

THE STEREO SCENE: TEN HI-FI FALLACIES

Popular Electronics

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SSB
(Single Sideband)
For CB
Is Now!

THE OP AMP—What It Is
& How It Works

BUILD: Continental Speaker
System / Underground
Metal Locator /
Underwater Fish Finder

PRODUCT TESTS: Garrard
Zero 100 Turntable,
Simpson Model A 2-meter
Transceiver, & others

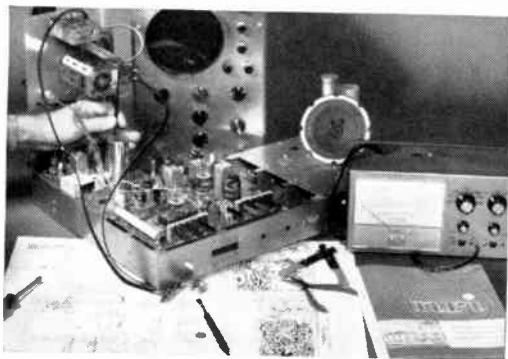




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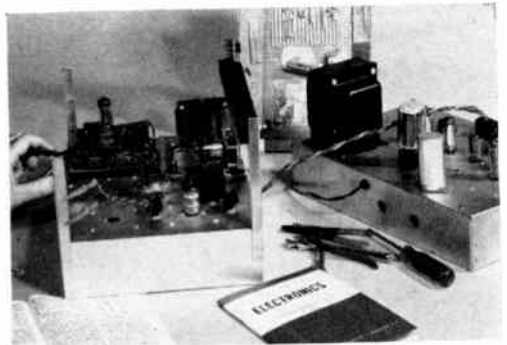
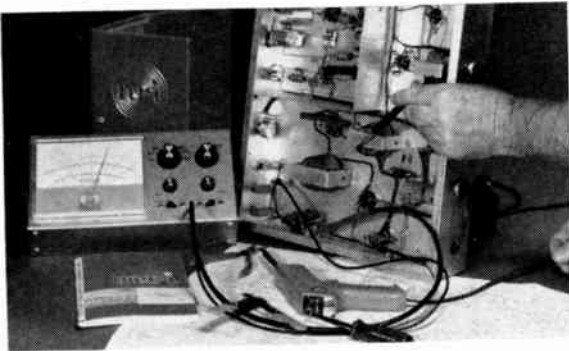
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POPULAR ELECTRONICS is Indexed
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By Milton S. Snitzer, Editor

TRUCK HIJACKING AND ELECTRONICS

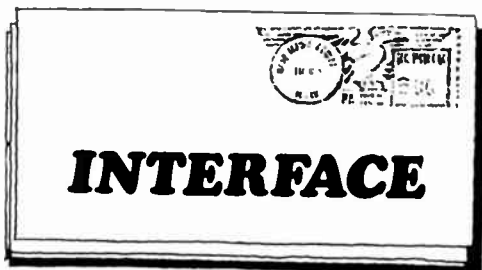
The other day, we were invited to a hijacking. We spent a couple of hours riding around New York City trailing a truck that was following its regular delivery route; and we were promised that we would see a hijacking attempt foiled by a newly developed electronic device. It may seem a far cry from the depressed aerospace industry, with its thousands of unemployed, to the not-so-depressed business of hijacking; but at least one company is making the transition from supplying electronic equipment for moon shots, to helping solve one of our important urban problems.

With the total estimated losses due to hijacked cargo running into millions of dollars, truckers are increasingly concerned with this problem, which has assumed major proportions for the first time since the notorious thirties. Law enforcement authorities estimate that the national hijacking toll in 1970 surpassed \$1 billion. In the New York City area alone, in the first quarter of 1971, 94 trucks were hijacked en route to their destinations, 24 fully loaded parked trucks were stolen, and there were 250 other incidents of theft or robbery involving trucks.

The device being demonstrated to us is called "Routemaster," a product of the Dynamics Corporation of America, and it is an example of how space research can be converted to aid business and provide employment in a lagging economy. A far more complex version of the system was the inertial guidance black-box used in our moon shots. Now, in a simplified version, a gyroscope is used to check on turns made by the truck while a tie-in to the truck's odometer measures distance. A slow-moving pre-programmed punched tape carries information on the truck's route. To achieve maximum accuracy, the system is reset at every turn. The product, with a suggested selling price of around \$1000, is currently being consigned to truckers for field tests.

We knew the test hijacking was taking place when a large red light mounted on the back of the truck suddenly went on and an ear-piercing siren wailed. Though the driver appeared to be trying to continue with his plan, the truck was disabled before it had gone a couple of blocks. The "Routemaster" had detected the wrong turn, set off the warning devices, and finally prevented the vehicle from proceeding. And, if it had been a bona fide hijacking, the police would have arrived soon after.

Hats off to Dynamics Corp. of America for their innovative approach to the problems of an economy as it turns toward peace. They have been able to turn the knowledge gained through work in space programs to aiding business by preventing crime—at the same time helping to provide needed employment. Those of us who are interested in electronics, either as professionals or hobbyists, appreciate the vital contribution electronics can make in this period of transition.



PRINCEPS PUZZLE

The "Princeps Puzzle" (May 1971, p 26) is an IC analog of an almost identical puzzle I constructed using relays in 1956. Readers may be interested in knowing that the sequence of states traversed during a correct solution is a binary counting sequence in Gray code. The number of steps required for solution is the largest integer contained in $\frac{2}{3}$ times 2^n , where n is the number of stages in the puzzle. The factor $\frac{2}{3}$ arises because all 1's is not the largest number expressible with n bits in Gray code.

But "a minute or two" to solve it? Really! Although my unit has only seven bits, the family record is ten seconds, held by my 77-year old mother-in-law. By extrapolation she should be able to solve your eight-bit puzzle in twenty seconds or less. Can any of you

young squirts top that? Besides that, my unit has two buttons per light, on and off, requiring twice as many decisions per bit.

D. A. KEMPER
Northridge, Calif.

SO-CALLED "RMS POWER" RATINGS

Those hi-fi component manufacturers who insist on using the incorrect term "rms power" in rating the output of their amplifiers and receivers are merely demonstrating their lack of technical knowledge. Voltage and current have rms values, but there is no such thing as "rms power."

A sine wave of voltage has an rms (root means square, or effective) value that is 0.707 of its peak value; it has an average value of 0.636 of its peak. When you take the square of the rms value of output voltage from an amplifier and divide it by the load impedance (E^2/R), you obtain an average value of output power. In the case of the voltage, the rms value is actually the square root of the average or mean square of all the values of instantaneous values taken over an entire cycle; hence, the name "rms." The power, on the other hand, cannot be derived this way. It is merely an average value.

True, "average" is not a very dramatic term to use for promoting a product, and it doesn't sound as technical as rms. But at

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INTERFACE (Continued from page 8)

least it is correct. Other correct terms that could be used are: "steady-state power" or "continuous power."

In view of the Federal Trade Commission's upcoming ruling on power ratings in advertising, the most prominent rating disclosed will be continuous power. But we will probably be seeing more and more the use of the incorrect term "rms power."

MARC SAUL
Floral Park, N.Y.

We couldn't have said it better ourselves. But reader Saul is probably fighting a losing battle since the incorrect abbreviation "rms power" is so short, sweet, and technical sounding.

UNIVERSAL TIGER REALLY ROARS

After assembling my "Universal Tiger" power amplifier ("Assembling A Universal Tiger," Oct. 1970), I ran it through a few tests of my own. Needless to say, the amplifier came through with flying colors. Measured frequency response was literally flat from 5 Hz to beyond 75,000 Hz. Transient response is remarkable, providing a fidelity that can be described only as superb. My Universal Tiger does not have the optional distortion control, but distortion is practically nonexistent. I must admit that this is a superb power amplifier.

I have only one recommendation to make. It is safer to use a standard 3-ampere fuse for the recommended 5-ampere fuse. Most fuses carry a 100 percent or more overload rating, and the 5-ampere fuse may not blow in time to save an expensive speaker system. A 3-ampere fuse is more than adequate for most purposes.

A. ROBERT BONNEFIL

We agree. The 3-ampere fuse will undoubtedly supply ear-shattering volume.

A COMMITMENT TO THE BEST

Like most self-styled stereo nuts, I'm interested in what's generally considered to be the "best" available stereo components. "The Best Of Everything" (Stereo Scene, April 1971), therefore, made quite enjoyable reading for me. Although I realize that objectivity is usually the prime requisite in test reports, it is refreshing to have a stereo expert commit himself by expressing his personal preferences in print.

DALE A. LEWIS
Detroit, Mich.

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reference page that simplifies the selection of equipment.

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Approximately 400 pages are contained in "Applications Memos," a paperback handbook available from Signetics Corp. The handbook contains an introduction to digital logic and discusses digital considerations by family, decoding and steering, counters, shift registers and memories, interface and display elements, linear considerations, timing circuits, and parallel data handling. If you're interested in digital logic, this is a handy book to have in your library.

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A New 32-page catalog that features helium-neon lasers for industrial, research, and educational applications has just been published by Metrologic Instruments, Inc. Seven laser models ranging in price from \$99.50 to \$275 are described and illustrated. The catalog lists laser education kits designed for optics experiments, a laser communicator, holographic systems, power supplies, optics benches, photometers, and accessories. The catalog provides price information on all items as well as a cross-

A new "Sound and Communications Equipment" catalog covering industrial sound products has just been issued by the Altec Division of LTV Ling Altec, Inc. The 16-page, two-color catalog illustrates and provides basic technical information on sound equipment and Altec's exclusive "Acoustavoicing" process for theatres, recording studios, convention centers, airports, business, etc. Altec telephone products are detailed along with intercom systems.

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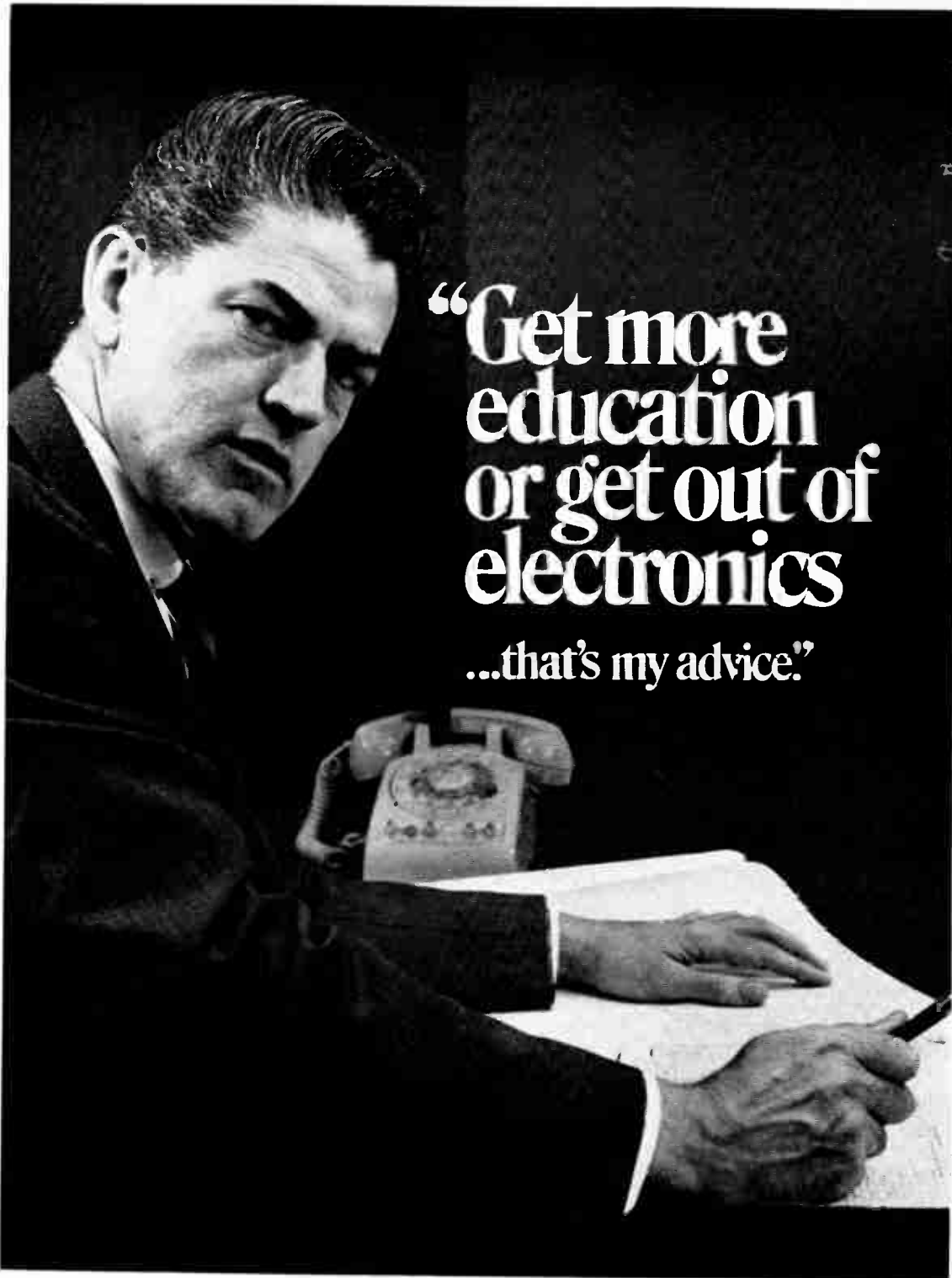
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by Stan Prentiss

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Published by Tab Books, Blue Ridge Summit, PA 17214. Hard cover. 255 pages. \$7.95.

SIMPLE TRANSISTOR PROJECTS FOR HOBBYISTS & STUDENTS

by Larry Steckler

The author has used his expertise as an electronics magazine editor to put together in this book a unique collection of useful projects built around most of the various types of solid-state devices—including the IC. The lineup includes a wide diversity of projects, more than 30 in all, as well as hints on breadboarding materials and the handling of semiconductor devices. For each project listed, there are a short theory of operation section, a schematic diagram, and a parts list. The projects are for home and/or car use.

Published by Tab Books, Blue Ridge Summit, PA 17214. 192 pages. \$7.95 hard cover; \$4.95 soft cover.

