual vibration within the motor is isolated from the chassis by a three-point damped suspension. Finally every assembled Dual chassis is "tuned" to a resonance frequency below 10 Hz.

The best guarantee.

All these precision features and refinements don't mean that a Dual turntable must be handled with undue care. So we're not being rash when we include a full year guarantee covering both parts and labor for every Dual. That's up to four times the guarantee you'll find on other automatic units.

Now, if you'd like to know what several independent test labs say about Dual, we'll send you complete reprints of their reports.

Better yet, just visit your franchised United Audio dealer. You'll see for yourself that only a Dual performs precisely like a Dual.

Dual

Dual 1215S $109.50

Dual 1218 $155.00

Dual 1229. $199.50

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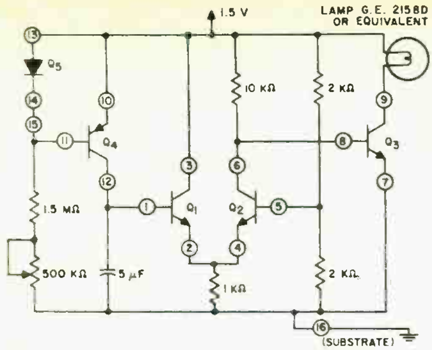


Fig. 2. This 10-second timer circuit using a CA3096E transistor array is powered by a 1.5-volt supply and is used to turn on power to a light bulb.

i-f. The new CA3049T (12-lead TO-5) and CA3102E (14-lead DIP) high-frequency differential amplifiers sport an impressive cutoff frequency of 1.35 GHz, allowing operation from dc well into the uhf region. What are the applications? They include mixers, oscillators, balanced modulators, product detectors, and anywhere that a good pair of high-frequency differential amplifiers can be used. As an example, a 200-MHz front end using the devices can achieve 23 dB of gain with a 4.6-dB noise figure.

Prices for the arrays, in quantities of 1 to 99, are CA3096E at $2.06; CA3096AE, $2.64; CA3095E, $4.95; CA3049T, $3.22; and CA3102E, $3.75.

Further information is available from:
RCA Solid State Division
Box 3200
Sommerville, NJ 08876

National Consumer/Automotive Products. Jumping into the consumer area with both feet, National Semiconductor has introduced several items (in addition to the LM381 recently introduced).

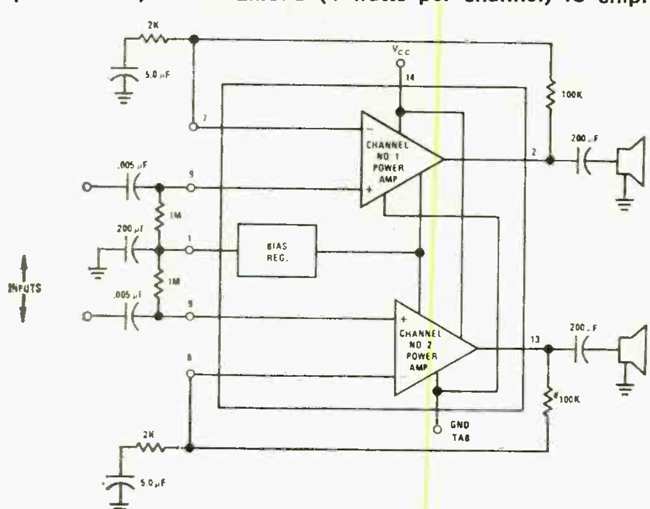
The LM377 and LM378 are stereo output amplifiers of similar basic design but different power outputs. The former has 2 watts per channel into 8 ohms while the latter boasts 4 watts per channel into 16 ohms. Both chips have a high open loop gain of 116 dB, harmonic distortion of 1% and operate from single supplies from 10 to 26 volts.

For single-channel use, the LM380 is available with a fixed gain of 50 and minimum power of 2.5 watts into 8 ohms. Operation is from a single supply up to 22 volts, with simple input biasing and automatic dc-centered output setting. The chip is in a unique 14-pin package with multiple copper ground leads for heat sinks. Applications for the LM380 are in simple phono amplifiers, line drivers, AM/FM/TV sound outputs, servos, and power oscillators.

For a real wallop in automotive sound, the LM383 delivers 5 watts of power into 4 ohms from a 14-volt supply, while distortion is a low 1%. This chip also has a high-gain (1500) preamplifier section along with an output stage with a gain of 10.

With all of these National power amplifiers, thermal overload and short-circuit protection are standard. A representative ap-

Fig. 3. Stereo power amplifier using the LM377 (2 watts per channel) or the LM378 (4 watts per channel) IC chip.



plication for the LM377 and LM378 is shown in Fig. 3.

Further details are available from:
National Semiconductor Corporation
2900 Semiconductor Dr.
Santa Clara, CA 95051

LED and Electro-Optic Developments from Monsanto. A pair of light-emitting diodes (LED's) has been introduced by Monsanto. The new devices, MV5094 and MV5491, can operate on an ac source; whereas this type of operation previously required an external reverse-voltage clamping diode.

The new arrangement is simple: two LED's are placed back-to-back in parallel in a single package. The MV5094 is a pair of red LED's connected as such, while the MV5491 is a red/green combo. Two different colors permit a single lamp to display 4 different states, such as red for positive dc, green for negative dc, red/green for ac, and nothing for no voltage. For factory orders, Monsanto will even custom combine other colors from the standard red, green, or yellow basic LED's.

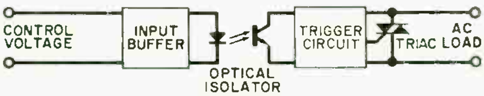


Fig. 4. Circuit of MSR100 solid-state relay using a light-emitting diode.

Ever have a problem with relay driving or transient suppression? The answer may be in one of Monsanto's new MSR100 series of solid-state relays. These devices use LED phototransistor electro-optic coupling for control, with the phototransistor triggering a zero-crossing synchronized triac to switch ac currents of 10 amperes (Fig. 4). The synchronous switching automatically minimizes load transients; and since there is no control coil, no r-f interference is generated.

The devices come in screw-terminal, aluminum heat-sink packages with normally open or closed contacts. Voltage ratings are as high as 280 volts ac. Input control is either dc (TTL) or 120/240 volts. In quantities of 1 to 9, prices are $1.75 for MV5094; $5.81 for MV5491; and $20.00 for MSR100.

For further information:
Monsanto Commercial Products Co.
Electronic Special Products
10131 Bubb Road.
Cupertino, CA 95014

CRYSTALS FOR CB & Ham Communication

TO KEEP YOUR SIGNALS STEADY AS A ROCK, YOU NEED QUARTZ CRYSTALS IN PROPER CIRCUITS

BY R. R. FREELAND

President, International Crystal Manufacturing Co.

QUARTZ crystalline material, natural and "grown" by man, has become the most widely used device for controlling radio frequencies. Historically, crystal frequency control began with radio amateurs back in the late 1920's. Full-scale production and use of crystals in the commercial market began during World War II. Since 1945, however, considerable effort has gone into improving crystal production methods and the circuits in which crystals are used to provide close control over frequencies over wide temperature ranges.

Many crystals, particularly quartz, exhibit a property known as "piezoelectricity," whereby they convert mechanical energy into electrical vibrations (oscillations) and vice-versa. A crystal blank cut from quartz will vibrate mechanically about one or more nodal points when a voltage is applied to it. Both fundamental and harmonic (whole multiples of the fundamental) oscillations are generated by the crystal.

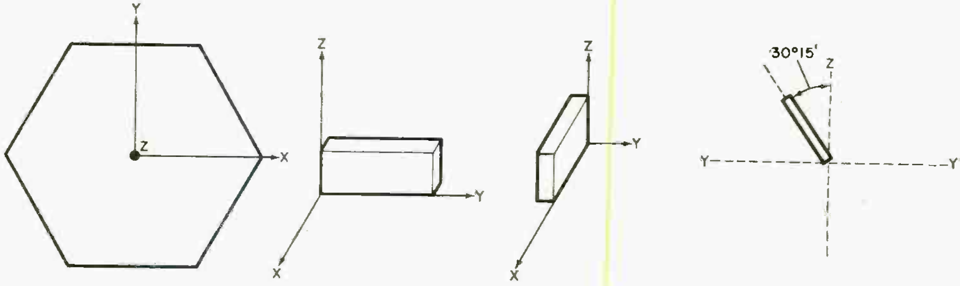
The fundamental frequency at which a crystal is made to oscillate depends upon many factors but mainly the crystal's size and thickness, the angle of "cut," and operating temperature. As far as size and thickness are concerned, the smaller they are, the higher will be the operating frequency. The cut of the crystal refers to the manner in which the blank is sliced from the bulk crystal material, taking into account the six-sided crystalline structure.

Of the general modes of oscillation obtainable from a crystal (extensional, shear, and flexure), we are interested in only the shear mode for amateur radio and CB applications. In this mode, wave propagation is parallel to the thickness dimension.

The thickness shear is sometimes called the high-frequency shear mode. The quartz can also oscillate at a mechanical harmonic (must be an odd number) such that the two opposite faces of the blank effectively move in opposite directions. The mechanical harmonic should not be confused with the electrical harmonic which can be any multiple of the fundamental frequency.

The orientation of the raw quartz crystal is universally defined by assigning X, Y, and Z axes as shown in Fig. 1. The Z axis is commonly referred to as the "optical" axis owing to the fact that it can be located by optical methods. No piezoelectric effects are directly associated with it as they are with the X (electrical) and Y (mechanical) axes. X-cut crystals are used mainly for low-

Fig. 1. Axes for the mother quartz crystal. Both X-cut and Y-cut blanks are shown. The AT-cut crystal is widely used.



frequency applications, and Y cuts are used mainly for medium- and high-frequency applications. Hence, our only interest here is in the various Y-cut crystals.

A simple Y-cut crystal is a poor frequency control device. So, the simple Y cut has been replaced by rotated-Y cuts, the most

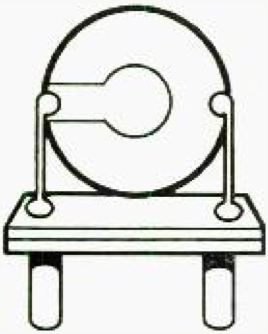


Fig. 2. Edge-clamp or cemented-lead mount.

common of which is the AT cut whose plane is rotated around the X axis by approximately 35° from the Z axis. By carefully selecting the angle of rotation, crystals with very small temperature coefficients can be fabricated. For critical requirements, angle tolerances are maintained within 15 seconds of arc. For less critical ham and CB applications, the tolerance can be within 3 minutes of arc.

The AT crystal is commonly mounted in its holder by the edge-clamp method (cemented lead mount) as shown in Fig. 2. Plated electrodes cover part of the crystal face. Plating on the opposite faces extends to the edges to provide good electrical contact. By keeping the electrode area small, the capacitance is reduced and the principal activity is confined to the central region of the crystal to improve stability. This, in turn, reduces the impedance of the supporting wires.

High-quality piano wire supports the crystal. A small amount of conductive cement assures a good connection between the wire and the plated electrode. (With the plated-wire mounted crystal, calibration tolerances can be as high as 0.001 percent.) The crystal is sealed in a vacuum or dry-nitrogen-filled glass or metal case.

Crystals are designed and processed to undergo a minimum of aging during their useful lives. A 10-part-per-million rate the first year is not an unreasonable figure. The aging rate decreases with time and usually levels off after about six months of operation. Pre-aging by heat cycling can reduce the initial aging period.

When a crystal is put into operation, the lower the drive level, the longer its useful life. The aging factors are more pronounced when a crystal is operated at high drive levels, and the higher operating voltage increases the possibility of corona discharges which, together with greater vibration amplitudes, can lead to crystal failure. To obtain maximum life and stability, crystals should be operated at the lowest practicable drive levels.

Crystal Circuitry. The simplified equivalent circuit of a crystal in its holder is illustrated in Fig. 3. Capacitor *C2* represents the electrostatic capacitance between the electrodes, while *L*, *C1*, and *R* represent the equivalent mass, compliance, and frictional loss of the vibrating crystal. Capacitance *C2* can be measured by conventional methods; the series-resonant and anti-resonant impedances and frequencies can be measured by using a crystal impedance meter. From these two sets of measurements, *C1* and *L* can be calculated. (The crystal can appear as either a low-impedance device at series resonance or a high-impedance device at anti-resonance.)

Crystals can be operated at series resonance, but it is impractical to operate them at exactly the anti-resonant frequency. Adjusted to operate at maximum voltage (parallel resonance) at some proper phase and frequency, the crystal is most sensitive to frequency changes with small changes in effective load impedance. Both the equivalent impedance and resonant frequency change with effective load changes. A 30-to-40-pF load operates the crystal at a lower impedance point where small circuit changes have less effect and the adjustment range is smaller with the same trimmer capacitor.

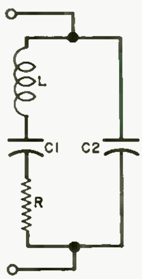


Fig. 3. This is a simplified schematic of an equivalent circuit for a typical quartz crystal mounted inside a holder.

The total shunt capacitance across the crystal plays an important part in determining the final frequency. However, the crystal

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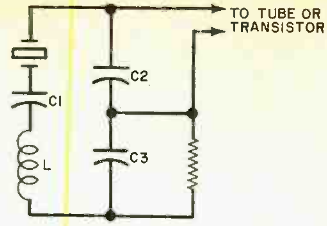


Fig. 4. Typical crystal oscillator circuit.

itself bears the primary responsibility for frequency stability, which is dependent upon the magnitude of the change in reactance with frequency.

Crystal Performance. Crystals can be graded according to activity, frequency stability, bandwidth, quality factor (Q), and parameter stability. Frequency stability is the crystal's ability to minimize frequency changes arising from variations in the parameters of the external circuit. Bandwidth is the useful operating frequency range of the crystal. Quality factor is simply a figure of merit. Parameter stability is the stability of the crystal parameters during changes in temperature, drive level, and tuning adjustments. The stability of a crystal oscillator depends upon both the crystal and the parameter stabilities.

Transmitter crystals are usually operated at the fundamental frequency into an approximate 32-pF load. A common crystal oscillator configuration is shown in Fig. 4. The maximum effective load is present in this circuit when *C1* is shorted. Inductor *L* is used to balance out capacitive reactance to permit operating at series resonance.

Many CB rigs provide a single trimmer capacitor for all channels instead of individual trimmers for each channel, which complicates correlation for many transmitters. Switch lead lengths and dress, as well as component locations, affect the oscillator load capacitance.

Most of the CB transmitters that cover all 23 channels reduce the number of crystals needed by combining several crystals to produce the desired frequencies and use the same group for the receiver's oscillator. Two crystals must be considered for determining the accuracy of the final signal frequency. Both crystals must track in tolerance over the temperature range to yield the desired results. Not only does the crystal's temperature characteristic become important, but the exact oscillator load must also be known to allow calibration. ◈

How We Hear The Way We Do

AUDITORY PERCEPTION AND STEREO PERSPECTIVE

BY FRANK M. KENNEY

A CURRENTLY available computer element, known as a random access memory digital IC, is capable of handling 1024 discrete information items. The circuitry for this device occupies an area measuring about 0.15" square (roughly ⅛" on each side). The spiral channel of the human ear arrays 30,000 auditory nerve terminals on an area slightly smaller than that required for the RAM device. When we listen to music or any other sound, all portions of this spiral, technically known as a cochlea, are stimulated to varying degrees.

Vibrations of air particles at the eardrums are transmitted to the oval window by a linkage of three small bones known as the "hammer," "anvil," and "stirrup." The oval window, in turn, transmits the vibrations to the cochlea.

The sound waves set up in the cochlea are then picked up and encoded by this remarkable nerve terminal array. The sound-producing vibrations are oscillations of air pressure above and below atmospheric pressure. The air particle vibrations match those at the sound source and emanate from the source just as the waves in a pond radiate out from the spot where the water's surface was disturbed by a fallen object.

We can use the surface behavior of water to explain some of the properties of sound propagation. Consider a stillwater lake on which a small rowboat is moored at dockside. If the water were disturbed by someone's casting a pebble into it near the boat, ripples would radiate outward in concentric rings from the point of disturbance. These ripples would eventually push against the boat, causing the latter to rock ever so slightly. However, if a large powered boat were to pass by, the disturbance set up by its wake would cause the smaller boat to rock violently. Respectively, low and high wave intensities would have occurred by the pressures created by the pebble and the powered boat. If we assign the intensity level of 120 decibels (dB) to the wave generated by the powered boat and 0 dB to the ripples caused by the pebble, we can describe any relative intensities occurring between these limits.

This scale is analogous to that established by acoustic engineers for sound intensity levels. The level at the highest tolerable sound intensity is 120 dB, the lowest perceptible (for the average listener) being 0 dB. An example of an intermediate sound intensity level is that of busy street traffic which is at about 70 dB.

Intensity & Overtones. Intensity is a physical characteristic of a sound wave. Loudness is a sensation arising from the gradual increase of sound wave intensity. In terms of frequency, auditory perception limits are usually described as ranging from 20 Hz to 20,000 Hz. However, the intensity of the sound wave and the auditory capability of the listener usually reduce these limits. The ear is most sensitive to frequencies near the upper range of a piccolo. About half of all listeners in a representative group can hear pure tones at this frequency when the intensity level is as low as 8 dB; one percent can hear the same tone when the level is as low as −5 dB.

Stringed musical instruments often set the mood in musical compositions. Consider a taut string anchored at both ends. When the string is "plucked," simple harmonic motion occurs, forming waveshapes. Depending on where the string was disturbed by a guitar pick or violin bow, different frequencies and harmonics arise.

Any musical instrument creates standing waves in a similar manner and with similar characteristics. In the case of wind instruments, longitudinal waves traveling along the tube are reflected at the ends. Interference between waves traveling in opposite directions creates standing waves. These standing waves originate the vibrations of air particles that stimulate the auditory nerves.