ABC'S OF TAPE RECORDING, Third Edition

by Norman H. Crowhurst

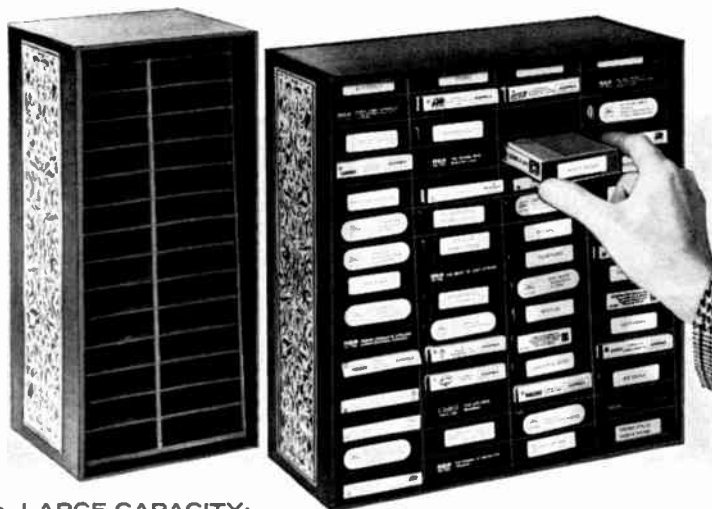
There is no end to the uses of a tape recorder. In this new edition of a popular handbook, the author tells how tape recorders work, how to choose the recorder best suited to individual needs, and how to use the recorder for entertaining as well as for practical purposes. You will learn how to judge recording quality and how to keep a recorder in operating order. Many new illus-

(Continued on page 98)

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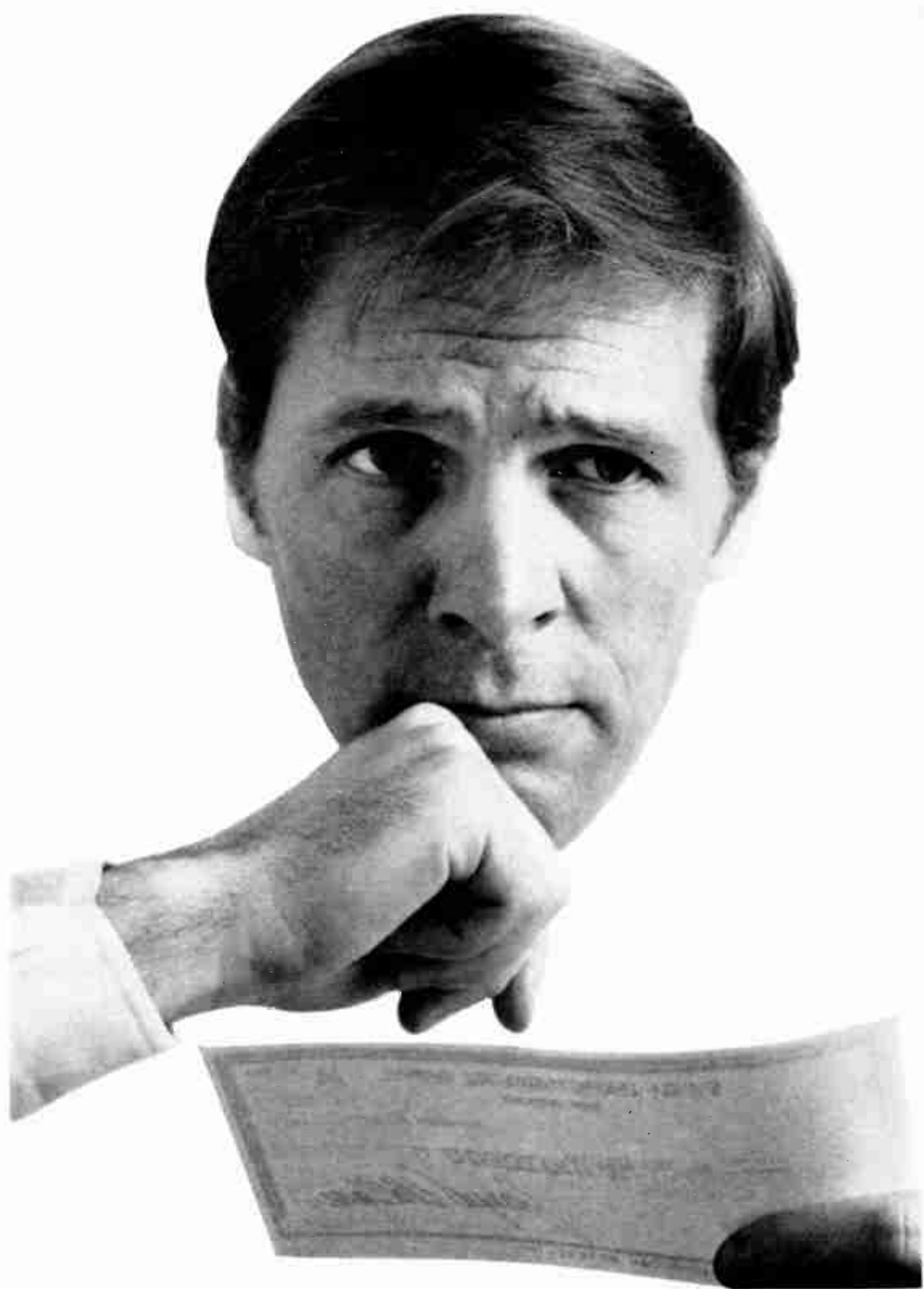
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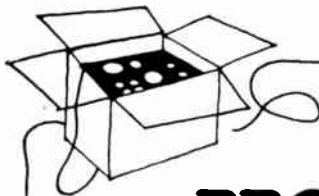
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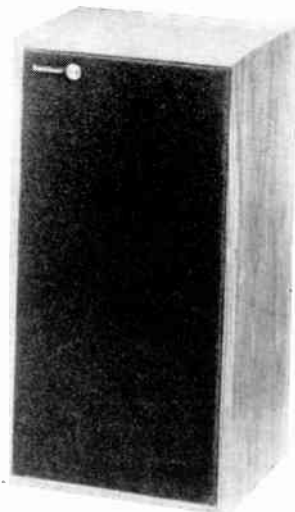
Additional information on products described in this section is available from the manufacturers. Each new product is identified by a corresponding number on the Reader Service Page. To obtain additional information on any of them, circle the number on the Reader Service Page, fill in your name and address, and mail it in accordance with the instructions.

RECTILINEAR BUDGET SPEAKER—If you're looking for a two-way speaker system that isn't in the astronomical price range, investigate the Model XI, made by *Rectilinear Research & Development Corp.* It has a 10-inch woofer and 3-inch tweeter (both extended range moving coil types) and the enclosure is a tube-vented bass reflex. Crossover is at 1800 Hz and there is a tweeter level control. Cabinet is 23" x 12" x 10½". Price \$69.50.

Circle No. 80 on Reader Service Card

MICROLUX STYLUS CLEANER—The *Duotone Company's* new Microlux stylus cleaner, when applied with a small brush, not only cleans the phono cartridge stylus but also acts as a deterrent to further accumulation of dirt. The application of the cleaner does not harm the stylus, its mounting, or records. The antistatic chemical dissolves dirt that hardens and effectively becomes a part of the stylus point. The stylus cleaner chemical comes in a plastic storage case with an accompanying brush.

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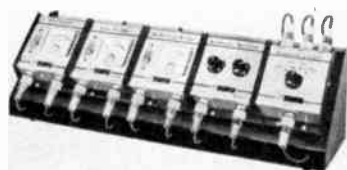


TRIPLETT 2¾ DIGIT DVOM—Using a ½-digit concept to increase resolution and accuracy the *Triplett Corp.* Model 6028 has a 10-ohm full-scale range to give good resolution down to 50 milliohms. It has a 10-megohm input resistance on all ac and dc voltage ranges and fool-proof 100% overrange, out-of-range, and reverse polarity indications. The digital readout display consists of two cold cathode tubes, three neon bulbs indicating 0 and 5 half digits, 1 overrange digit, and a movable decimal point. When all the numbers are displayed simultaneously, an out-of-range condition exists. A soft blur in the two decade tubes and only a 0 displayed in the half digit form indicates reverse or wrong polarity. Three pushbutton switches are used for positive and negative ohms and ac. Price is \$275.

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ANTENNA SPECIALISTS CB STATION INSTRUMENTS—A new line of CB test instruments and accessories has been announced by *Antenna Specialists Co.* Included in the line are all the instruments, switches, and accessories needed to control and monitor the well-equipped CB station. Items include the Model M-251 modulation bridge; Model M-252 wattmeter; a 4-way antenna switch; VSWR bridge; remote speaker; antenna matcher; and the Model M-256 console. The console accommodates up to five instruments at a convenient viewing angle to allow full-time monitoring of the station.

Circle No. 83 on Reader Service Card



NEW PRODUCTS

TEAC AUTO CASSETTE PLAYER—With the popularity of cassette players in automobiles growing, TEAC Corp. of America has announced its Model AC-7 for vertical or horizontal installation. It has continuous playback in both directions, a transport that utilizes two flywheels, a servo controlled drive motor and integrated circuitry. A unique design feature allows the cassette to drop directly onto the drive mechanism instead of having the drive mechanism move up to the cassette. Wow and flutter is less than 0.3% and frequency range is from 40 to 8000 Hz.

Circle No. 84 on Reader Service Card



TELCOMM SSB CB TRANSCEIVER—The SSB-120 from Telcomm Industries Inc. is for the operator desiring SSB communication only. The transceiver uses standard miniature plug-in crystals (one per channel) which free the operator from synthesizer problems. Power for the SSB-120 transceiver can be obtained from a 12-volt dc source or, merely by changing power cords, from any 117-volt ac source.

Circle No. 85 on Reader Service Card

HEATHKIT CHART RECORDER KIT—The Heath Company's new Model IR-18M 10" chart recorder is a sophisticated laboratory instrument selling, in kit form, for a really moderate price. The recorder provides 12 different chart speeds from 5 sec/in. to 200 min/in. Two input ranges permit accurate measurements 0 to 1 mV and 0 to 10 mV full scale. It employs a light-operated modulator which eliminates the problems encountered with mechanical choppers. A multitude of transistors, diodes, and IC's are used in the servo amplifier and chart-speed circuit boards. The kit comes with a roll of graph paper and fountain pen with ink cartridges.

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LAFAYETTE/DYNAQUAD ADAPTER—By adding the new Lafayette Radio Electronics "Dynaquad" adapter and two additional speaker systems to an existing two-channel stereo amplifier or receiver, you can obtain dramatic four-channel sound from regular stereo tapes, discs, and broadcasts. The adapter has a 4-position function switch with a special "balance" position for achieving precise balance between the four speakers in the system, a "rear level" control for adjusting the volume of the rear speakers, and a function switch which can be used to play the front and rear speakers separately.

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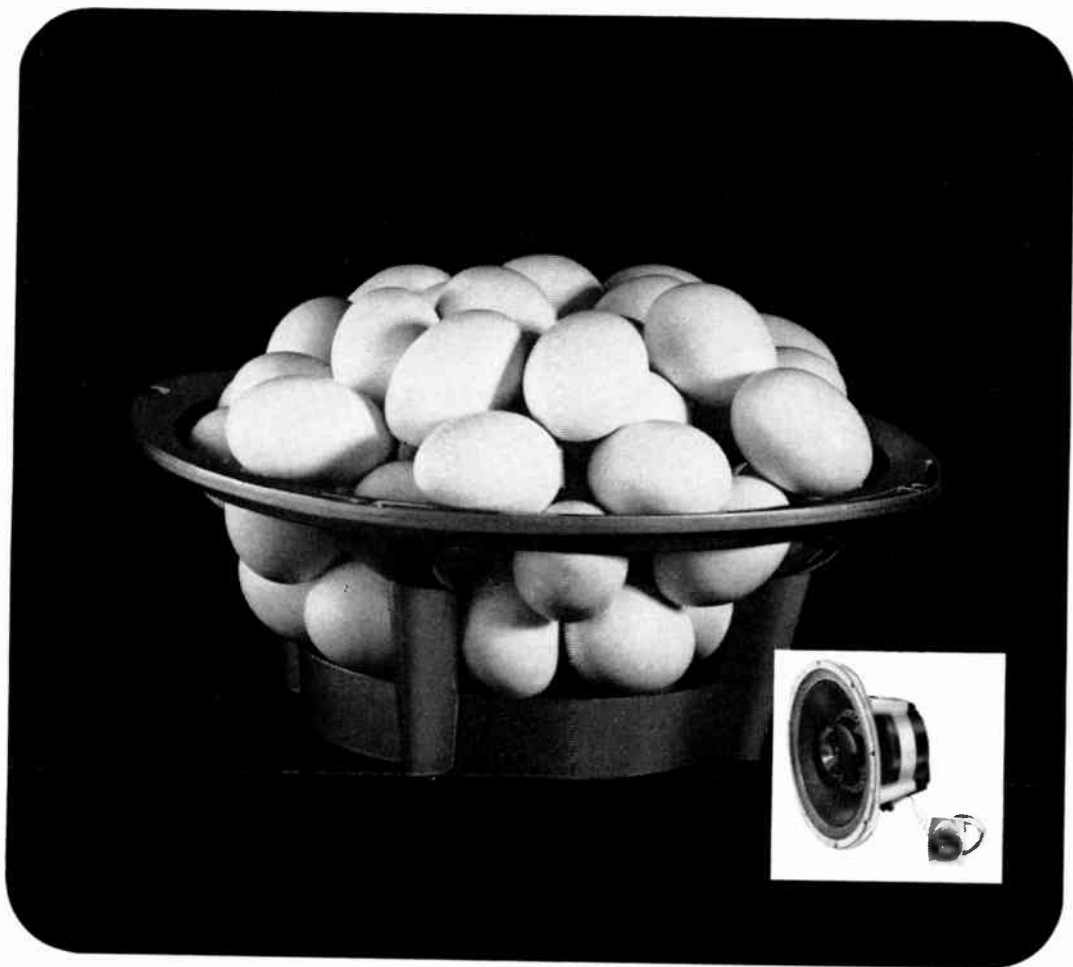
PIONEER AM/STEREO FM RECEIVER—The first receiver to have its own reverberation amplifier is the Model SX-9000 available from U.S. Pioneer Electronics Corp. This deluxe AM stereo FM receiver also has other goodies such as 240 watts of output music power into a 4-ohm load, 1.6 μ V sensitivity, more than 65 dB signal-to-noise ratio, and a frequency response of 10-35,000 Hz \pm 1 dB. The SX-9000 is extremely versatile, having facilities for two tape decks, two turntables, two headphones, and two speaker systems.

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(Continued on page 69)



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Single Sideband for CB is Now!

QUESTIONS AND ANSWERS ON THE NEWEST

AND HOTTEST THING TO HIT CB

COVER STORY

BY HERBERT FRIEDMAN

IF YOU'RE TIRED of paying for and experimenting with antennas, clippers, compressors, and other "talk power" devices, all in the hope of getting a little extra range out of your CB gear, then it's time to think of switching to single sideband—or SSB as it is called.

Advantages of SSB. Think in terms of SSB and you think in terms of twice the AM range, sharply reduced interference from other stations, less ignition noise interference, and—most of all—46 CB channels in the same space occupied by the "old" 23 channels. (Just doubling the number of channels can cut interference up to 50%.)

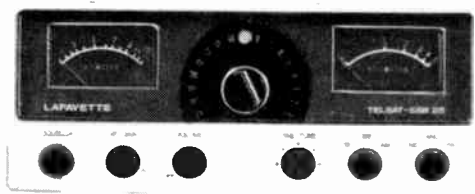
Basically, SSB is simply a different way of getting your voice from one point to another. In an AM system, the trans-

mitter consists of an r-f generator and an audio amplifier called a modulator. The r-f signal output from the generator serves no useful purpose other than to demodulate the signal at the receiver; and this could be done just as easily with a "carrier" injected in the receiver. Yet the carrier uses 66% of the total available power. In a CB AM transmitter running the full legal input, the power to the r-f final amplifier is 5 watts. The maximum modulation that can be applied to an AM transmitter is 50% of the power input to the r-f final—or 2.5 watts. Add the 5 watts r-f input to 2.5 watts of audio and the total power input is 7.5 watts, yet the 2.5 watts of audio, which does all the work (producing intelligence) represents only 33% of the total power.

In an SSB transmitter, the carrier and

one sideband are essentially eliminated and all the available power input goes into transmitting the modulation. This represents a substantial power gain over the modulation delivered by an AM system.

So without going one step further, we see that SSB provides at least 8 times greater effective output than a conven-



Lafayette Telesat—SSB 25

tional AM CB transmitter. As far as the receiving station is concerned, the SSB signal is 8 times stronger than an AM signal.

The carrier needed for demodulation is supplied by the SSB receiver, though the bfo (beat frequency oscillator) in a communications receiver can be used for carrier insertion.

Since there is no carrier in SSB transmission, there is no heterodyne interference if all stations on the channel are using SSB. And since SSB demodulation is essentially a single-tone conversion process by the injected carrier, ignition system impulse noise is not as annoying or signal-masking as it is on AM.

From a straight communications viewpoint, then, SSB is superior in every way to conventional AM. How SSB might affect your own CB operations is best illustrated by the following typical questions asked by other CB'ers.

Q. Is SSB compatible with AM?

A. No. AM signals sound like chatter on SSB receivers and vice versa. However, CB SSB rigs usually provide a standard AM detector for reception of AM signals.

Q. How bad is the interference when AM and SSB stations are using the same channel?

A. The interference is actually less than if the channel were all AM or all SSB. As far as AM is concerned, the interfering SSB signals have no carrier-

caused heterodyne interference. To the SSB stations, the AM interference is chatter or an intermittent heterodyne. In practice, if the interfering AM station is on the exact frequency of the SSB station, there will be no intermittent heterodyne.

Q. What causes SSB signals to sound either too high or too low in pitch?

A. The frequency of the inserted carrier must be very precise. If it is not exactly matched to the suppressed carrier of the transmitter, the voice tone will be sharply altered. All SSB receivers have a "fine tuning" control or "clarifier" that matches the inserted carrier to the original carrier for proper voice reproduction.

Q. Exactly how does SSB provide 46 channels in the space of 23?

A. SSB uses only one sideband with the maximum sideband deviation equal to the highest modulating frequency of 5000 Hz. It is therefore possible to have two SSB transmitters on the same channel, one using the upper sideband and one the lower. The total bandwidth of both signals is 10,000 Hz—the space utilized by a single AM station.

Q. Wouldn't two SSB stations using the same channel interfere with each other even though they utilize different sidebands?

A. In a properly designed receiver, only one sideband per channel can be received at a time. All SSB rigs are equipped with a mode switch that selects either upper or lower sideband transmission and reception.

Q. Is it possible to work a station on the same channel but on the other sideband?

A. Yes. While there is no logic in doing so, the mode switch can be set to the opposite sideband when receiving. So far, all SSB rigs use a single switch for selection of the transmit and receive sidebands.

Q. Can I use a selective calling or tone squelch device with an SSB transceiver?

A. Theoretically, yes. Practically, no. The pitch of the audio output is determined by the frequency and stability of

the inserted carrier and the receiver tuning control. The combined stability is not presently high enough to insure that the tone burst will come out of the receiver at exactly the same frequency it went into the transmitter. Nor is the transmitter stability presently high enough to insure that the transmitted tone is the same frequency it went in.

Q. Do squelch controls work with SSB?

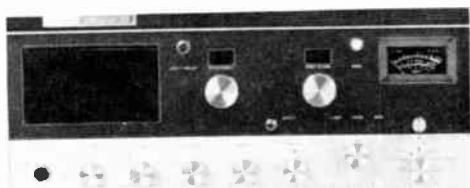
A. SSB has no effect on standard squelch operations.

Q. Why do all SSB units have r-f gain controls?

A. Under moderate-to-strong signal conditions, better SSB reception is obtained if the volume control is run almost wide open with the speaker level determined by the r-f gain control. For SSB, the lower the r-f gain, the better.

Q. Do SSB transceivers have automatic gain control to prevent receiver blasting on strong signals?

A. Yes, SSB receivers employ a fast-acting agc which can generally follow a word rate. It is not a long-term agc such as that used in AM receivers. Unfortunately, if the agc is not properly designed—if it “hangs up” for a moment or two—the beginning of the following word can be lost.



Tram Titan III

Q. Since SSB is the transmission of only the modulation, couldn't greater talk power be realized by the use of a modulation booster device?

A. As a general rule, a modulation booster cannot be used with SSB since it can cause almost infinite power to be generated at the beginning of the modulation waveform. In a typical solid-state transmitter, the instantaneous drive to infinite power input could destroy the output stage. Instead, alc (automatic level

control) is usually built directly into the transmitter by the manufacturer.

Q. What is meant by frequency shaping and speech processing?

A. Frequency shaping means that the SSB modulator responds only to the important intelligence-carrying frequencies: 300 to 3000 Hz (or 250 to 3500 Hz). This puts all of the transmitted sideband en-



Midland 13-880B

ergy where it is needed. There is no power wasted in transmitting the low frequencies which only produce the characteristics by which we recognize who is speaking. Speech processing generally implies frequency shaping and/or compression or clipping. Shaping and processing are also used for AM.

Q. Why are SSB transmitters allowed 10 watts input when AM transmitters are limited to 5 watts?

A. The 10-watt PEP rating seen in SSB specifications is not measured in the same way as for AM transmitters. AM transmitters are rated in average power input—the final plate voltage times the final plate current. On the other hand, PEP means peak envelope power, which is the rms value of the instantaneous peak power input (or output) to the SSB final. As a rule, when using two-tone SSB modulation for tests, the equivalent average power input is half of the PEP input, though different measuring techniques can show a PEP equal to 3 times the average dc power input. There is no direct comparison. Ten watts PEP is not the equal of twice 5 watts; because it is sideband, 10 watts PEP is at least 8 times as effective as 5 watts of average power at 100% modulation.



SBE Sidebander

Q. What effect does a high standing wave ratio have on SSB transmission?

A. The same as for any other transmitter. The losses due to a high SWR are the same for SSB, though a large mismatch between the transmitter and the line can cause modulation distortion. (A mismatch will not generally cause distortion in an AM transmitter.) Typical SWR's of 3:1 or less have no effect on SSB transmitters.

Q. Is an SSB transceiver more difficult to operate?

A. Not really. The mobile type of units might have one or two extra controls—such as r-f gain and mode (SSB-AM selector). Otherwise, they are operated in the same manner as any other transceiver, though fine tuning might be slightly more critical.

Q. Do SSB transceivers have the same features such as those on AM models: S-meters, PA and remote speaker outputs, etc.?

A. SSB does not affect the "extra" features. An SSB transceiver might have some or all of the advantages common to AM units.

Q. How does the overall performance of SSB equipment compare with AM equipment?

A. So far, SSB gear is similar in performance to the better quality AM units. Selectivity in terms of adjacent channel rejection is high (40 dB or better); image rejection is the same as for AM; and mechanical construction is good. Since SSB requires greater stability than AM, the SSB equipment receives a better factory alignment and adjustment.

Q. While I understand the power gain advantage in transmitting, how does SSB improve reception?

A. Rather than use the carrier for demodulation as in AM, SSB signals use an injected carrier whose level can be optimized for maximum sensitivity. Often, the SSB sensitivity is 3 to 6 dB higher than for AM. Also, SSB signal intelligence extraction of 80% can be obtained with a 6-dB $(S+N)/N$ ratio. AM requires a 10-dB $(S+N)/N$ ratio for 80% intelligence extraction.

Q. Would not a less expensive double sideband (DSB) transceiver deliver the same performance as SSB?

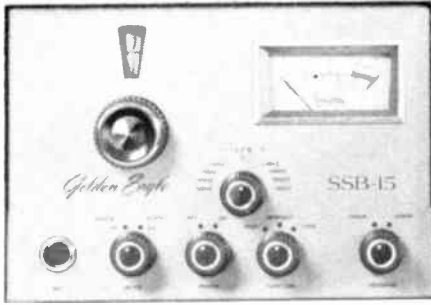
A. Yes, a real double sideband rig with fully suppressed carrier would deliver almost the same performance as SSB, but because there are two sidebands, the DSB signal would occupy the entire channel. Keep in mind that DSB is not the same thing as DSB with reduced carrier (DSBRC). The latter is almost the same as AM, with the carrier present but at a reduced level. DSBRC is received on a standard AM receiver. Its carrier still produces heterodyne interference—as with conventional AM. An SSB signal starts out as DSB, but one sideband is removed by a filter before the signal reaches the final r-f amplifier.

Q. Since an AM transmitter uses a class C amplifier with typical efficiencies of 80%, doesn't the SSB final amplifier, which is linear, have less efficiency and, therefore, less output?

A. The difference in efficiency between class C power amplifiers for AM and the linear amplifiers for SSB is about 12%, too small to have a significant effect in view of the much greater gain in effective power output at the modulating frequencies.

Q. What is meant when an SSB signal is referred to as "inverted"?

A. When transmitting the upper sideband, the modulation frequencies are in their natural order; the higher modulation frequencies correspond to a higher r-f frequency. But when transmitting the lower sideband, the high modulation frequencies are actually lower in r-f frequency than the low modulation frequencies, which are close to the carrier frequency. The lower sideband modulation is therefore termed "inverted." The receiver automatically straightens the whole thing out since the inserted carrier always represents the precise carrier frequency. Some confusion has come about over the term inverted because scrambler devices (such as those used for telephones) have an inverted speech process that can be decoded by inserting an audio frequency carrier. But the term is really unimportant in narrow-band voice communications.



Browning Golden Eagle SSB-15

Q. How difficult is it to receive CB SSB on a communications receiver?

A. It's easy. Just run the volume control wide open, ride gain with the r-f gain control (with the avc off) and adjust the bfo until the signal clears into intelligible speech. However, both conversion oscillators and bfo must have good stability if you don't want the modulation to disintegrate into unintelligible chatter. SSB reception requires much greater receiver stability than AM.

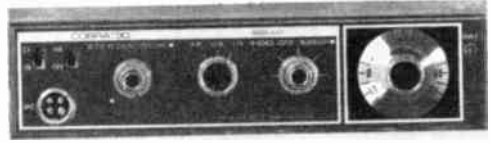
To Summarize. As you can see, except for the incompatibility between AM and SSB, the latter has no disadvantages for the CB'er. Even under worst case conditions, SSB provides a stronger signal at the receiver in terms of recovered audio. Practical tests show that, as a general rule, the CB'er can expect at least twice the range over conventional AM transmission.

Channel splitting, a byproduct of SSB, really does result in a doubling of the

available channel space. In metropolitan areas a substantial reduction in QRM interference could be obtained if a large number of CB'ers switched to SSB—or if specific channels were unofficially set aside for AM and SSB operation.

Admittedly, the cost of SSB equipment is greater than it is for AM; but judging by quality (comparing SSB to top-of-the-line AM equipment), the cost differential is not that much greater—especially if you consider the money that can be saved when you don't need talk power boosters and super antennas. (Of course, a super antenna will give the same edge to SSB that it does to anything else.)

The one obvious difference between AM and SSB equipment is in size. There are no "pocket" SSB rigs. A compact SSB



Dynascan Cobra 130

mobile unit is about 1/3 to 1/2 larger than an equivalent AM unit, so don't expect to hide it in the glove compartment. Base station SSB rigs are about equal in size to comparable AM units.

But price and appearance should really not be the basis for a decision. If you're interested in maximum communication effectiveness in terms of range and reduced interference, there is only one choice: single sideband. ♦

ABOUT OUR COVER

Although all of the equipment that is shown throughout this article is available commercially, the single sideband CB transceiver depicted on the cover is not. It is our own design and the product of our artist's imagination.

—Editor

The Operational Amplifier

What it is & How it works

THIS VERSATILE LINEAR IC OPENS UP

MANY NEW AREAS FOR THE SERIOUS EXPERIMENTER

BY RALPH TENNY

THE OPERATIONAL AMPLIFIER (usually shortened to op amp) is actually nothing more than a dc coupled amplifier with very high gain and with external components connected to it to control its response characteristics. Though there was nothing new about the circuit, the term operational amplifier gained recognition in the early days of electronic computation when op amps were first used to perform certain mathematical operations.

Today's op amp (usually referring to an integrated circuit device) approaches in performance the elusive "perfect amplifier" which, if it existed, would have the following characteristics:

1. Infinite gain; a very small change in input should produce an infinite change in output.
2. Zero output for zero input.
3. Infinite input impedance; no power consumed from the driving source.
4. Zero output impedance; output voltage should remain the same even if load resistance drops to zero.

5. Infinite bandwidth; zero rise time.

6. Insensitivity to either power supply or temperature variations.

Although such a perfect amplifier has not yet been developed, modern semiconductor technology has produced an op amp whose characteristics come quite close to the perfect case.

What's in an Op Amp? A typical op amp consists of three basic parts as shown in Fig. 1: a high-impedance differential amplifier that has low drift and wide bandwidth; a high-gain stage; and an output stage that isolates the gain stage from the external load and provides the actual power output.