Two different musical instruments might create tones having the same fundamental frequencies, but the intensities of discrete tone waves and the harmonic content will differ. Upon sensing the waves, the cochlea distinguishes and separates the tones. The difference is described as quality where the tone might be called full, mellow, tinny, round, etc. The characteristic of a sound wave is established by its quality which is determined by the number of its overtones and their respective intensities, in addition to their fundamental frequency.

The interception of a wave by another of exactly the same frequency increases the amplitude of the wave. A traveling wave also sets up vibrations when intercepted by an object that has the same natural frequency. A vibrating tuning fork, for example, will create standing waves at a remote twin.

Auditory Perspective. Three factors are essential to auditory perception. These are intensity differences, phase differences, and the ratio of direct to reverberant sound. At sea level, the propagation velocity of a sound wave is approximately 770 mi/hr. From a sound source to the listener's ears, the difference between the respective distances will not exceed 6¼". Attenuation of the sound waves could not vary appreciably at the ears due to interception by other waves in this distance.

It seems then that intensity differences would result from the incidence of the waves at the listener's head. Obviously, the wave traveling from a source at the listener's side would directly contact the near ear, while the intensity of the wave reaching the opposite ear would be decreased by a combination of reflection and refraction of the sound wave. When the sound contacts the porous surface of the head, heat is developed, resulting in a loss of energy in the sound wave. When the temperature of the air is changed by the interception of thermal and sound waves, the velocity of propagation decreases near the surface, and the direction of travel is altered to guide the sound wave around the obstruction (head). At the same time, the intensity of the sound wave is decreased due to energy loss resulting from the expenditure of energy-creating heat at the surface. There is an intensity difference that depends on how far the wave must travel in contact with the surface of the head before it reaches the opposite ear.

A bat flying around in a cave transmits sound pulses clocked at a time base. Analysis by the bat's sensory nerves measuring the time required for the pulses to bounce off the cave walls and return keeps the bat informed regarding the line of flight to the cave walls, floor, and ceiling.

When someone speaks or yells in a rocky cave, the sound is usually distinct and easily heard. In a soft earthen excavation or cavity, the sound seems to get lost almost immediately after the source makes it. The first phenomenon illustrates reflection of the sound waves by hard, dense surfaces. Because of the proximity of adjacent or opposite surfaces, the waves are reflected back and forth for some time before they die out. The latter phenomenon demonstrates the result when the sound chamber's walls are excessively absorbent.

Information regarding boundary conditions at a sound source is perceived by the ear by comparing direct and reverberant sound waves. With direct sound as the reference for comparison, the ratio of direct to reverberant sound indicates depth or expanse of space at the sound source.

Originally, it was believed that auditory perspective was derived from phase differences or differences in the arrival time of sound waves at the listener's ears. Early binaural systems were proposed in which two microphones were placed 12 centimeters (cm) apart to approximate the spacing between the listener's ears. The signals

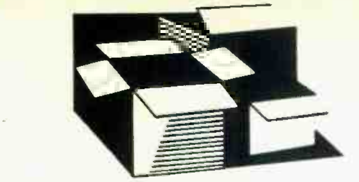
received at the mikes were then transmitted by cables to two earphones. It was suggested that the reproduced sound would accurately reproduce the original sound localization.

Dr. Harvey Fletcher, for many years with Bell Telephone Laboratories, pointed out the need for at least nine mikes because sound originates in three-dimensional space. Also, phase differences alone cannot accurately report the sound source's location because, excepting the situations where sound sources are located directly to the right or left of the listener, there exist two sound source locations from which the difference in distance to the two ears are the same.

Equipped with an audio signal generator, regulating equipment to vary sound intensity at each earphone, and earphones, one can demonstrate intensity-difference localization of sound sources. Since musical instruments generate both fundamental and harmonic frequencies, and combinations of these create other frequencies, it would be impossible to conduct the demonstration by using musical instruments to originate the sounds.

For the purpose of illustrating the experiment, we will take the liberty of describing the sounds as trumpet blasts. A convenient reference level would be 65 dB, which is greater than the intensity of a quiet radio playing in the home but less than that at a busy street corner. An intensity of 65 dB is very close to the level at which we conduct a conversation. If we blew a trumpet blast with a 70-dB level at the right earphone and 61 dB at the left, the listener would locate the sound source directly to his right, or the 3-o'clock position. Now, if a booming chord emanating from a 10-ton pipe organ were received at respective levels of 75 dB at the right and 65 dB at the left, the sound source would appear to be located at the 1-o'clock position (right of center). By suddenly increasing the intensity to 78 dB and decreasing it to 64 dB at the right and left earphones, respectively, the pipe organ would seem to have been moved to the right rear, or 4-o'clock position. Hence, sound localization effects can be electronically created through sound intensity control.

It appears, then, that the factor of prime importance in sound source localization is intensity difference, with phase difference a secondary factor. Depth or sound source chamber conditions are reported by ratio of direct to reverberant sounds. ◈



New Products

TWO NEW HARMAN-KARDON CITATION TUNERS

The Citation 14 and 15 tuners recently added to the Harman-Kardon lineup are said to represent the latest technological advances in FM design, including the utilization of a new phase-locked-loop configuration in the multiplex circuit that automatically adjusts for maximum stereo separation and minimum distortion as each station is tuned. In the front end, solid-state LC filters provide rejection of spurious noise and distortion. A new quieting meter (as opposed to the usual signal-strength meter) allows the user to tune for optimum incoming-signal quality rather than just maximum signal. The two new tuners are basically the same in design and performance, the major difference being that the Citation 14 has a built-in Dolby noise reduction system while the Citation 15 does not.

Circle No. 70 on Reader Service Card

SONY 4-CHANNEL SOUND SYSTEM

A new Sony 4-channel stereo cartridge playback system for the home has been introduced by Superscope, Inc. Designated the TC-824CS, the system includes a compact 8-track cartridge player with integrated 4-channel amplifier and four speaker systems, all in matching rosewood

cabinets. For flexible operation, the system can accommodate a record changer or a stereo FM tuner through two sets of auxiliary stereo inputs. Selection of the input source is made by a function switch on the front panel of the player. The playback unit features a separate level control for each channel in addition to a master volume control that affects all channels simultaneously, as well as tone controls, bass boost switch, and a quadraphonic playback indicator lamp.

Circle No. 71 on Reader Service Card

PEARCE-SIMPSON CB BASE STATION

The world's smallest CB base station is the latest addition to the Pearce-Simpson CB line of equipment. Only 6½" deep, 4¾" wide, and 4" high, the Wildcat II mobile rig mounts onto a custom 117-volt ac power supply. When not

being used as a base station, the Wildcat can go mobile wherever 12 volts dc is available. Plug-in noise cancelling microphone, S/r-f meter that changes color and brightness during transmit and receive, six-channel operation, and a ceramic filter are only some of the features to look for.

Circle No. 72 on Reader Service Card

TEN-TEC COMMUNICATIONS RECEIVER

Just added to their line of amateur radio equipment is the Ten-Tec Model 315 communications receiver. The all solid-state receiver is designed to provide coverage on all amateur bands between 3.5 MHz and 30 MHz. It has permeability tuning, linear frequency readout, 9-MHz crystal lattice i-f section, pulsed crystal calibrator, and low-noise MOSFET r-f amplifier and mixer designs. Its built-in 117-volt ac power supply can be easily converted to provide 12-volt dc operation. An accessory plug-in audio filter is available to narrow the bandpass to 300 Hz for CW operation.

Circle No. 73 on Reader Service Card

E.F. JOHNSON SCANNING MONITOR

The E.F. Johnson Company has announced the latest addition to their line of Duo-Scan® scanning monitor receivers. The new model covers both the vhf high band and uhf channels. Eight channels can be set up on any combination of vhf and/or uhf with simple jumper plug changes. The receiver provides lock-out switches to bypass channels, as well as manual operation for continuous monitoring of a single channel. Two ceramic selectivity filters are used to prevent the common problem of strong nearby FM transmissions from covering up the desired broadcast. A sensitive receiver eliminates the need for preamplifiers, yet the "front end" is immune to overloading.

Circle No. 74 on Reader Service Card

ELECTRO-VOICE UNIVERSAL DECODER

By now, Electro-Voice dealers have in stock the new Model EVX-44 4-channel Universal Matrix Decoder. The EVX-44 is designed to properly decode all presently used or proposed 4-channel matrix systems employed in records, tapes, and FM broadcasting. It operates automatically, relieving the user of the need for switching from one "system" to another. Also, different types of encoded records and standard stereo records can be played while intermixed. As a bonus, the decoder also provides enhancement of regular stereo programs to provide a 4-channel effect.

Circle No. 75 on Reader Service Card

HEATHKIT MEDIUM-POWER STEREO RECEIVER

The new Heathkit Model AR-1214 stereo receiver fills a medium range gap in the Heathkit line. The amplifier section develops a clean 15 watts continuous per channel into 8-ohm loads. Two IC's and two ceramic filters in the i-f strip provide better than 60-dB selectivity and su-

perior amplifying and limiting characteristics. A phase-locked loop demodulator gives 40-dB typical channel separation at less than 0.5% distortion. Other features include a black-out dial panel, stereo indicator light, speaker on/off button, AM and stereo FM tuning, vinyl case top and walnut-finished end panels, and push-button source/mode selection and power on/off switches.

Circle No. 76 on Reader Service Card

AIWA AM/FM CASSETTE SYSTEM

The Model TPR 3001 from Aiwa Co. combines a cassette tape recorder with an AM/FM tuner and integrated amplifier in one compact package. Featured are one-touch cassette operation with automatic ejector and sleep timer which cuts out the power when the tape comes to an end; sound mixer; constant-speed servo motor; and a full 30-watt music power audio system.

Circle No. 77 on Reader Service Card

ELECTRO TUNES "TRONIC TUNER"

Among the new line of musical instrument tuners being offered by Electro Tunes. Inc., is the Model 747 which tunes any electric. acoustic, or bass 4- and 6-string guitars. Called the "Tronic Tuner," its design is based on digital circuitry and other solid-state components. It has an electronic "magic-eye" tube that indicates when each string has been accurately tuned and provides an audio indication of tuning accuracy. An electronic tuning fork type of device provides a reference tone signal at the precise frequency of each string. Accuracy of tuning is within 0.01 percent, or approximately 0.25 Hz.

Circle No. 78 on Reader Service Card

SANYO PORTABLE ELECTRONIC CALCULATOR

A 16-digit portable electronic calculator that fits into the palm of a hand is being marketed by Sanyo Electric, Inc. The Model ICC-808D calculator is a four-function machine with a floating input/fixed output decimal locator system which allows entry of the decimal point at any location and a choice of zero, two, or four places from the right in the answer. An error lamp goes on when the calculator's capacity is exceeded. When a number exceeds eight digits, an arrow signals the user to depress a shift key to read the second part of the answer.

Circle No. 79 on Reader Service Card

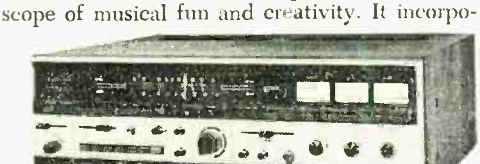
TI INTRODUCES THREE NEW CALCULATORS

A line of three new calculators introduced by Texas Instruments, Inc., marks the company's formal entry into the electronic calculator market. The line includes the Model TI-2500 portable calculator which features four arithmetic functions, floating decimal point system, and eight-digit light-emitting diode readout display. The Models TI-3000 and TI-3500 are desk calculators, also with four arithmetic functions but featuring gas-discharge readout displays. The floating-decimal-point TI-3000 is an eight-digit unit. The TI-3500 uses a 10-digit display and can be operated with either a fully floating or a preset (second or fourth position) decimal point.

Circle No. 80 on Reader Service Card

KENWOOD "ELECTRONIC MARVEL" RECEIVER

Kenwood's new Model KR-6170 stereo receiver is an electronic marvel that permits the widest scope of musical fun and creativity. It incorpo-



rates such unique features as an electronic rhythm composer, reverberation unit, front panel jacks for two electric guitars, multiple mixing of live and source sound, and an array of level, frequency, volume, balance, and tone controls that offer unlimited possibilities for unique effects. A Multi-Presence Control can be used to expand the simple bass and treble controls to include automatic variations that boost or attenuate high and low frequencies for best reproduction of special styles of music. Power level meters indicate the output volume level.

Circle No. 81 on Reader Service Card

JFD TV/FM COLINEAR ANTENNA

A new series of Color Whiz 82 TV/FM antennas employing advanced design and construction features is currently being marketed by JFD Electronics Corp. The Color Whiz antenna utilizes cross-phased dual-band elements that deliver the same gain, directivity, and front-to-back ratio of conventional antennas that are up to twice as big. The director section features a new flat planar construction that results in a larger signal-gathering area to produce TV pictures with sharper detail and more intense color than under marginally acceptable conditions. More than eight models comprise the Color Whiz series which ranges from metropolitan to deep-fringe types. A vhf-uhf signal splitter is included with each antenna.

Circle No. 82 on Reader Service Card

ATLAS SOUND WEATHER-RESISTANT SPEAKER

An attractive all-metal outdoor reflex speaker designed to industrial standards is being introduced to the consumer market by Atlas Sound for such installations as home patios and pool areas. Designated the Model WR-5, the moderately-priced speaker offers high intelligibility and sound reproduction, plus easy, inconspicuous installation. In addition to background music and radio/TV sound reproduction, the new speaker can also be used as a sensitive microphone for intercom talk-back and monitoring applications. The WR-5 handles 7.5 watts of program power, has a frequency range of 375 to 10,000 Hz, and is rated at 8 ohms. The 4"-deep speaker has a 6" bell.

Circle No. 83 on Reader Service Card

CROSSWORD PUZZLE ANSWER

(See p. 64)

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ROBINS TONE-ARM TYPE RECORD CLEANER

A new automatic phonograph record cleaner that looks like and is as delicately balanced as a precision tonearm is available from Robins Industries Corp. (Consumer Products Div.). Called the "Groovemaster," the cleaner is said to be designed for both professional and amateur use. As a disc spins, a velvet cylinder on the head of the Groovemaster rides gently over the record's surface, removing dust and dirt from the grooves. A nylon brush provided for applying anti-static cleaning fluid to the cylinder can also be used to clean the cylinder itself.

Circle No. 84 on Reader Service Card

PACE CITIZENS BAND TRANSCEIVER

Pace Communications Div. is currently marketing a new 23-channel CB transceiver designed for high-performance base station operation. The Model DX 2300B features a special built-in fan that keeps the transceiver cool and reliable under

continuous operating conditions. Excellent selectivity is provided by a special six-section tuned network selectivity filter in a dual-conversion superhet receiver. These filters provide added noise reduction by narrowing the bandwidth to a much greater degree than is possible with other filter types. Superior frequency stability permits the rig to maintain a consistent 0.25 μV sensitivity. And a special modulation booster circuit provides efficient upward modulation that results in extended transmitter range.

Circle No. 85 on Reader Service Card

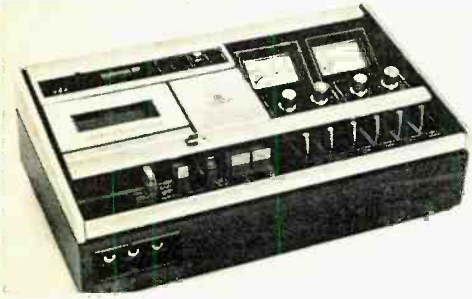
ANTENNACRAFT TV ANTENNAS

The CDX Series of seven antenna models recently introduced by Antennacraft Co. has a TV antenna model for every receiving condition from metropolitan to deep fringe. The top-of-the-line CDX 1150 with 60 elements and a 15½-ft boom is for extreme fringe areas. Several features in the series included in the CDX 1150 have been patented for their design quality. A flip-eze boom extension makes extra-long booms easy to handle, while a cradle mount adds strength and stability as well as a low profile for high wind resistance. Other models in the series are the 1050, 950, 850, 750, 650, and 550 which range from deep fringe to metropolitan area designs.

Circle No. 86 on Reader Service Card

WOLLENSAK CASSETTE DECK

A stereo cassette deck, the Model 4765, embodying the Wollensak heavy-duty bi-peripheral drive system and Dolby tape and FM broadcast noise reduction circuits is being distributed by the 3M Company. Featured in the 4765 are



large professional-style VU meters, separate record and playback level controls, ferrite head, "Cassette Guardian" end-of-tape sensing and shut-off, and an adjustable high-level/low-impedance headphone for monitoring and playback. A tape selector switch is also provided for changing record/playback equalization and record current for regular and high-performance tapes and chromium-dioxide tapes.

Circle No. 87 on Reader Service Card

NATIONAL TEL TRONICS SPEAKER ENCLOSURE

National Tel Tronics has developed a new idea in prefabricated speaker enclosures. The enclosure is designed to fold together in 12 minutes or less to provide a sturdy hi-fi-quality cabinet. No tools, cutting, or screws or nails are needed. Made of heavy ¾"-thick wood panels, the air-tight acoustic suspension speaker enclosure is available in two versions: The CK 20-2 is designed to accommodate two drivers in a two-way configuration, while the CK 20-3 is a three-driver setup for three-way systems. (Two NTT/Peerless speaker kits to complement the enclosure models are also available.) The enclosures are finished in a vinyl walnut veneer and come with a complementary grille.

Circle No. 88 on Reader Service Card

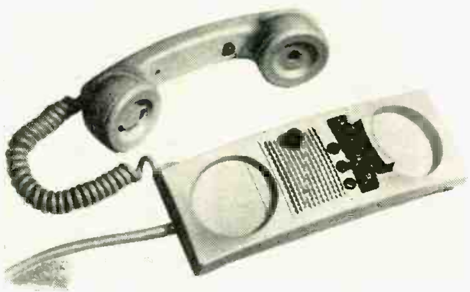
CHRONOMITE "INSTANT" RESISTOR KIT

Details of a new "Instant Ohm" resistor kit were recently released by Chronomite Labs. The kit is ideal for making resistors, shunts, or multipliers for repair, production, and experimental use on the spot for only about 2¢ each. Each kit contains seven resistance wires ranging from 0.5 to 300 ohms per foot, 11 epoxy bobbins, instructions, and simple schematics. The complete kit is housed in an acrylic plastic container. Both Manganin and Karma wire are provided in the kit, selected for their low temperature coefficient of resistance.