The conventional symbol for an op amp, together with the characteristics of a perfect amplifier are shown in Fig. 2. Note that both polarities of the supply voltage are used (with the common grounded). This is necessary for the op amp to be able to deliver both positive and negative (with respect to ground) signals at the output.



Fig. 1. The basic arrangement of a typical op amp. Such a circuit could contain up to a couple of dozen transistors and associated resistors, all on a very tiny silicon chip.

The schematic of a basic differential amplifier is shown in Fig. 3. The currents to the emitter-coupled transistors (Q1 and Q2) are supplied by the constant-current source (Q3). The characteristics of the differential pair and the associated resistors are closely matched in the manufacturing process. If the two input voltages are either zero or are similar in level and polarity, the amplifier is balanced because the collector currents are equal. Therefore, a zero voltage difference exists between the two collectors. The sum of the emitter currents is always equal to the current supplied by the constant-current source so that, if one transistor draws more current, the other must take less. Thus if the input to one transistor causes it to draw more current, the current in the other decreases and the voltage difference between the two collectors changes in a differential manner. The differential swing is greater than the simple variation that can be obtained from only one transistor.

To further understand the operation of the differential amplifier, consider the diagrams in Fig. 4. In A, a positive-going signal applied to the minus input produces a negative-going output. Thus the configuration at A is called an inverter and the minus input is called the invert-

ing input. If the same signal is applied to the positive (non-inverting) input, the output is positive-going and the configuration is called a follower. Because no feedback is used in Fig. 4, the amplifiers are operating "open loop" and a small input produces a large output.

Actually, operational amplifiers are usually used with some form of feedback (closed loop) as shown in Fig. 5. In this inverter arrangement, feedback resistor R2 is connected from the output back to the inverting input to produce a signal which works against the input to reduce its effect. Resistor R1 isolates the inverting input from the signal source and represents the circuit's input resistance. The non-inverting input is grounded in this case.

Assume that a 1-volt signal is applied to R1. Due to the high input impedance of the op amp, essentially no current will flow into the input terminal (also called the summing junction), and there is a zero voltage drop between the two input terminals. The summing junction remains at zero potential. Since R1 is 1000 ohms, the 1-volt input signal creates a current of 1 mA through R1 and it flows also through R2 to the output terminal. However, 1 mA of current through the 10,000-ohm resistor creates a voltage

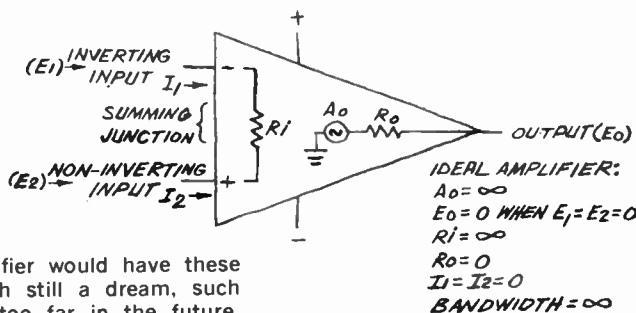


Fig. 2. A perfect amplifier would have these characteristics. Although still a dream, such a circuit may not be too far in the future.

IDEAL AMPLIFIER:
 $A_0 = \infty$
 $E_0 = 0$ WHEN $E_1 = E_2 = 0$
 $R_i = \infty$
 $R_o = 0$
 $I_1 = I_2 = 0$
 $BANDWIDTH = \infty$

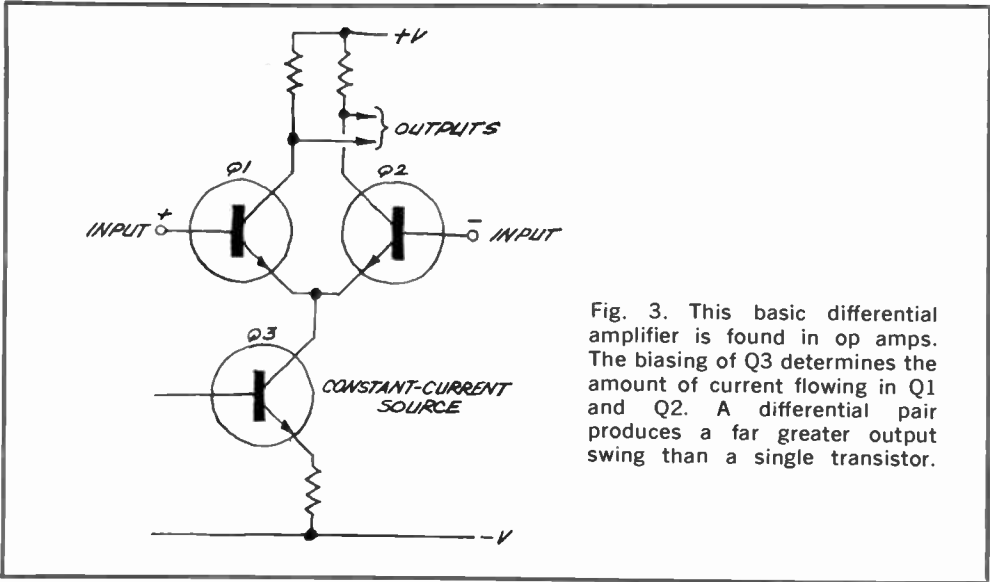


Fig. 3. This basic differential amplifier is found in op amps. The biasing of Q3 determines the amount of current flowing in Q1 and Q2. A differential pair produces a far greater output swing than a single transistor.

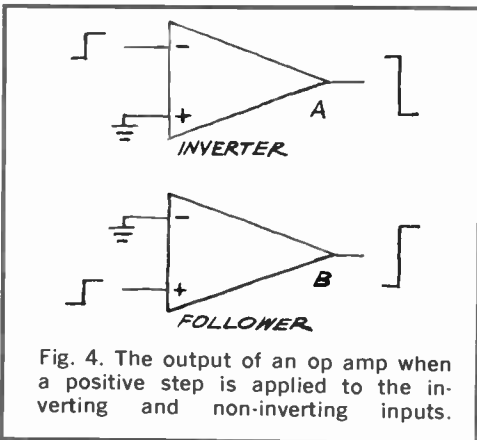


Fig. 4. The output of an op amp when a positive step is applied to the inverting and non-inverting inputs.

drop of 10 volts so the output terminal must go to -10 volts. Thus the configuration is a gain-of-10 inverter.

Frequency sensitive networks can be used with op amps to create oscillators and frequency selective amplifiers. With

a capacitor in the feedback loop, the op amp acts as an integrator; and with a capacitor in the input, a differentiator is formed.

Feedback is not necessary in some op amp circuits. For example, if one input is connected to a reference voltage and the other to a varying input signal (see Fig. 6), the open-loop amplifier will respond to the potential difference between the two inputs. Due to the high gain, the output level will swing widely (almost equal to the power supply voltages) as the varying voltage equals and exceeds the reference voltage. Note the input-output waveforms shown in Fig. 6. When the input signal is less than the reference, the op amp output is highly positive, and vice versa. If the two inputs were reversed, the phase relationships would also be reversed.

Other op amp circuits can be used as multi-signal summers, adders, or subtractors.

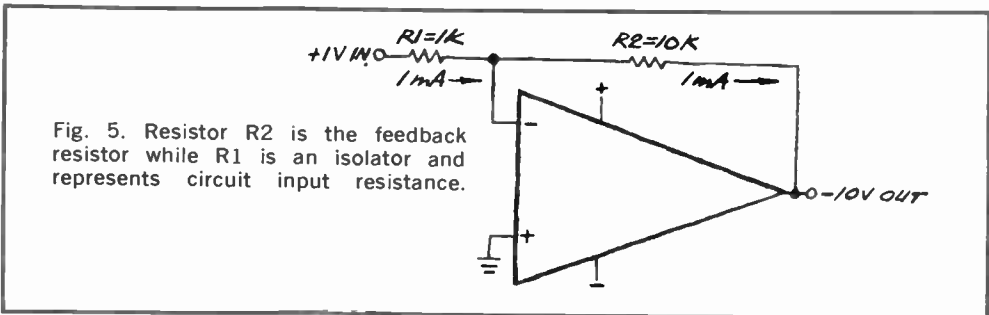


Fig. 5. Resistor R2 is the feedback resistor while R1 is an isolator and represents circuit input resistance.

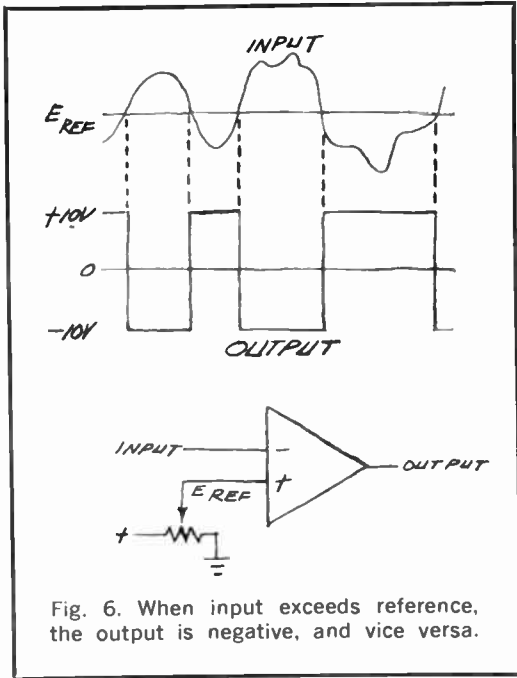


Fig. 6. When input exceeds reference, the output is negative, and vice versa.

tion circuits. The second part of this article will illustrate a number of practical examples.

Compensation. Because high-gain op amps are usually used in a feedback mode, the feedback must be controlled to assure that the circuit is stable with frequency and will not oscillate if the input-output phase difference changes drastically. When no phase compensation is furnished, the gain of the feedback signal may be greater than unity when the phase angle approaches 180°. In this case, feedback that is negative at low frequencies, becomes positive at higher

frequencies and unwanted oscillation may result.

To overcome this tendency toward unwanted oscillation, the frequency response and phase-shift characteristics of the op amp must be compensated—that is, onboard passive components (usually resistors and capacitors) are used to tailor the frequency response and phase-shift characteristics. One form of compensation uses a resistor and capacitor in series. In this case the amount of feedback increases as the frequency goes up and the reactance of the capacitor goes down; but the upper limit is determined by the resistor value which remains constant at the high frequencies.

Another popular form of compensation is called output limiting and can take the form of a low-value capacitor connected from the output back to the input. This output compensation is used to supplement the other compensation. The type of compensation used in any case is unique for the type of op amp and the application.

Sometimes compensation is obtained by bypassing the op amp to ground. If an op amp requires compensation, suitable terminals are provided on the package. There are some types that require no compensation and are so identified in the manufacturer's specifications.

A typical circuit with compensation is shown in Fig. 7. This circuit also has a null network which balances out the effect of offset voltage and current. This will be discussed later in more detail.

Each circuit using an op amp has certain closed-loop characteristics that must be taken into account by the circuit designer. For example, Fig. 8 shows the

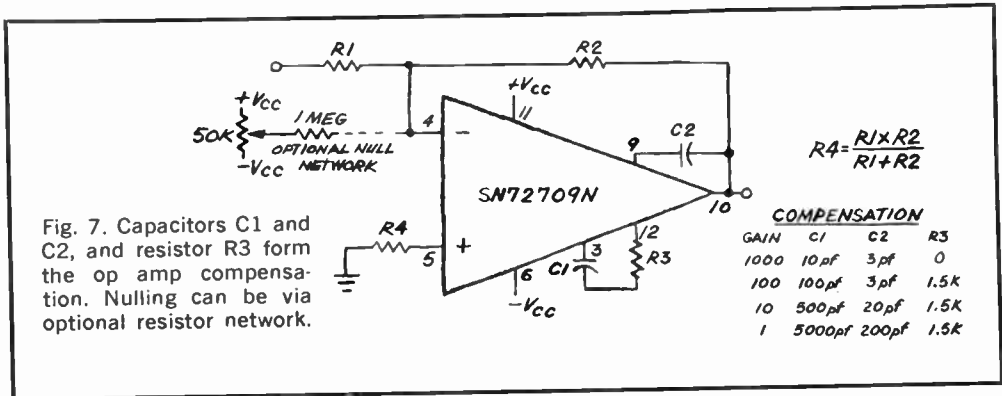


Fig. 7. Capacitors C1 and C2, and resistor R3 form the op amp compensation. Nulling can be via optional resistor network.

$$R4 = \frac{R1 \times R2}{R1 + R2}$$

basic characteristics of a follower, an inverter, and a difference amplifier whose output is proportional to the difference between the two inputs.

Performance Limitations. Op amps have performance limitations—as do all electronic components. These limitations are given in the specification sheets but for most purposes, the critical performance specs are power output, open-loop characteristics, bandwidth, input limitations, offset voltage, and offset current.

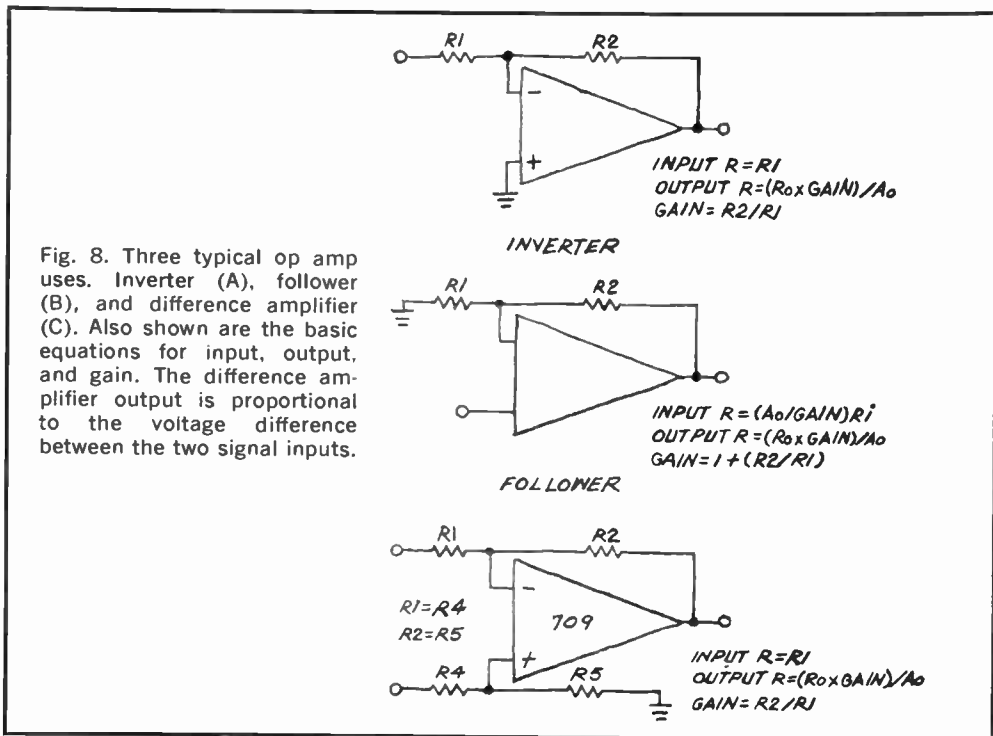
The most important specification is usually power output. The popular 709 IC op amp will develop ± 10 volts at 5 mA output, using a bipolar 15-volt power supply. Note that the 5 mA is the total output current, including that used by the feedback network.

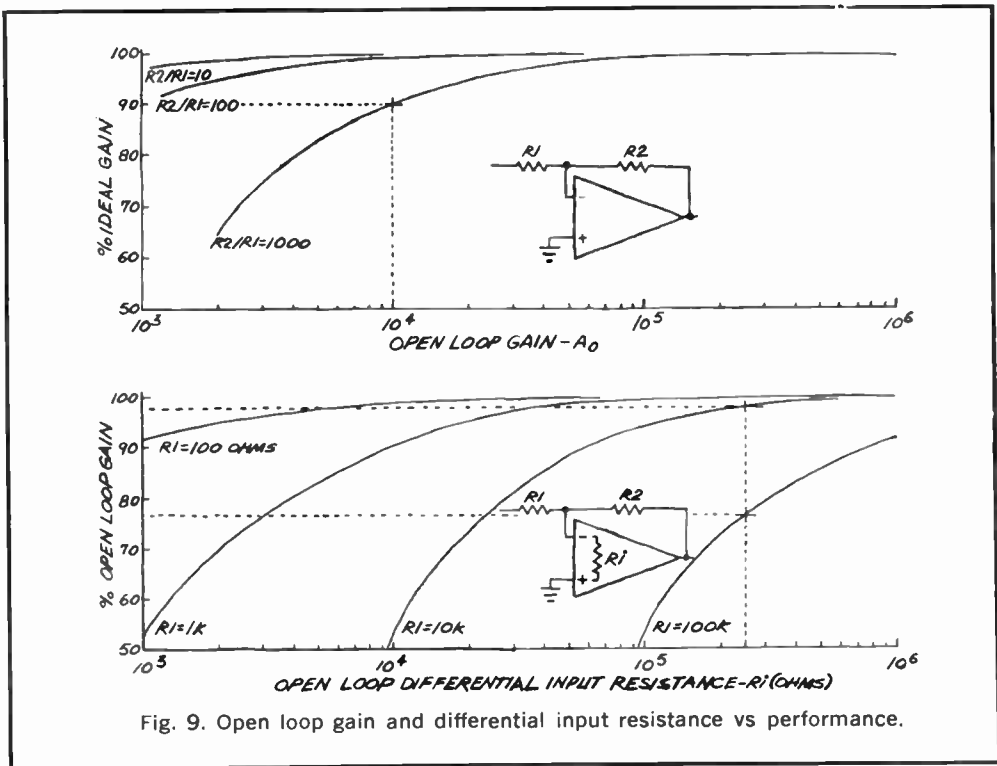
The effects of open loop gain and differential input resistance on final circuit performance are given in Fig. 9. To use the open loop gain graph, draw a vertical line at the open loop gain of the op amp being used. Where this line cuts the curve determined by the resistance values (R_2/R_1), read the percentage of ideal gain on the vertical axis. In the example

in Fig. 9, the open loop gain was 10,000, R_2/R_1 was 1000 and the percentage was 90%, meaning that the gain is actually 900 (90% of R_2/R_1).

The lower graph of Fig. 9 shows the effect of the external resistors on open loop gain as a function of the open loop input resistance. It also demonstrates that the open loop input resistance should be as high as possible. For example, a typical 709 has an input resistance of 250,000 ohms. Draw a vertical line from this point on the horizontal axis. If R_1 is 100,000 ohms, the open loop gain would then be 77% of normal. In this case the specified open loop gain is 50,000, so the actual gain would be 38,000. This is the figure to be used in determining ideal gain from the upper graph in Fig. 9. For the same amplifier, if R_1 is reduced to 10,000 ohms, the open loop gain would be 95% of the specified 50,000. For $R_1 = 1000$ ohms or less, the effect of open loop gain would be minimal. Of course, R_1 determines the input resistance so this factor must be taken into consideration.

Bandwidth and Slew Rate. Suppose a



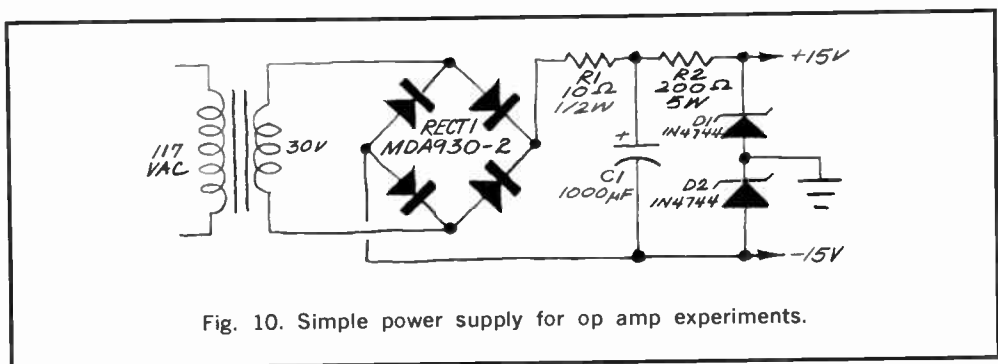


high-frequency, high-amplitude signal is fed into the op amp. Because the various elements within the op amp have some capacitor characteristics (mainly semiconductor junctions and strays due to proximity of conducting paths) a finite amount of time will be required to charge and discharge them. This prevents the output voltage from following the input signal instantaneously. Thus, these internal capacitances limit the rate at which the output voltage can change or slew. The maximum time rate of change of the output is identified as the slew rate and is specified as volts per microsecond. The

slew rate of a feedback amplifier depends on a number of factors, including the value of the closed loop gain.

Bandwidth and slew rate are related in that slew rate limits the bandwidth. The latter is usually expressed as a large signal bandwidth or the highest frequency at which the amplifier will develop its rated output without distortion. A particular amplifier is capable of having a higher frequency response with a smaller output.

Offset Error. Even though extreme care is used in the fabrication of an op amp,



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SA-100B Stereo Amplifier. Solid-state, 10 watts, phono/tuner inputs. Walnut case.

TM-100 AM/FM Stereo Tuner. Solid state, walnut enclosure.

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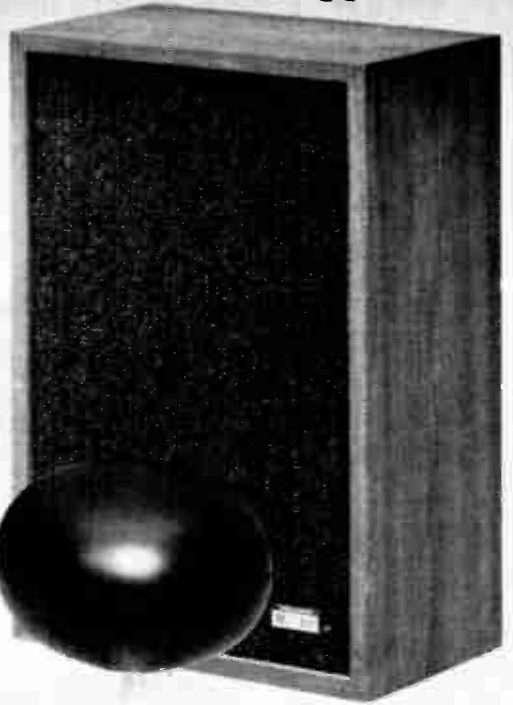
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a very slight mismatch may still occur between the internal components. The result of this mismatch prevents the amplifier from having a zero output for a zero input. This, of course, may be a problem when using the op amp in a dc circuit. Compensation for this offset voltage is made by using a nulling network such as that shown in Fig. 7, in which the nulling potentiometer is adjusted for zero output with zero input.

Common-Mode Error. Because it is very difficult to create a perfectly balanced system, the signal present at one input of a differential pair may affect the signal on the other input. The result is called common-mode error and it is smallest when the specification called "common-mode rejection ratio" is the highest.

Power Supply Considerations. Changes in the power supply of an op amp circuit often change the open loop gain, the common-mode input limits, and the input bias current. For example, the open loop gain of a typical 709 doubles when the power supply is changed from ± 10 to ± 15 volts. Input voltage limits change in proportion to the supply voltage and the bias current increases about 10% for a 50% increase in the supply voltage.

This sensitivity to power supply voltage seems to rule out batteries as a source but this need not be true. Circuits of moderate impedance having gains of 100 or less will not degrade appreciably if batteries with high current capacity are used and they are changed frequently. Mercury and rechargeable nickel-cadmium types have "flat" discharge curves and give good performance for a premium price. If battery power is a necessity, some manufacturers make discrete amplifiers for use with unregulated supplies.

Power supplies regulated by zener diodes furnish regulation close enough for most op amp applications. A typical supply of this type is shown in Fig. 10. Note that neither side of the filter capacitor is grounded since the supply develops both positive and negative voltages. The triangular ground symbol between the two diodes is an "instrumentation ground" and indicates that all ground connections within the system should be connected together but grounded to the

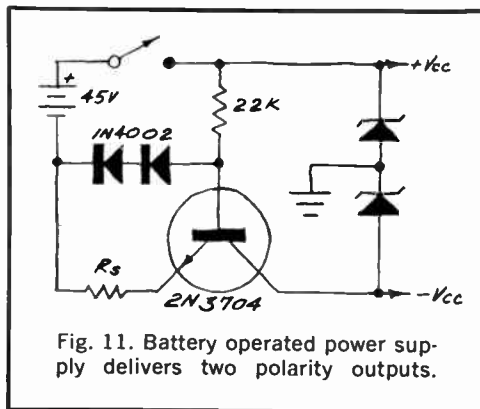


Fig. 11. Battery operated power supply delivers two polarity outputs.

chassis at one point only. This minimizes circulating ground currents. In extreme cases, the input connectors are also isolated from the metallic ground and connected to the instrumentation ground only.

The circuit of a single-battery, zener-controlled supply is shown in Fig. 11. The emitter resistor should be chosen so that the current through the zener diodes is about 50% above that required for the amplifier and associated load.

Critical op amp circuits require extremely close regulation—similar to that provided by a high-quality supply that uses one of the commercially available IC voltage regulators.

No matter what type of power supply you use, all op amp manufacturers suggest the use of a bypass capacitor close to the amplifier on the power supply leads. In fact this is mandatory if power supply leads are long. The recommended capacitor size is about 0.1 μ F.

[Part 2, on applications, will appear in the September issue.—Ed.]



BY DAVID B. WEEMS



The "Continental" SPEAKER SYSTEM

OFFBEAT LAYOUT AND EUROPEAN SPEAKERS
ADD UP TO TOP-NOTCH SOUND

THE U.S. MARKET for high-fidelity component loudspeakers was dominated by American and British manufacturers until the Japanese grabbed a piece of the action in recent years. The only serious continental European challenge to the market came in the 1950's when Philips of Holland sent over the Norelco FRS speakers. ("FRS" stood for "Full-

Response Speakers.") The Norelco speakers were popular for a while, then faded from the scene.

Now the Norelco loudspeakers are back. The new line, imported by Amperex Division of North American Philips Co., is good news for those hi-fi buffs who build their own speaker systems. Norelco's components for sealed-box systems,

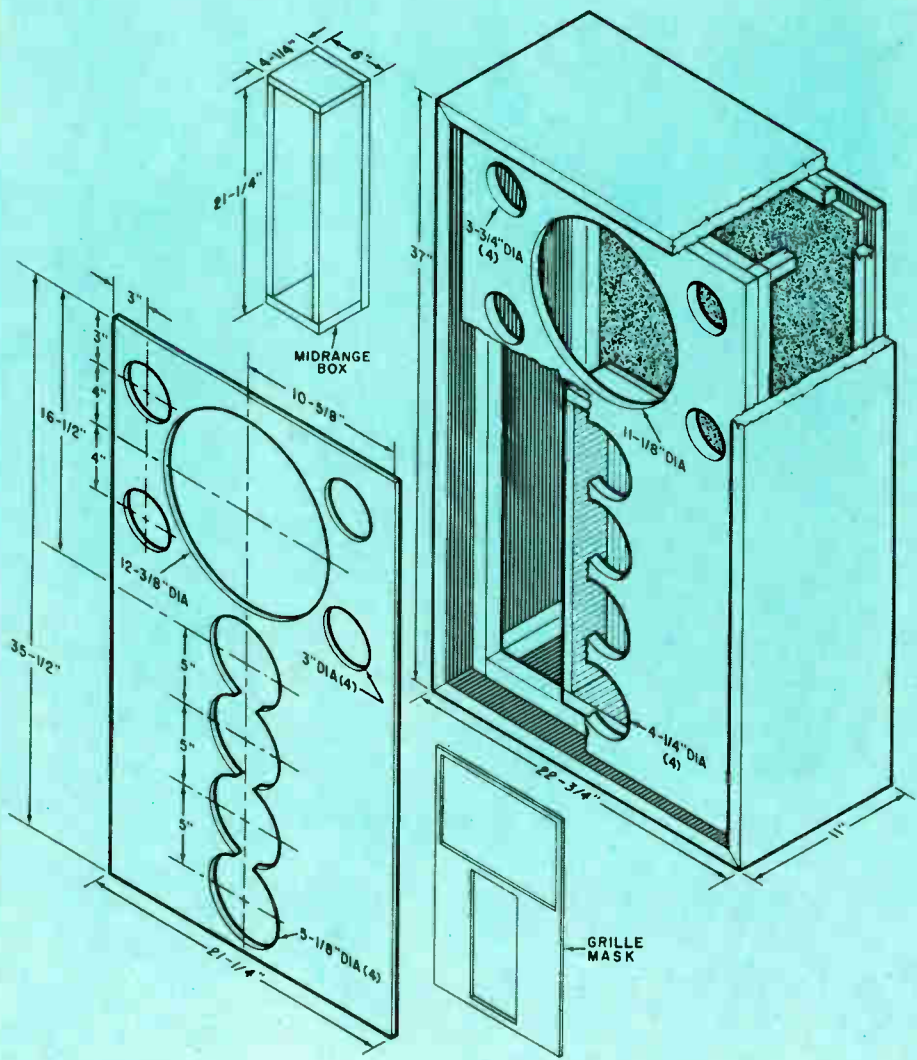


Fig. 1. Unconventional design and layout of speakers requires use of two-thickness speaker mounting board and rear panel for stiffening the shallow enclosure.

woofers, midrange speakers, tweeters, and crossover networks fill a real need ignored by many manufacturers.