Circle No. 89 on Reader Service Card

BOGEN 3-CHANNEL TELEPHONE INTERCOM

The Bogen Model TCP-3 is a telephone-intercom system with three channels and built-in paging facilities. It is ideal for use in offices, plants, stores, hotels, etc. Designed to quickly locate and communicate with personnel, the TCP-3

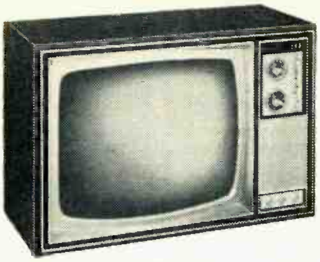


provides three common lines that permit three simultaneous conversations in the system and assuring the availability of a line even if one or two prior calls are already in progress. The entire system can be connected to a music source to provide background music through built-in speakers. A "Ring" button is provided to call the operator for connecting the TCP-3 to an outside line for incoming and outgoing calls when the Model INL-1 Telephone Interface Adapter is used.

Circle No. 90 on Reader Service Card

Save on Heathkit® Color TV...

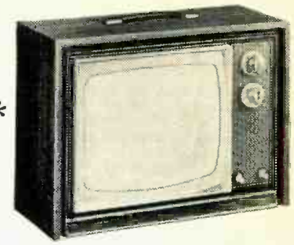
Save $50.00*



Price reduced on 18 in. diagonal Color TV — was 399.95* NOW 349.95* (less cabinet)

Solid-state modular circuitry spells reliable operation and easy assembly. And as in all Heathkit TVs, the GR-269 comes with a full complement of alignment and self-service equipment — dot generator, convergence board, test meter and troubleshooting book. Factory assembled and aligned AFT module for perfect picture and sound at a touch. VHF tuner with MOSFET circuitry for high sensitivity, superior reception under marginal conditions. UHF tuner with hot-carrier diode design for low noise, high sensitivity. Both tuners factory assembled and aligned as is the 3-stage IF assembly. "Instant-on", switch-controlled degaussing, hi-fi sound output; 75 and 300 ohm antenna inputs; exclusive Heath Magna-Shield, standard. Picture tube warranted 2 full years. **Kit GR-269**, less cabinet, 100 lbs. **Assembled GRA-402-18**, walnut-grained vinyl clad wood cabinet shown, 16½" H x 25" W x 11" D, 27 lbs....**29.95***

Save $50.00*

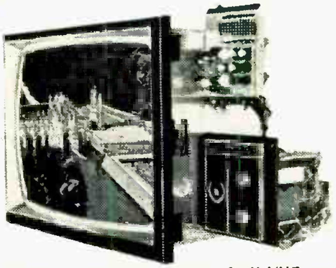


Price reduced on 14 in. diagonal Portable Color TV — was 349.95* NOW 299.95* (includes cabinet)

Set aside about a dozen evenings. Build-up 10 circuit boards, prepare the chassis, terminals and connectors. Install and solder the wiring harness and point-to-point conductors. Result: the Heathkit GR-169, with picture purity and brightness that puts it at the top of its class. And, thanks to built-in maintenance equipment, you keep it that way — with plug-in modular circuit boards, troubleshooting meter and data book to help you fix it right at home. A "big" little TV, the GR-169 has all the secondary controls found in our larger models — color, tint, contrast, horizontal and vertical hold, height, AGC, color killer, switch-controlled degaussing. Measures a compact 16" H x 20½" W x 16" D. Carry it from room to room or across the country — this is the portable that bounces back with console-like performance. **Kit GR-169**, 69 lbs., including cabinet.

and on 350 other electronic kits in the FREE '73 Heathkit Catalog

Our best 25 in. diagonal solid-state Color TV ...599.95*
(less cabinet)



Power detent selection of all VHF and any 12 pre-selected UHF channels; exclusive angular tint control for consistently better flesh tones; voltage controlled varactor UHF tuner and MOSFET VHF tuner for unmatched sensitivity; black matrix tube, built-in dot generator, convergence panel and volt-ohm meter — full remote control options, too. It's Heathkit TV at its finest. **Kit GR-900**, less cabinet, 125 lbs.

NEW 4-Channel Amplifier with "Universal" decoder circuitry... 359.95* (less cabinet)

You select discrete 4-channel, or switch-in the "Universal" decoder for reproduction of all the matrixed 4-channel discs now on the market, plus "derived" 4-channel from conventional stereo. Four solid-state amplifiers produce 200 watts (4x50 IHF) into 8 ohms, with power bandwidth on all channels from less than 5 Hz to greater than 45 kHz at 0.25% distortion. **Kit AA2010**, 37 lbs. **AAA-2004-1**, pecan cabinet, 7 lbs. **24.95***

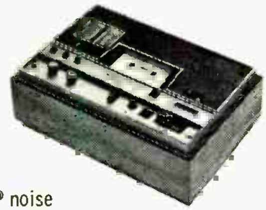
NEW "Universal" 4-Channel Decoder...39.95*

Reproduces all matrixed discs, plus "derived" 4-channel from conventional stereo materials. Plug it into your receiver's tape monitor circuit, add a second stereo amp and speakers and you're set. **Kit AD-2022**, 4 lbs.

NEW Ultrasonic Intrusion Alarm... 49.95*

Disguised as an ordinary library book, this novel device fits unobtrusively anywhere in the home. Transmitter disperses a 41 kHz signal which bounces off walls and returns to the receiver where it's monitored for any change in amplitude. Triggers lights and any conventional alarm device — just plug them into AC outlets on the rear panel. Can be installed anywhere there's a 120 VAC outlet. An enjoyable 2-evening kit. **Kit GD-39**, 5 lbs.

NEW Cassette Deck with Dolby circuitry ...249.95*



A kit-form cassette deck utilizing the famous Dolby® noise reduction system. Accommodates the greater fidelity and dynamic range of chromium dioxide cassettes. Independent switches provide Dolby on/off and regular or CrO_2 bias control. Domestic-make tape transport comes preassembled for easy kit building. **Kit AD-1530**, 21 lbs.

NEW 6-Digit Electronic Alarm Clock...54.95*

Displays hours, minutes and seconds on highly visible cold-cathode readout tubes. A gentle "beeper" alarm can be set for 24-hour cycle and features a snooze switch that gives you seven more minutes of sleep before the alarm sounds off again. Conventional 12-hour or 24-hour international time display. **Kit GC-1005**, 4 lbs.

See them all at your Heathkit Electronic Center...or send for Free '73 Heathkit Catalog.

HEATHKIT ELECTRONIC CENTERS

ARIZ.: Phoenix, 2727 W. Indian School Rd.; **CALIF.: Anaheim,** 330 E. Ball Rd.; **El Cerrito,** 6000 Potrero Ave.; **Los Angeles,** 2309 S. Flower St.; **Pomona,** 1555 Orange Grove Ave. N.; **Redwood City,** 2001 Middlefield Rd.; **San Diego (La Mesa),** 8363 Center Dr.; **Woodland Hills,** 22504 Ventura Blvd.; **COLO.: Denver,** 5940 W. 38th Ave.; **CONN.: Hartford (Avon),** 395 W. Main St. (Rte. 44); **FLA.: Miami (Hialeah),** 4705 W. 16th Ave.; **GA.: Atlanta,** 5285 Roswell Rd.; **ILL.: Chicago,** 3462-66 W. Devon Ave.; **Downers Grove,** 224 Ogden Ave.; **IND.: Indianapolis,** 2112 E. 62nd Ave.; **KANSAS: Kansas City (Mission),** 5960 Lamar Ave.; **MD.: Baltimore,** 1713 E. Joppa Rd.; **Rockville,** 5542 Nicholson Lane; **MASS.: Boston (Wellesley),** 165 Worcester St.; **MICH.: Detroit,** 18645 W. Eight Mile Rd. & 18149 E. Eight Mile Rd.; **MINN.: Minneapolis (Hopkins),** 101 Shady Oak Rd.; **MO.: St. Louis,** 9296 Gravois Ave.; **N.J.: Fair Lawn,** 35-07 Broadway (Rte. 4); **N.Y.: Buffalo (Amherst),** 3476 Sheridan Dr.; **New York City,** 35 W. 45th St.; **Jericho, L.I.,** 15 Jericho Turnpike; **Rochester,** Long Ridge Plaza; **OHIO: Cincinnati (Woodlawn),** 10133 Springfield Pike; **Cleveland,** 5444 Pearl Rd.; **PA.: Philadelphia,** 6318 Roosevelt Blvd.; **Pittsburgh,** 3482 Wm. Penn Hwy.; **TEXAS: Dallas,** 2715 Ross Ave.; **Houston,** 3705 Westheimer; **WASH.: Seattle,** 221 Third Ave.; **WIS.: Milwaukee,** 5215 Fond du Lac.

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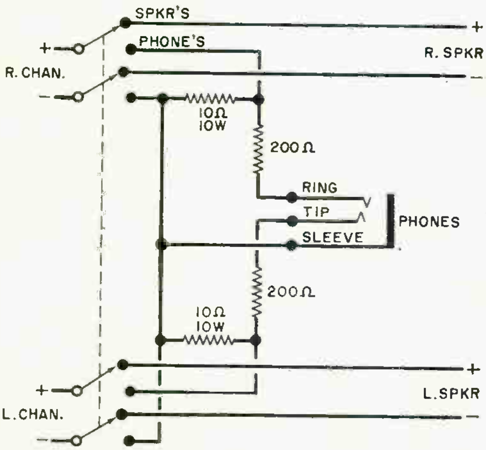
Prices & specifications subject to change without notice.
*Mail order prices; F.O.B. factory CL-461R

CIRCLE NO. 13 ON READER SERVICE CARD

Hobby Scene

Q. My stereo radio does not have provisions for earphones. Is there some simple way that I can add something (preferably outboard) so that phones can be used?

A. The simple circuit shown below is hooked between the output of each channel and the associated speaker. The four-pole, double-throw switch is used to make the selection. The values of the resistors in series with the phones can be adjusted for relative volume or balancing of the two phones.

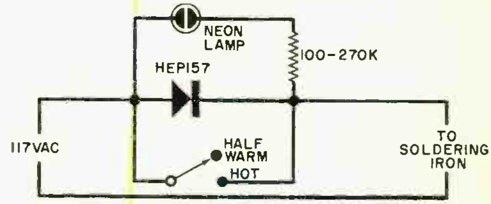


Q. A number of your projects have used various types of operational amplifier IC's. My local parts distributor does not carry any of these. Where can I buy them?

A. If you take a look at the various mail order house ads at the back of this magazine, you will note that Solid State Sales, Solid State Systems, Poly Paks, B&F Enterprises, and others include various types of op amps in their listings, usually priced well under $1. They are sold as 741, 709, etc., without prefixes or suffixes to identify the manufacturer. Regardless of the manufacturer, somewhere in the description of his op amp will be the 709, 741, etc. to describe the op amp. The specifications and pin designations for a particular op amp are usually identical among manufacturers.

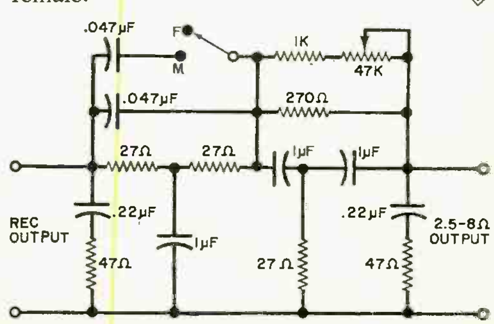
Q. If I leave my soldering iron on all the time, it wastes a lot of power. If I turn it off, I have to wait quite a while before I can use it. Is there some way of keeping the iron just warm until I need it, then allowing it to heat normally?

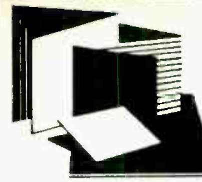
A. Connect the circuit shown below between your iron and the power socket. Use a switch that can handle the iron's wattage. The neon indicator lamp is optional.



Q. As an avid shortwave listener I would like to know if there is any way that I can bring out an announcer's voice from the background in order to make a more reliable identification.

A. NASA had the same problem with one of of the Apollo shots, and they came up with the circuit shown below. Actually, only three portions of speech are required: 300-400 Hz, 900-1700 Hz for a male voice (1100-1900 for a female), and 2500-3000 Hz. The bands between 40 and 900 Hz and 1900 and 2500 Hz seem to contribute very little to intelligibility. In the circuit, the potentiometer adjusts the null at about 600 Hz and the switch provides for male or female. ◈





New Literature

1973 HEATHKIT CATALOG

The world's largest selection of electronic kits can be found in the 1973 Heathkit catalog. Included in the catalog listings are such items as color TV receivers, audio/hi-fi equipment, marine gear, and equipment for the radio amateur. New listings in the automotive lineup include an inductive pickup timing light and a CD ignition system. More than a dozen pages in the catalog are given over to descriptions of a digital electronic clock, electronic calculator, security systems, intercoms, etc. Address: Heath Co., Benton Harbor, MI 49022.

1972-1973 TAB TECHNICAL BOOK CATALOG

More than 235 current and forthcoming technical book titles, plus ten unique Electronic Book/Kits setups, are illustrated in the latest 28-page catalog recently released by Tab Books. The electronics categories cover everything from amateur radio to computer technology to general electronic servicing, experimenting, and hobby manuals. Address: Tab Books, Blue Ridge Summit, PA 17214.

XCELITE HAND TOOLS SHEETS

Tools for the electronics enthusiast are featured in three binder sheets recently released by Xcelite. Bulletin N971 describes a complete technician/serviceman's tool kit that comes in a sturdy attache case and includes just about any non-powered hand tool needed in electronics. Bulletin 572L describes coax stripper/cutters and a heat sink tool. And Bulletin CC 71/72 describes a wide range of professional-quality tools of special interest to electronics enthusiasts. Address: Xcelite Inc., Orchard Park, NY 14127.

RCA COS/MOS IC PRODUCT GUIDE

A completely revised eight-page catalog that describes RCA's COS/MOS digital IC's is available as publication No. COS-278B. It contains logic diagrams with terminal designations and quick selection data charts for 52 IC's including gates, flip-flops. latches, multivibrators, shift registers, counters, counter/decoder/drivers, multiplexers, arithmetic circuits, memories, and a phase-locked loop. Address: RCA Solid State Div., Box 3200, Somerville, NJ 08876.

EICO SECURITY SYSTEMS CATALOG

Eico, maker of the world's largest do-it-yourself line of professional home protection devices and systems, has just released a handy combination short-form catalog. The 12-page publication describes five "Fail-Safe" security systems and 37 accessories. Address: Eico Electronic Instruments Co., Inc., 283 Malta St., Brooklyn, NY 11207.

SPRAGUE SEMICONDUCTOR REPLACEMENT GUIDE

A comprehensive 52-page Semiconductor Replacement Manual, No. K-500, is available from Sprague Products Co., It contains listings for more than 30,000 OEM part numbers that can be replaced by the company's new line of 82 semiconductor devices. Address: Sprague, 395 Marshall St., North Adams, MA 01247.

SHURE CARTRIDGE STYLUS GUIDEBOOK

Since the stylus in a hi-fi cartridge is the source of sound for any stereo system, it makes sense to know about the function, care, and replacement of this vital component. For a detailed look at the critical role of the stylus, you can send for Shure's new brochure titled "A Visit to the Small World of a Stylus." Address: Shure Brothers, Inc., 222 Hartrey Ave., Evanston, IL 60204.

Electronics Library

PRINCIPLES OF ELECTRONIC COMMUNICATIONS

by Matthew Mandl

Throughout this comprehensive book, all the basic circuitry discussed is illustrated from the standpoint of operational characteristics and what the contribution is to the entire system. Complete systems, including multiplexing, stereo FM, SCA, TV, and AM, are covered in detail. The first three chapters cover signals and spectra, modulation and sidebands, and signal generation and shaping. The book then progresses through the various principles of communication. Notations, prefixes, constants, etc., used are in the International System of Units (SI), and graphs and tables are included to supplement and clarify the discussions.

Published by Prentice-Hall, Inc., Englewood Cliffs, NJ 07632. Hard cover. 339 pages. $12.00.

104 EASY TRANSISTOR PROJECTS YOU CAN BUILD

by Robert M. Brown

Tab Books has entered the booming electronic kit market in a rather unique way by combining a kit with a book in one package at the cost of the kit alone. The result is "Book/Kits," and the first such to reach us contained a potpourri of 104 simple transistor projects and a light-dimmer kit. (Ten different Book/Kits are currently on the market.) The projects described in the book that accompanied our kit provide something for everyone. There are projects on audio, amateur radio, CB, shortwave listening, test gear, and devices to use around the home. Each project is accompanied by a short description, schematic diagram, and complete parts list.

Published by Tab Books, Blue Ridge Summit, PA 17214. Soft cover. 223 pages. $3.95.

HI-FI STEREO HANDBOOK, Fourth Edition

by William F. Boyce

This easy-to-read book explains such things as the differences between mono, stereo, and quadraphonic sound systems; meaning of high fidelity; different sources of program material; kinds of distortion; and multiple speaker systems. New material on stereo cartridge styli, headphones, adapter circuits, tape cartridge players, 4-channel encoders and decoders, etc., has been added since the last edition.

Published by Howard W. Sams & Co., Inc., 4300 West 62 St., Indianapolis, IN 46268. Soft cover. 400 pages. $5.95.