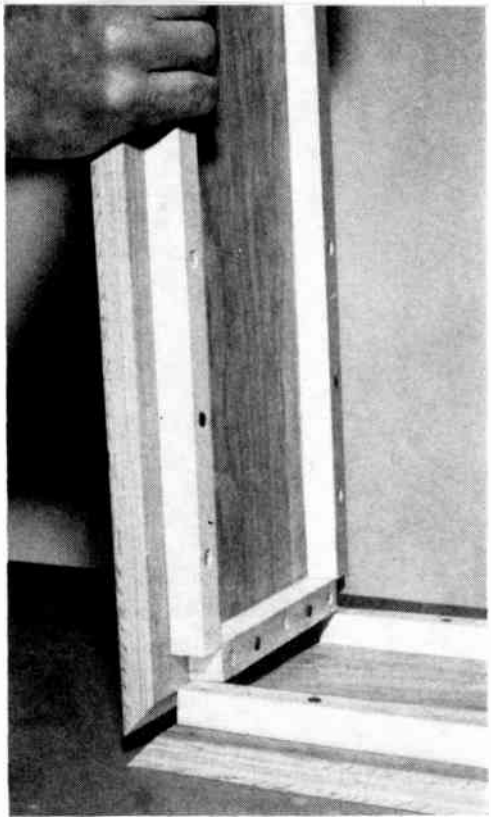
Amprex sells a book which is quite useful for the speaker system constructor, although the measurements provided in the plans are all based on the metric system. ("Building Hi-Fi Speaker Systems." M.D. Hull & K.R. de Vries. N.V. Philips' Gloeilampenfabrieken, Eind-

hoven. The Netherlands, 1970.) The speaker system described in these pages, which we have called the "Continental" as a result of the origin of the speakers used, is No. 23 of 24 different two- and three-way systems described in the Amprex book.

The Continental is a three-way system, employing a total of nine loud-speakers (one 12" woofer, four 5" mid-range

BILL OF MATERIALS

- 1—12" woofer (Norelco No. AD 1256/W)*
 - 4—5" midrange speakers (Norelco No. AD 5060/W8)*
 - 4—1" tweeters (Norelco No. AD 0160/T)*
 - 1—Crossover network (Norelco No. 4304-078-71971)*
 - 2—37" X 11" pieces of $\frac{3}{4}$ " fir plywood for enclosure sides
 - 2—22 $\frac{3}{4}$ " X 11" pieces of $\frac{3}{4}$ " fir plywood for enclosure top and bottom
 - 2—35 $\frac{1}{2}$ " X 21 $\frac{1}{4}$ " pieces of $\frac{3}{4}$ " fir plywood for enclosure rear panel and speaker mounting board
 - 1—35 $\frac{1}{2}$ " X 21 $\frac{1}{4}$ " piece of $\frac{1}{4}$ " interior plywood for front panel
 - 1—Piece of Celotex (approximately 33 $\frac{1}{2}$ " X 19 $\frac{1}{2}$ " X $\frac{1}{2}$ ") for rear panel stiffener
 - 4—6' lengths of $\frac{3}{4}$ " X $\frac{3}{4}$ " pine for cleats and corner blocks
 - 2—19 $\frac{3}{4}$ " X 3 $\frac{1}{2}$ " pieces of $\frac{3}{4}$ " pine for midrange column sides
 - 2—6" X 3 $\frac{1}{2}$ " pieces of $\frac{3}{4}$ " pine for midrange column top and bottom
 - 1—21 $\frac{1}{4}$ " X 6" piece of $\frac{3}{4}$ " pine for rear of midrange column
 - 1—Piece of $\frac{1}{4}$ " Masonite (approximately 35 $\frac{1}{2}$ " X 21 $\frac{1}{4}$ " X $\frac{1}{4}$ ") for grille frame
 - 1—Package of $\frac{3}{4}$ "-wide ribbon veneer trim
 - 12-doz. #8 X 1 $\frac{1}{4}$ " flathead wood screws
 - 3-doz. #8 X 1 $\frac{1}{2}$ " flathead wood screws
 - 1-doz. #8 X 2" flathead wood screws
 - 2-doz. #8 X $\frac{3}{4}$ " flathead wood screws
 - 2-doz. #10 X 1" panhead sheet metal screws
 - 4—#8 X 1" round head brass screws (for mounting crossover network)
 - 32—#8 X $\frac{1}{2}$ " panhead sheet metal screws for mounting midrange speakers
 - 8—#10 X $\frac{3}{4}$ " panhead sheet metal screws for mounting woofer
 - 12—#10 X $\frac{3}{4}$ " panhead sheet metal screws for mounting tweeters
 - 12—Heavy-duty oval service cable straps ($\frac{5}{8}$ "-wide with 1" mounting flange and 1"-long X $\frac{3}{8}$ " high cavity) for tweeter mounting
 - Misc.—Grille cloth; glue and contact cement; silicone rubber compound; speaker zip cord; two-lug screw-type terminal strip; $\frac{3}{8}$ "-long standoffs; fiberglass wool; solder; etc.
- * The nine speakers and crossover network are available as Norelco System 23 for \$84.95, plus shipping, from McGee Radio Co., 1901 McGee St., Kansas City, Mo. 64108.



Sides, top, and bottom panels should be miter cut to provide invisible joints when enclosure is assembled with corner blocks.

speakers can be a serious problem in any speaker system which utilizes more than one midrange speaker or more than one high-frequency speaker (tweeter). In the Continental, the problem is avoided in the high-frequency range by placing the tweeters far apart (with reference to the wavelength of the sound).

For the midrange, another solution was found: arranging the speakers in a vertical column. This effectively restricts to the vertical plane interactions between the speakers.

The offbeat speaker arrangement leads to another unusual characteristic: The inside of the enclosure from front to rear is extremely shallow, requiring special bracing of the speaker mounting board and the rear panel of the enclosure. The limited depth was dictated by the size of the speaker mounting board and the cubic volume requirement. A deeper enclosure (with no change in the dimensions of the speaker board) would have a larger-than-optimum volume, limiting the power-handling capability of the woofer.

speakers, and four 1" tweeters) and an appropriate crossover network. It is rated at 40 watts, and system resonance is a low 40 Hz—which qualifies the Continental for real high-fidelity duty.

About System. The layout of component loudspeakers in the Continental (see Fig. 1) is a bit unconventional—but not without purpose. Interaction between

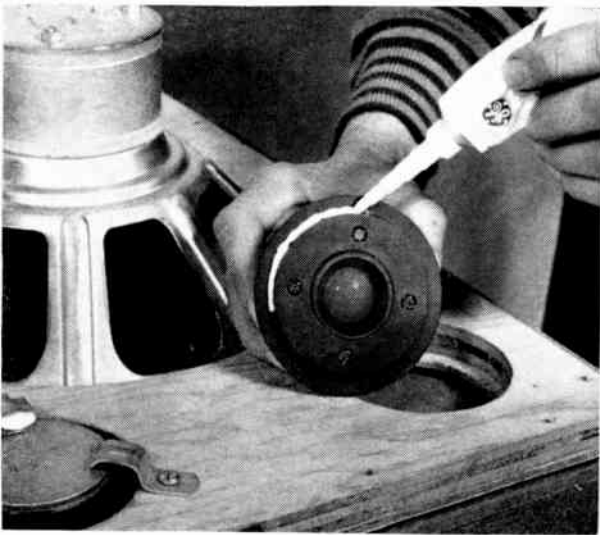


Fig. 2. Smear of silicone rubber compound on speaker serves as gasket. Note use of special cable clamps in mounting tweeters.

Assembling Enclosure. Except for the panels that make up the speaker mounting board, the construction of the enclosure is along conventional lines. All permanent assemblies must be fastened together with glue and screws. Use a $7/64$ " drill for guide holes and a $3/64$ " drill for pilot holes. And, unless otherwise specified, use #8 X $1/4$ " flathead wood screws throughout.

The first step to be performed is to cut to the dimensions specified in Fig. 1 and in the Bill of Materials the six $3/4$ " and

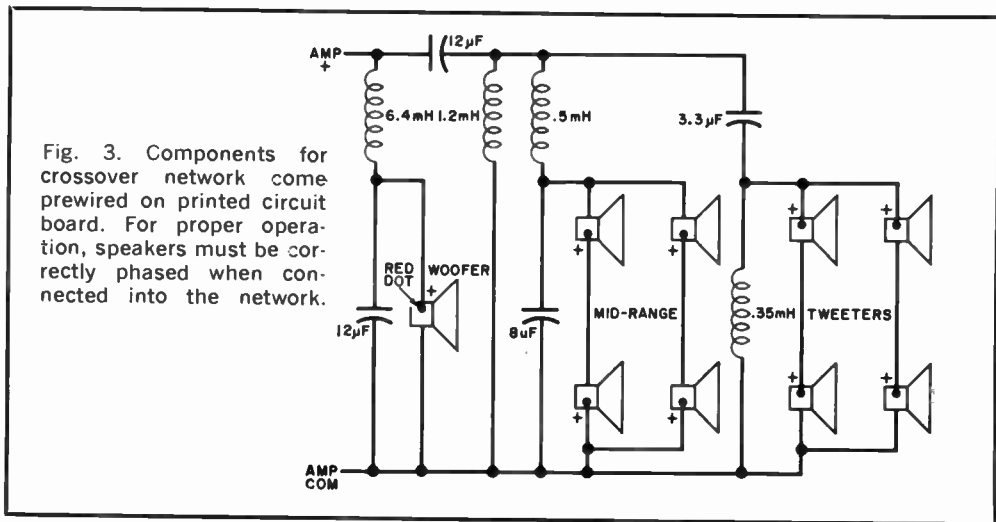
one $1/4$ " panels that make up the enclosure proper. Do NOT, however, at this time make the speaker cutouts in either the front $3/4$ " or $1/4$ " plywood panels.

When cutting the panels to size, remember to miter cut the ends of the top, bottom, and side panels at 45° angles to provide "invisible" joints when the enclosure is assembled. Assemble the enclosure shell (top, sides, and bottom), using corner blocks and cleats. Set the rear panel into place on the appropriate cleats and mark the cleat outline on the inside surface of the panel.

Remove the rear panel from the enclosure shell and lay it on a flat surface. Drill guide holes through the panel at 4"-6" intervals, starting 2" from each corner, spaced $3/16$ " from all four edges. Next, cut a piece of $1/2$ "-thick Celotex to just fit within the cleat outline. Then cut a 1" X 2" slot out of the Celotex, locating the slot in the center of the panel and about one-third of the way from the bottom edge.

Coat the mating surfaces of the rear panel and the Celotex with glue and fasten the two pieces together with #10 X 1" panhead sheet metal screws. Place the assembly, Celotex side down, on a flat surface and heavily weight it until the glue thoroughly sets.

Meanwhile, proceed to work on the front panel assembly. An extra sheet of $1/4$ " plywood serves the double purpose of strengthening the speaker board and permitting flush mounting of the tweeters and midrange speakers. First sandwich



the $\frac{3}{4}$ " and $\frac{1}{4}$ " plywood panels together with the aid of C clamps or small finishing nails driven through the $\frac{1}{4}$ " and into the $\frac{3}{4}$ " panels at the corners. Now, referring back to Fig. 1, locate the centers for each of the nine speaker cutouts and at each location drill a small guide hole through both panels.

Separate the two panels and identify the guide hole pairs so that when they are reassembled the appropriate cutout pairs mate perfectly. Set aside the $\frac{1}{4}$ " panel. Then use a compass to strike the cutout outlines on the $\frac{3}{4}$ " panel. Working carefully, use a router or sabre saw with a fine blade to remove the wood for the cutouts. These cutouts should be as close to circular as possible.

Next, prepare the $\frac{1}{4}$ " panel as described above. When you are finished, the woofer and midrange speaker cutouts will be larger in diameter than the cutouts for the same speakers in the $\frac{3}{4}$ " panel. Conversely, the tweeter cutouts will be smaller in diameter.

Cut to size the parts that make up the midrange column box. Then assemble the box shell (sides, top, and bottom) with glue and screws. Prepare but do not mount the rear panel of the column box just yet.

Temporarily set the $\frac{3}{4}$ " speaker board panel in place in the front of the enclosure shell. With a pencil, mark the cleat outline on the inside surface of the panel. Remove the panel and set it on a flat surface. Center the column box shell over the midrange speaker cutouts, locating the shell so that its bottom surface just clears the line for the bottom cleat. Mark the outline of the column shell on the panel. Remove and set aside the column shell.

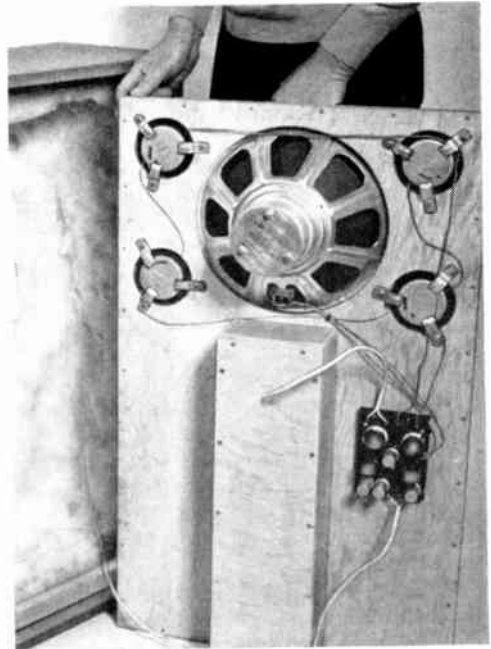
Next, strike lines parallel to and spaced $\frac{3}{16}$ " in from the four lines marked for the column box outline. Starting 1" from each corner made by the new lines, drill guide holes at 2" to 3" intervals.