1973 RCA DATABOOKS, Six Volumes

Some 3400 pages make up RCA's latest Databook set in which are discussed the company's entire line of linear and COS/MOS digital IC's, discrete MOS devices, power transistors, thyristors, rectifiers, r-f devices, and hybrid circuits. Volumes SSD-201A (720 pages, $2.50) and SSD-202A (408 pages, $1.50) cover data sheets and application notes, respectively, for linear IC's and discrete MOS devices. SSD-203A (488 pages, $2) describes COS/MOS digital IC's. SSD-204A (728 pages, $2) encompasses power transistors and hybrid circuits. SSD-205A (544 pages, $2) covers r-f power devices. And SSD-206A (528 pages, $2) covers thyristors, etc.

Published by RCA Solid State Div., Box 3200, Somerville, NJ 08876. Soft covers. $12.00 for entire SSD-200A set.

101 QUESTIONS & ANSWERS ABOUT AM, FM, & SSB

by Leo G. Sands

Written in the popular Q&A format, this book covers both the history and the basic technical aspects of the three types of modulation commonly used today, as well as receivers for demodulation. Divided into three parts headed AM, FM, and SSB, the book explains the advantages and disadvantages of each modulation and demodulation method as well as the basic circuits employed in the process. Technicians, experimenters, CB'ers, prospective hams, etc., will find this book a good reference source.

Published by Howard W. Sams & Co., Inc., 4300 West 62 St., Indianapolis, IN 46268. Soft cover. 96 pages. $3.95.

HANDBOOK OF ELECTRONIC TABLES, Second Edition

by Martin Clifford

Among the most popular and useful books to anyone engaged in electronics, from the student right on through the graduate engineering levels, are those devoted to practical reference material. This new edition of a book that has been around for a few years fits very well into that category. In its second edition, this book has been expanded by almost 50 percent and now contains tables, conversion charts, basic laws, and equivalent circuits for vectors, LC resonance products, cube roots, coefficients, powers, roots, logs of pi, abbreviations, color codes, etc.

Published by Tab Books, Blue Ridge Summit, PA 17214. 224 pages. $7.95 hard cover; $4.95 soft cover.

Surplus Scene

By Alexander W. Burawa, Associate Editor

DEALER PROFILE NO. 2: SOLID STATE SYSTEMS, INC.

IN THE PAST, we have taken the liberty in this column of introducing to our readers several dealers that do not fit the "image" of the "traditional" surplus parts supplier. In selecting candidates for such mention, we have set certain criteria. Two of the most important of these are that the dealers offer parts and/or equipment that is in great demand, and that the prices asked for their goods be in line with those demanded by the traditional surplus dealers for similar items. The foregoing is by way of introducing you to Solid State Systems, Inc. (P.O. Box 773, Columbia, MO 65201).

Solid State Systems, as its name implies, is primarily a supplier of new semiconductor devices. Their particular specialty is digital TTL IC's with the line including most of the standard 7400 series, the more popular of the 74100 series, and—believe it or not—the heretofore difficult to obtain 74S00 series of Schottky TTL devices. Almost two dozen linear IC types have made the list, as have eight diodes, and one transistor. The transistor is a silicon npn r-f capable of a response out to 250 MHz at 400 mW.

Since the company handles a very comprehensive line of digital IC's, it is only natural to assume that they also stock numeric readout displays. They do. Two types are listed; one is an LED readout similar to Monsanto's MAN-1, while the other is a miniature incandescent type. To make working with dual in-line IC's and the readouts easy, SSS also offers Molex IC socket pins and molded wire-wrap sockets, the first in continuous strips of 100 each and the latter in 14- and 16-pin configurations.

Other items in the lineup include IC-type voltage regulators; Allen-Bradley military-grade resistors in 81 standard values from 2.7 ohms to 22 megohms; high- and low-voltage disk-type, axial-lead, and upright electrolytic capacitors; and a Stancor 25.2-volt center-tapped transformer rated at 1 ampere for use with LM series IC's.

We must emphasize that these are all new, direct-from-the-manufacturer items offered for sale by a company that cannot be classified as a "surplus" dealer. But the good news is the prices asked for the items the company handles. For example, 7490 decade counters are listed for 80¢ each, 7447 BCD-to-seven-segment decoder/drivers for $1.16 each, 74141 BCD-to-decoder/driver with blanking IC's for $1.63 each, and 74S112 dual JK edge-triggered flip-flops for $1.82 each. The linear (op amp) IC's are equally low priced, as are all other items listed.

We have saved the best for last. SSS offers a really bargain priced decade counting unit that includes decade count/decode IC's, readout, and PC board. The basic kit goes for $9.00, but options like LED readout, digital IC latch, and factory wired and tested units are available at minimum extra cost. A really sophisticated wired and tested unit containing an LED readout, 74192 up/down decade counter, 7475 latch, 7447 decoder, and PC board will cost a total of $15.75—not a bad deal, considering what a counter like this will do in a project.

The company itself is fairly new, having been incorporated only in August of 1971. To our knowledge, Solid State Systems, Inc., is very reliable. They maintain this reliability through modern means, like using a computer to process orders received, keep tabs on inventory, and for ordering new inventory. As a general rule, all orders are processed and shipped within 24 hours after the company receives them.

As of this writing, no catalog is available from Solid State Systems, Inc. One is planned for the near future, but you can keep up with the company's offerings and prices by referring to the ads in this magazine. ◈

ELECTRONICS MARKET PLACE

NON-DISPLAY CLASSIFIED: COMMERCIAL RATE: For firms or individuals offering commercial products or services, $1.60 per word (including name and address). Minimum order $16.00. Payment must accompany copy except when ads are placed by accredited advertising agencies. Frequency discount: 5% for 6 months; 10% for 12 months paid in advance. **READER RATE:** For individuals with a personal item to buy or sell, $1.00 per word (including name and address.) No minimum! Payment must accompany copy. **DISPLAY CLASSIFIED:** 1" by 1 column (2⅝" wide), $200.00. 2" by 1 column, $400.00. 3" by 1 column, $600.00. Advertiser to supply cuts. For frequency rates, please inquire.

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

FOR SALE

FREE! bargain catalog. Fiber optics. LED's, transistors, diodes, rectifiers. SCR's, triacs, parts. Poly Paks, Box 942, Lynnfield, Mass. 01940.

GOVERNMENT Surplus Receivers. Transmitters, Snooperscopes, Radios, Parts, Picture Catalog 25¢. Meshna. Nahant. Mass. 01908.

ROCKETS: Ideal for miniature transmitter tests. New illustrated catalog. 25¢. Single and multistage kits, cones, engines, launchers, trackers, rocket aerial cameras, technical information. Fast service. Estes Industries, Dept. 18-G, Penrose, Colorado 81240.

LOWEST Prices Electronic Parts. Confidential Catalog Free. **KNAPP,** 3174 8TH Ave. S.W., Largo, Fla. 33540.

ELECTRONIC PARTS, semiconductors, kits. FREE FLYER. Large catalog $1.00 deposit. BIGELOW ELECTRONICS, Bluffton, Ohio 45817.

WE SELL CONSTRUCTION PLANS. TELEPHONE: Answering Machine, Speakerphone, Carphone, Phonevision. Auto Dialer, Touch Button Dialer, Central Dial System. **TELEVISION:** $35.00 Color Converter, Video Tape Recorder. $25.00 Camera. **HOBBYIST:** Electron Microscope, 96 Hour Tape Music System. Ultrasonic Dishwasher, Radar-Oven. Plans $4.95 each. **NEW ITEM:** $75. Electronic Pocket Calculator, $7.50. **COURSES:** Telephone Engineering $39.50. Detective Electronics $22.50. Integrated Circuit Engineering, $49.50. **NEW SUPER HOBBY CATALOG** plus year's subscription to Electronic New Letter **AIRMAILED** $1.00. Don Britton Enterprises, 6200 Wilshire Blvd., Los Angeles, Calif. 90048.

RADIO—T.V. Tubes—36¢ each. Send for free catalog. Cornell, 4213 University, San Diego, Calif. 92105.

SENCORE, B&K Test Equipment Unbelievable Prices. Free Catalog and Price Sheet. Fordham Radio, 265 East 149th Street, Bronx, N.Y. 10451.

CONVERT any television to sensitive. big-screen oscilloscope. Only minor changes required. No electronic experience necessary. Illustrated plans. $2.00. Relco-A33, Box 10563, Houston, Texas 77018.

METERS—Surplus. new, used, panel or portable. Send for list. Hanchett. Box 5577, Riverside, CA 92507.

PYROTECHNICAL chemicals, casings, tools, supplies. fuse. literature. Giant, illustrated catalogue/handbook includes formulas, instructions—50¢, with samples—$1.00. Westech, Box 593, Logan, Utah 84321.

ELECTRONIC COMPONENTS—Distributor prices, Free catalog. Box 2581. El Cajon, California 92021.

ANTIGRAVITY, experiment and theory. Rushed—$2.00. U.S. Inquiries. Intertech 7A6, Box 5373, Station-F, Ottawa, Canada.

JAPAN HONG KONG DIRECTORY. World products information. $1.00 today. Sekai Shogyo Annai, Hillyard. Washington 99207.

EUROPEAN and Japanese bargains catalogs. $1 each. Dee, P.O. Box 9308, North Hollywood, Calif. 91609.