Sandwich together the $\frac{1}{4}$ " and $\frac{3}{4}$ " plywood panels that make up the speaker mounting board. Now, exercising extreme care when handling the speakers, use a tweeter to test each pair of cutouts for proper fit. Adjust the panel orientations so that the tweeter fits properly at each of the four locations. Similarly, use a midrange speaker to check for proper fit at each of its cutout locations. If any ad-

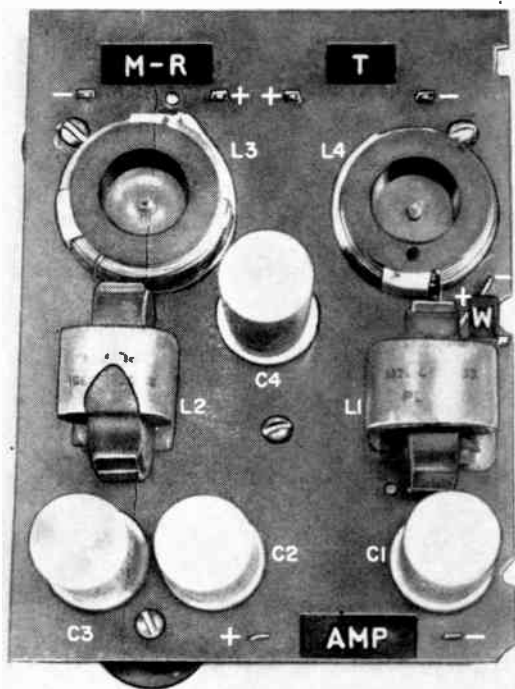
justments have to be made when the midrange speaker is being used, the tweeter cutouts will have to be rechecked.

When you are satisfied that all speakers fit properly in their cutouts, drive a finishing nail through the $\frac{1}{4}$ " panel into the $\frac{3}{4}$ " panel at all four corners to prevent them from slipping around and to serve as reference points when the panels are finally glued together. Now, drill pilot holes through the $\frac{1}{4}$ " panel and into the $\frac{3}{4}$ " panel, but do not completely penetrate through the thicker panel. Locate these holes at 4" to 6" intervals over the entire surface of the board, including the spaces between the speaker cutouts. Invert the panel assembly and extend the guide holes for the midrange column box to completely penetrate the $\frac{1}{4}$ " panel. Remove the clamps and partially withdraw the nails at the corners to separate the two panels. Then enlarge the pilot holes in the $\frac{1}{4}$ " panel to guide hole size.

Drive the corner nails far enough through the $\frac{1}{4}$ " panel to hold the panels apart until the points of the nails are fitted into the reference holes. Evenly coat with glue the mating surfaces of both panels. Then fit the panels together



Crossover network is mounted to right of midrange box on the speaker board assembly. Acoustical padding in enclosure is optional.



Proper phasing must be carefully observed when connecting speakers to crossover network. Woofer (W), tweeter (T), midrange (M-R), and amplifier (AMP) lugs are clearly marked according to polarity (phasing) in photo at the left.

by aligning the nails with the holes, and hammer the nails down. Drive #8 X $\frac{3}{4}$ " flathead wood screws through the guide holes to securely anchor the panels together. Then install the midrange speaker column shell on the speaker mounting board with #8 X 2" flathead wood screws. Lay the assembly, $\frac{1}{4}$ " panel side down, on a flat surface and heavily weight it until the glue sets.

Assuming the rear panel assembly is ready to be worked on, unweight it and drill a pair of $\frac{1}{2}$ "-diameter holes through the plywood panel within the slot. Locate these holes on centers which mate with the lugs on a two-contact screwtype terminal strip. Feed one conductor of a 36" length of speaker zip cord through each hole and solder to the lugs on the terminal strip.

Slide the terminal strip into place on the rear panel and fasten it down with small brass screws. Screw down the screws on the terminal strip. Then fill the cavities around the solder lugs and screw ends with silicone rubber compound to provide an air-tight seal. Mount the rear

panel assembly in the enclosure shell with #8 X 1" wood screws, using caulking compound to provide an air seal.

When the speaker mounting board is ready to be worked on, round the front edges of the tweeter cutouts in the $\frac{1}{4}$ " panel. Now, measure in $\frac{3}{8}$ " on all four sides of the panel, strike lines parallel to the edges, and sink guide holes at 4" to 6" intervals along the lines. This done, apply a coat or two of flat black to the front surface of the speaker mounting board assembly.

Using contact cement, apply a ribbon of wood veneer edge trim to the exposed raw edges of the plywood panels at the front of the enclosure. Then smoothly sand, stain, and finish the enclosure as desired.

Line the interior walls of the enclosure with a minimum of 1" thickness of fiberglass wool or other acoustical damping material. Then attach to the bottom of the enclosure self-sticking rubber feet.

Speaker Installation. Set the speaker mounting board on a pair of sawhorses or

other convenient supports, face up. Apply a thick bead of silicone rubber compound around the rear rims of the speakers. Install the woofer and midrange speakers with screws from the front of the board. The tweeters mount through the rear of the board with the aid of special oval service cable straps as shown in Fig. 2. It is important that you use only those cable straps described in the Bill of Materials.

Install the crossover network to one side of the midrange speaker column, using brass screws and $\frac{3}{8}$ " spacers. Then begin wiring the speakers together as shown in Fig. 3. First wire the midrange speakers in series-parallel and check to make sure that all cones move in a common direction when a 1.5-volt battery is connected across the network.

Connect and solder one end of an 18"-long piece of zip cord to the midrange speaker network. Drill a $\frac{1}{4}$ " hole through the center of the rear panel of the column, and pass the free end of the cord through. Mark the lead connected to the red dot terminals on the speakers. Then fasten the panel down on the rear of the column shell with glue and screws, and

fill in the zip cord exit hole with silicone rubber compound.

Wire together the tweeters, relying exclusively on the red dot markings for proper polarity. (Do not use the battery to check out the tweeters.) Finish wiring, connecting the speaker networks to the crossover network and the crossover network to the free end of the speaker cable coming from the screw-type terminal strip.

Check out the speaker wiring by connecting an amplifier or other source to the Continental via the terminal strip and listening to each speaker in turn at low volume levels to make sure each speaker is operating. If all seems to be okay, install the speaker board assembly in the enclosure, using caulking compound, if necessary, to insure a good seal.

The large speaker board will produce a tremendous compression of the air inside the shallow enclosure if it is carelessly inserted. In fact, the sudden rise in pressure can even rupture the woofer cone. So, go slow and give the air time to escape. Ease the speaker board assembly slowly into the enclosure to allow sufficient time for the air pressure to stabilize before screwing down and sealing the board.

Finally, staple or tack a piece of grille cloth over the Masonite frame and fit the grille assembly into the front of the enclosure. If you miscalculated with the dimensions of the assembly and the fit isn't tight enough, you can use a few drops of silicone rubber compound on the back of the frame to hold it in place.

You will find that the sound of the Continental is extremely wide range. The high-frequency response is particularly open and nondirectional. There is no sense of veiled sound, nor masking of high notes, nor of distortion.

The Norelco engineers are apparently opposed to the idea of mixing-level controls with speaker systems; so, the Continental has none of the usual midrange or tweeter L-pads. If the high frequencies are too pronounced for your listening room, use the treble control on your amplifier to compensate. There will be a slight loss in the midrange in many situations due to the low placement of the midrange speakers. But, all in all, this is a "listenable" speaker system, well worth the effort of building. ♦



Speaker board must be slowly eased into enclosure to prevent damaging the woofer cone.



WITH A LITTLE PRACTICE, YOU MIGHT EVEN
BE ABLE TO IDENTIFY THE TYPE AND NUMBER OF FISH

IT IS an established fact that many marine creatures (especially porpoises) communicate with each other and use a form of sonar to locate and catch their food. Other fish seem to make noises for no particular reason while still others produce noises as a result of their movements. The latter is true of shrimp and other shellfish. (Schools of shrimp have been fouling up sonar operations for years.) So the underwater world is far from being the "silent deep" and, in some cases, is as noisy as a boiler factory.

If you would like to listen in on what goes on down there—and maybe spot a likely place for good fishing—you can build your own underwater fish detector for less than \$15. By lowering the detector into the water in various locations, you can determine whether there are any of the noise-making creatures about and, with a little practice, determine their type and approximate number. The commercial version of this detector is used—quite successfully—by professional shrimpers off the Florida coast.

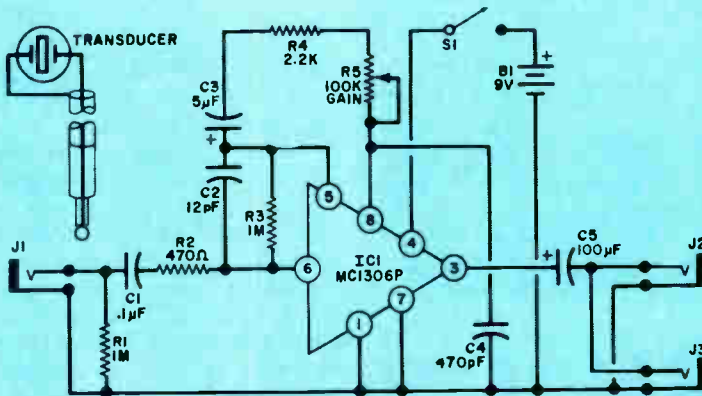


Fig. 1. The system is basically a ceramic transducer coupled to a high-gain amplifier. Only one output jack is actually required, the other can be used with an optional tape recorder.

PARTS LIST

- B1—9-volt battery
- C1—0.1- μ F disc capacitor
- C2—12-pF disc capacitor
- C3—5- μ F, 15-volt electrolytic capacitor
- C4—470-pF disc capacitor
- C5—100- μ F, 15-volt electrolytic capacitor
- IC1—MCI306P (Motorola)
- J1-J3—Miniature phone jack
- R1,R3—1-megohm, $\frac{1}{4}$ -watt resistor
- R2—470-ohm, $\frac{1}{4}$ -watt resistor
- R4—2200-ohm, $\frac{1}{4}$ -watt resistor
- R5—100,000-ohm miniature potentiometer with S1

- S1—Spst switch on R5
- Misc.—Suitable chassis, battery clip, battery mount, knob, mounting hardware, headset, speaker, transducer (see note).

Note—The following are available from Alpha Research Corp., Box 1005, Merritt Island, FL 32952: PC board at \$5.73; transducer UFD-10 (10' cable) at \$10.23, both postpaid; complete kit including transducer, chassis, and prerecorded cassette tape of fish sounds, less battery and headset, SFD-10 at \$14.75 or SFD-100 at \$19.25, postpaid; cassette alone at \$2.50.

(Text continued on page 97)

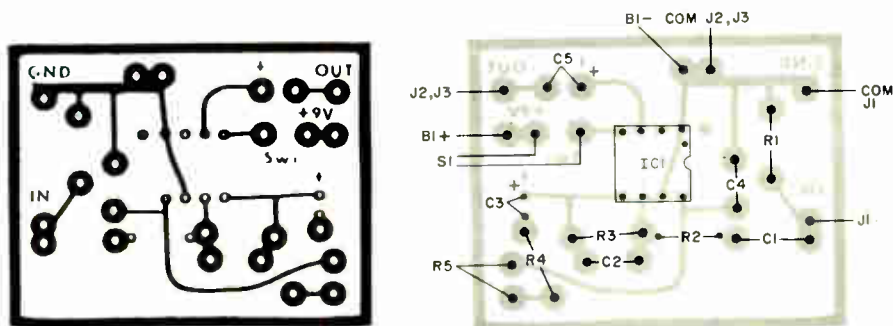


Fig. 2. Actual size foil pattern (left) and component installation (right).



DIGITAL JAPAN

THERE'S NO FOOT-DRAGGING
IN THE USE OF DIGITAL
READOUTS IN NIPPON

DIGITAL READOUT DEVICES have been a topic of major interest in the worldwide electronics industry for several years now. Even so, there seem to be few applications where the advantages of such devices have appeared outside of the laboratory and technically oriented industries. This is true even in the United States. But at least one country isn't dragging its feet.

Japan has felt differently toward digital readout devices. Both electromechanical and electronic readouts have been incorporated into numerous pieces of equipment in common usage by the average Japanese. Digital clocks, for example, though in use for some time in the U.S., are far more widely used in Japan. However, many applications for the digital readout are much more original.

In Japan, supermarkets use electronically indicating scales for weighing food products. Separate readouts on these scales show weight, cost per unit weight, and total item cost.

Sophisticated coin-operated vending machines sell railroad tickets at busy stations. The vending machines will accept almost any type of Japanese currency, issue a ticket for whatever destination desired, and automatically return the correct change. Almost all of these

Scale in Japanese supermarket has digital readouts for weight, unit and total prices.

machines employ electronic digital readout to indicate the total value of the currency inserted, and some indicate other information as well.

What appears to be the first widespread application of digital readouts in Japan has still not caught on in the U.S. To avoid accidental damage to their pumps, Japanese service stations frequently suspend their gas filler hoses from the roof that covers the driveway. The interesting feature here is that the amount of fuel purchased and its total cost can be seen on large, clear digital readouts mounted on the front wall of the station. Various types of indicators are in use, but none of them appears to



Automatic railway ticket vendor indicates amount, issues ticket, and returns change.

be mechanical. And in some installations, a second set of readouts is mounted at the cashier's desk inside the station for greater convenience.

Digital readouts are seen with surprising regularity in Japan these days. So far, they have proved to be an effective tool for increasing speed and reducing confusion in the handling of numbers. It's not surprising that the Japanese have gotten the jump on the rest of the world. After all, for its size, Japan is the largest producer of electronic devices on Earth.

—Milton Mann

ELECTRONIC COMBINATION LOCK



UP TO 1 MILLION COMBINATIONS
CAN BE CREATED

BY J. A. NUNLEY

ELECTRONIC COMBINATION locks are not what you would call earth-shaking novelties these days. But many of them leave something to be desired when it comes to flexibility of combinations and selfprotection against being opened accidentally. The solid-state lock (patent pending) described here is capable of having 10,000 different combinations and, with slight modifications, can have a million or more. The basic circuit can be programmed to accept any four-digit combination—even four of the same number—while the simple encoding process permits changing the code within a few seconds if it is suspected that the code has been detected.

The circuit is self-protecting in that the combination cannot be entered too rapidly and if an incorrect combination is entered, a wait of about four seconds is required before a second try can be made. Trials of various combinations in an attempt to break the code take about six seconds each.