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AMATEUR SCIENTISTS, Electronics Experimenters, Science Fair Students . . . Construction Plans—Complete, including drawings, schematics, parts list with prices and sources . . . Robot Man — Psychedelic shows — Lasers — Emotion/Lie Detector — Touch-Tone Dial—Quadrasonic Adapter—Transistorized Ignition —Burglar Alarm—Sound Meter . . . over 60 items. Send 25¢ coin (no stamps) for complete catalog. Technical Writers Group, Box 5594, State College Station, Raleigh, N.C. 27607.

WE SELL CONSTRUCTION PLANS—gold recovery unit!—silver recovery unit—infra-red scope—x-ray fluoroscope—alternator adapter—200 watt inverter—electronic insect tap—burglar alarm system—chemical formulary—plans $5.00—plus many more!—ask for **FREE** catalog—Airmail 30¢. Creative Products, 1551 East Loop 820, Dept. E-373, Fort Worth, Texas 76112.

DIGITAL ELECTRONICS! Complete schematics, parts lists, theories —Discrete Component Digital Clock, $3.00—Sound Sensitive Switch, $1.50. Increase technical competence, hobby skills—Complete Course in Digital Electronics is highly effective, $10.00. Free literature. DYNASIGN, Box 60A7, Wayland, Mass. 01778.

CONSTRUCTION PLANS: Laser . . . $2.00. Missile Tracker . . . $2.00. Catalog 25¢. ESP Experimenters Kit . . . $2.00. Howard, P.O. Box 35271, Detroit, Michigan 48235.

ELECTRONIC IGNITION: Boosts Voltage. Only $19.95. Box 2002, Huntington Beach, Calif. 92647.

SURPLUS electronics for everyone. Free catalog. U.S. inquiries. ETCO, 464 McGill, Montreal, Canada.

FREE Catalog lists resistors, tubes, transistors, rectifiers, condensers, tools, tuners. etc. Hytron Hudson, Dept. PE, 2201 Bergenline Ave., Union City, N.J. 07087.

TEST EQUIPMENT, Aerospace-Laboratory Grade. Request your needs; will mail appropriate catalogs (we have 24 catalog categories). Only for Engineers, Businesses, Schools and advanced Technicians. Goodheart, Box 1220PE, Beverly Hills, Calif. 90213.

ELECTROENCEPHALOPHONE: brainwave monitor. Professional biofeedback instruments. J&J, 8102-E, Bainbridge, Wash. 98110.

SOUND SYNTHESIZER kits—Surf $11.95, Wind $11.95, Wind Chimes $16.95, Electronic Songbird $6.95, musical accessories, many more. Catalog free. PAIA Electronics, Box J14359, Oklahoma City, OK 73114.

GREGORY ELECTRONICS

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FM 2-WAY RADIO SAVINGS

Partial List—Send for New Catalog

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U51GGT

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$188

Private line (if available) add $35.

G.E. PROGRESS LINE STRIPS, physically complete. **AS IS!**

	LOW BAND MA/E13	LOW BAND MA/E16	VHF MA/E33	VHF MA/E36	UHF MA/E42
Power supply, 30 watts, less vibrator	$20.		$20.		$20.
Power supply, 60 watts, less vibrator		$25.		$25.	
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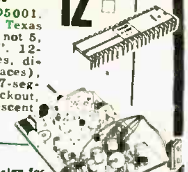

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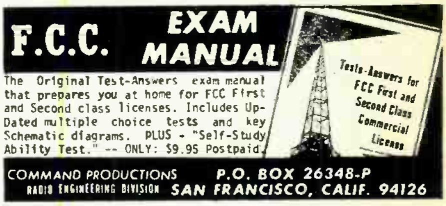

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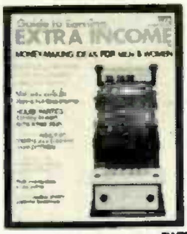

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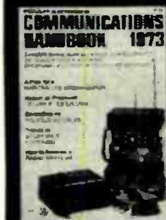

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7404	.28	.27	.25	.24
7405	.28	.27	.25	.24
7406	.52	.50	.47	.44
7407	.52	.50	.47	.44
7408	.32	.30	.29	.27
7409	.32	.30	.29	.27
7410	.26	.25	.23	.22
7411	.28	.27	.25	.24
7413	.58	.55	.52	.49
7416	.52	.50	.47	.44
7417	.52	.50	.47	.44
7418	.26	.25	.23	.22
7420	.26	.25	.23	.22
7421	.26	.25	.23	.22
7423	.80	.76	.72	.68
7425	.50	.48	.45	.43
7426	.34	.32	.31	.29
7430	.26	.25	.23	.22
7437	.56	.53	.50	.48
7438	.56	.53	.50	.48
7440	.26	.25	.23	.22
7441	1.73	1.64	1.55	1.46
7442	1.27	1.21	1.14	1.07
7443	1.27	1.21	1.14	1.07
7444	1.27	1.21	1.14	1.07
7445	1.71	1.62	1.53	1.44
7446	1.24	1.17	1.11	1.04
7447	1.16	1.10	1.04	.98
7448	1.44	1.37	1.29	1.22
7450	.26	.25	.23	.22
7451	.26	.25	.23	.22
7453	.26	.25	.23	.22
7454	.26	.25	.23	.22
7459	.26	.25	.23	.22
7460	.26	.25	.23	.22
7470	.42	.40	.38	.36
7472	.38	.36	.34	.32
7473	.50	.48	.45	.43
7474	.50	.48	.45	.43
7475	.80	.76	.72	.68
7476	.56	.53	.50	.48
7480	.76	.72	.68	.65
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7483	1.63	1.55	1.46	1.38
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7486	.58	.55	.52	.49
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7493	.80	.76	.72	.68
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74141	1.63	1.55	1.46	1.38
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74154	2.43	2.30	2.16	2.03
74155	1.46	1.39	1.31	1.23
74156	1.46	1.39	1.31	1.23
74157	1.56	1.48	1.39	1.31
74158	1.56	1.48	1.39	1.31
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74S03	.88	.84	.79	.75
74S04	1.00	.95	.90	.85
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74S08	.88	.84	.79	.75
74S09	.88	.84	.79	.75
74S10	.88	.84	.79	.75
74S15	.88	.84	.79	.75
74S20	.88	.84	.79	.75
74S21	.88	.84	.79	.75
74S22	.88	.84	.79	.75
74S40	1.00	.95	.90	.85
74S50	.88	.84	.79	.75
74S51	.88	.84	.79	.75
74S60	.88	.84	.79	.75
74S61	.88	.84	.79	.75
74S65	.88	.84	.79	.75
74S73	1.82	1.73	1.63	1.54
74S74	1.82	1.73	1.63	1.54
74S107	1.82	1.73	1.63	1.54
74S112	1.82	1.73	1.63	1.54
74S114	1.82	1.73	1.63	1.54
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NE561B	3.57	3.36	3.15	2.94
NE562B	3.57	3.36	3.15	2.94
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709V	.42	.40	.38	.36
710A	.42	.40	.38	.36
711A	.44	.42	.40	.37
723A	1.00	.95	.90	.85
733A	1.90	1.80	1.70	1.60
741T	.44	.42	.40	.37
747A	1.05	.99	.94	.88
748V	.48	.46	.43	.41
LM335	2.85	2.72	2.64	2.55
LM336	3.85	3.66	3.46	3.27
LM337	4.05	3.70	3.51	3.31
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1N270	.15	.14	.13	.12
1N914	.10	.09	.08	.07
1N4001	.10	.09	.08	.07
1N4002	.11	.10	.09	.08
1N4003	.13	.12	.11	.10
1N4006	.15	.14	.13	.12
1N747A thru 1N758A	.25	.22	.19	.16
2N3860	.25	.23	.21	.19

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All IC's are supplied in 8–, 14–, or 24–pin DIP (Dual-in-line) plastic or ceramic package except for NE536, NE540, SE540, LM101A, LM201, LM301, LM206, LM306, LM207 and LM105 which come in TO–5 package. Voltage Regulators LM335, LM336 and LM337 are supplied in TO–3 (Diamond) package.

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220µF, 15V	$.15	5µF, 50V	$.10
500µF, 15V	$.20	10µF, 50V	$.15
1000µF, 15V	$.30	20µF, 50V	$.20
20µF, 25V	$.15	50µF, 50V	$.20
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7416	.48	7495	.79
7420	.25	7494	1.10
7430	.25	74121	.70
7440	.25	74154	1.95
7441	1.30	74161	1.79
7442	1.30	74192	1.75
7446	1.50	74193	1.75
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400	.90	1.35	1.75	1.90
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300	.60	.90	1.50	
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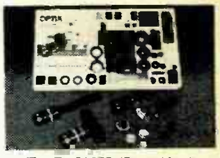

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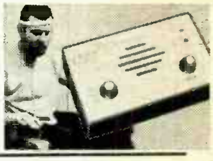

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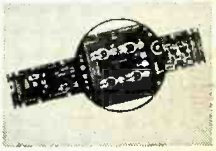

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