Any wrong digit, even if preceded by correct ones, cancels the stored information so that, even if the first three digits are guessed correctly, a wrong fourth one negates the attempt. Pressing several

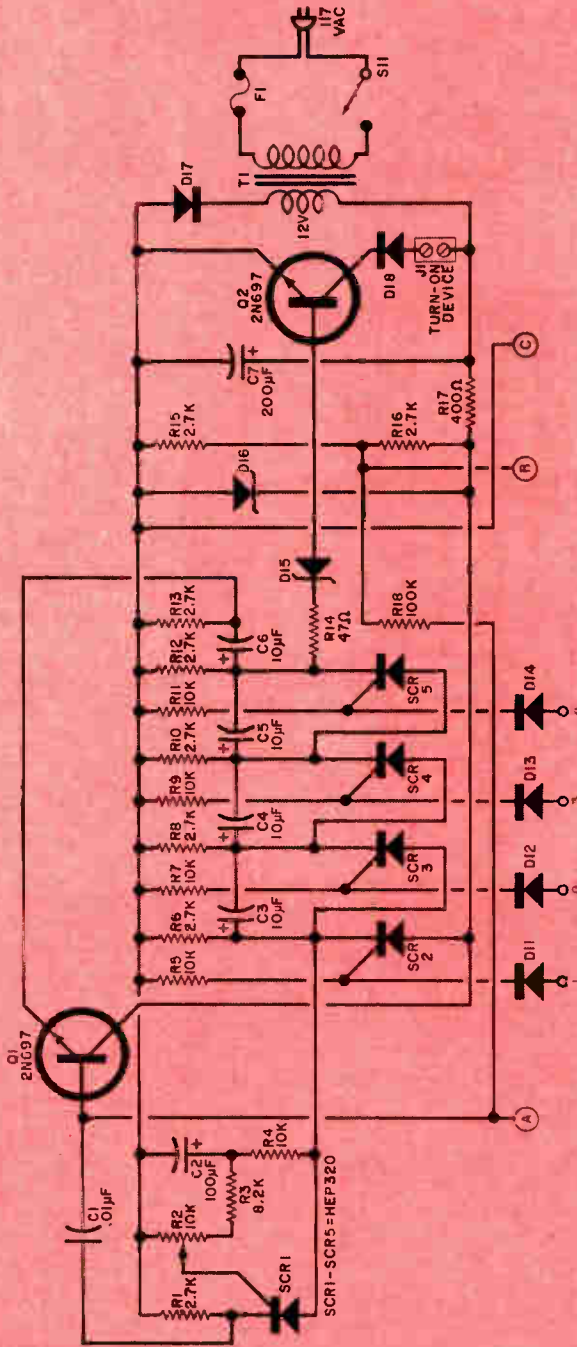
buttons at once is also useless since only the lowest number registers and is effective only if correct.

The power supply for the lock can be 117-volt line power or a 12-volt battery such as those found in cars, boats, and trailers.

Construction. The circuit of the lock (see Fig. 1) is divided into two sections. One part is the pushbutton keyboard and the other is the de-ciphering circuit. The two can be located as near or as far from each other as necessary. Any type of packaging can be used though the circuits should be enclosed so that they can't be tampered with. The mounting of the keyboard depends upon the application. The 14 gate diodes, *D1* through *D14*, can be of any type as long as they have a reverse breakdown of at least 12 volts.

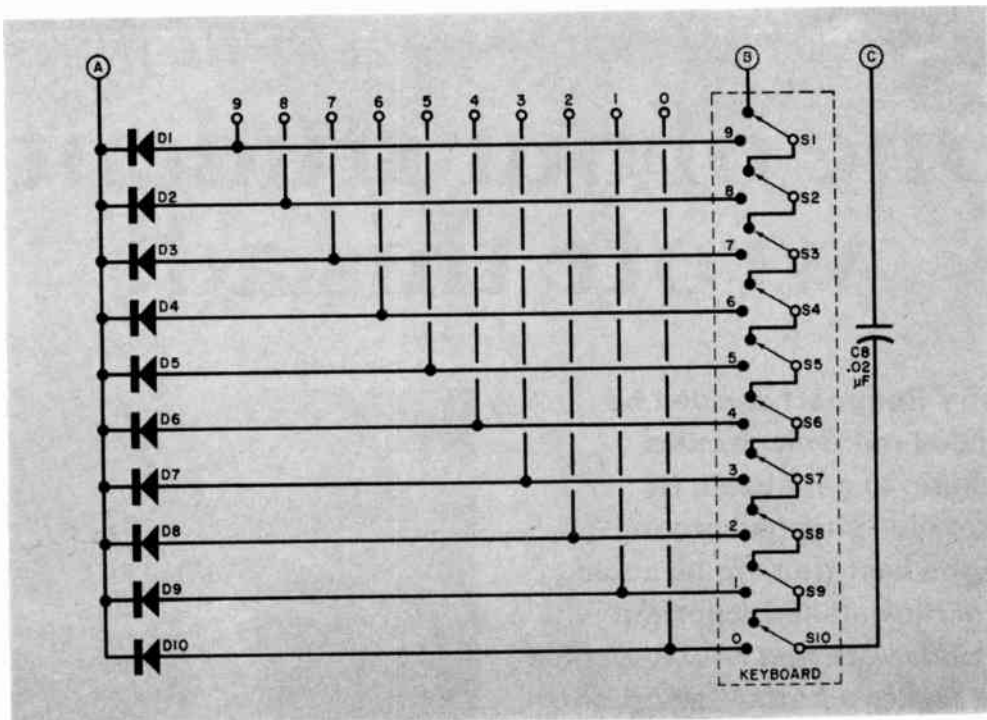
The connections between the electronic circuit (terminals 1 to 4) and the keyboard (terminals 0 to 9) determine the combination. In the prototype, simple spring-loaded wire clips were used for these connections. This does not provide an ideal low-resistance circuit but will suffice. If desired, four independent,

Fig. 1. Terminals 1 through 4 (below) represent the four sequential inputs. These are connected to any four of the 0 through 9 terminals (right). When the correct pushbuttons (S1-S1C) are depressed in right order, Q2 turns on. SCR1 is the timing generator



PARTS LIST

- C1—0.01- μ F capacitor
 C2—100- μ F, 15-volt electrolytic capacitor
 C3, C6—10- μ F, 15-volt electrolytic capacitor
 C4—200- μ F, 35-volt electrolytic capacitor
 C7—0.02- μ F capacitor
 C8—0.02- μ F capacitor
 D1—D14—Diode with 12-volt PIV
 D15—6-10-8-volt, 1-watt zener diode
 D16—12-volt, 10-watt zener diode
 D17—35PIV, 0.5A silicon rectifier diode
 D18—200PIV, 0.5A silicon diode
- F1—1A fuse and holder
 J1—Two-pin connector
 Q1, Q2—2N697, HEP53 (or similar) transistor
 R1, R6, R8, R10, R12, R13, R15, R16—2700-ohm, $\frac{1}{4}$ -watt resistor
 R2—10,000-ohm subminiature potentiometer
 R3—8200-ohm, $\frac{1}{4}$ -watt resistor
 R4, R5, R7, R9, R11—10,000-ohm, $\frac{1}{4}$ -watt resistor
- R14—47-ohm, $\frac{1}{4}$ -watt resistor
 R17—400-ohm, 5-watt resistor
 R18—100,000-ohm, $\frac{1}{4}$ -watt resistor
 S1—S10—Spdt pushbutton switch
 S11—Spst slide or toggle switch
 SCR1—SCR5—HEP320 silicon controlled rectifier
 Misc.—Suitable enclosure, multi-conductor cable, spring-loaded clips (10), line cord, solenoid, press-on type, etc.



single-circuit, 10-position rotary switches can be used. At any rate, diodes D11 through D14 must be connected to four of the leads from the keyboard matrix. To change any digit at any time, one of the four is moved to another location.

Theory of Circuit Design. The keyboard has 10 (or more) spdt pushbutton switches in series. One end of the series is connected to a source of approximately 6 volts dc and the other end to a higher voltage through capacitor C8. When all switches are in the off position, C8 is charged up to the voltage difference. If one of the pushbuttons is depressed, the charge on C8 is applied to one of the silicon controlled rectifiers SCR2 through SCR5 through one of the diodes D11 through D14. Simultaneously, it is connected to the timing circuit (SCR1) through one of diodes D1 through D10. When a pushbutton is depressed, all pushbuttons of a higher number are disconnected and have no effect until C8 is recharged.

Consider the operation in the most difficult case—when all numbers are the same. Assume the combination is 4444. All four digit register stages are connected to terminal 4 on the keyboard.

When S6 is depressed (to apply the 4), the charge on C8 is applied to SCR2 through SCR5 simultaneously. However, only SCR2 turns on since they are connected together by coupling capacitors. The latter appear as low impedances across the SCR's during their charging period and prevent the establishment of a minimum holding current. The discharge pulse from C8 is much shorter than the charging pulse across C3 through C5 so by the time the latter are charged up, the gate current available from C8 is gone. Pushbutton S6 is then released and C8 is allowed to recharge. When S6 is again depressed, the second digit register comes on but the rest are still inhibited by the coupling capacitors. Each subsequent operation of S6 turns on another stage until the complete code has been entered. For other, non-similar combinations, the inhibition principle of the coupling capacitors is not used but their charging rate determines the fastest rate at which discrete digits can be entered.

Once turned on, the SCR's remain in the conducting state as long as they have the minimum holding current. When cancellation stage Q1 is turned on, a voltage pulse is applied to capacitors C3 through C6 and the SCR's (SCR1 through SCR5)

One of our students wrote this ad!

Harry Remmert decided he needed more electronics training to get ahead. He carefully "shopped around" for the best training he could find. His detailed report on why he chose CIE and how it worked out makes a better "ad" than anything we could tell you. Here's his story, as he wrote it to us in his own words.

By Harry Remmert

AFTER SEVEN YEARS in my present position, I was made painfully aware of the fact that I had gotten just about all the on-the-job training available. When I asked my supervisor for an increase in pay, he said, "In what way are you a more valuable employee now than when you received your last raise?" Fortunately, I did receive the raise that time, but I realized that my pay was approaching the maximum for a person with my limited training.

Education was the obvious answer, but I had enrolled in three different night school courses over the years and had not completed any of them. I'd be tired, or want to do something else on class night, and would miss so many classes that I'd fall behind, lose interest, and drop out.

The Advantages of Home Study

Therefore, it was easy to decide that home study was the answer for someone like me, who doesn't want to be tied down. With home study there is no schedule. I am the boss, and I set the pace. There is no cramming for exams because I decide when I am ready, and only then do I take the exam. I never miss a point in the lecture because



Harry Remmert on the job. An Electronics Technician with a promising future, he tells his own story on these pages.

it is right there in print for as many re-readings as I find necessary. If I feel tired, stay late at work, or just feel lazy, I can skip school for a night or two and never fall behind. The total absence of all pressure helps me to learn more than I'd be able to grasp if I were just cramming it in to meet an exam deadline schedule. For me, these points give home study courses an overwhelming advantage over scheduled classroom instruction.

Having decided on home study, why did I choose CIE? I had catalogs from six different schools offering home study courses. The CIE catalog arrived in less than one week (four days before I received any of the other catalogs). This indicated (correctly) that from CIE I could expect fast service on grades, questions, etc. I eliminated those schools which were slow in sending catalogs.

FCC License Warranty Important

The First Class FCC Warranty* was also an attractive point. I had seen "Q" and "A" manuals for the FCC exams,

*CIE backs its FCC License-preparation courses with this famous Warranty: graduates must be able to pass the applicable FCC License exam or their tuition will be refunded in full.

and the material had always seemed just a little beyond my grasp. Score another point for CIE.

Another thing is that CIE offered a complete package: FCC License and technical school diploma. Completion time was reasonably short, and I could attain something definite without dragging it out over an interminable number of years. Here I eliminated those schools which gave college credits instead of graduation diplomas. I work in the R and D department of a large company and it's been my observation that technical school graduates generally hold better positions than men with a few college credits. A college degree is one thing, but I'm 32 years old, and 10 or 15 years of part-time college just isn't for me. No, I wanted to *graduate* in a year or two, not just *start*.

If a school offers both resident and correspondence training, it's my feeling that the correspondence men are sort of on the outside of things. Because I wanted to be a full-fledged student instead of just a tagalong, CIE's exclusively home study program naturally attracted me.

Then, too, it's the men who know their theory who are moving ahead where I work. They can read schematics and understand circuit operation. I want to be a good theory man.

From the foregoing, you can see I did not select CIE in any haphazard fashion. I knew what I was looking for, and only CIE had all the things I wanted.

Two Pay Raises in Less Than a Year

Only eleven months after I enrolled with CIE, I passed the FCC exams for First Class Radiotelephone License with Radar Endorsement. I had a pay increase even before I got my license and *another* only ten months later. I'm getting to be known as a theory man around work, instead of one of the screwdriver mechanics.

These are the tangible results. But just as important are the things I've learned. I am smarter now than I had ever thought I would be. It feels good to know that I know what I know now. Schematics that used to confuse me completely are now easy for me to read and interpret. Yes, it is nice to be smarter, and that's probably the most satisfying result of my CIE experience.

Praise for Student Service

In closing, I'd like to get in a compliment for my Correspondent Counselor who has faithfully seen to it that my supervisor knows I'm studying. I think the monthly reports to my supervisor and generally flattering commentary have been in large part responsible for my pay increases. My Counselor has given me much more student service than "the contract calls for," and I certainly owe him a sincere debt of gratitude.

And finally, there is Mr. Tom Duffy, my instructor. I don't believe I've ever had the individual attention in any classroom that I've received from Mr. Duffy. He is clear, authoritative, and spared no time or effort to answer my every question. In Mr. Duffy, I've received everything I could have expected from a full-time private tutor.

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I'm very, very satisfied with the whole CIE experience. Every penny I spent for my course was returned many times over, both in increased wages and in personal satisfaction.

Perhaps you too, like Harry Remmert, have realized that to get ahead in Electronics today, you need to know much more than the "screwdriver mechanics." They're limited to "thinking with their hands" . . . learning by taking things apart and putting them back together . . . soldering connections, testing circuits, and replacing components. Understandably, their pay is limited—and their future, too.

But for men like Harry Remmert, who have gotten the training they need in the fundamentals of Electronics, there are no such limitations. As "theory men," they think with their heads, not their hands. For trained technicians like this, the future is bright. Thousands of men will be needed in virtually every field of Electronics, from two-way mobile radio to computer testing and troubleshooting. And with this demand, salaries have skyrocketed. Many technicians earn \$10,000, \$12,000 or more a year.

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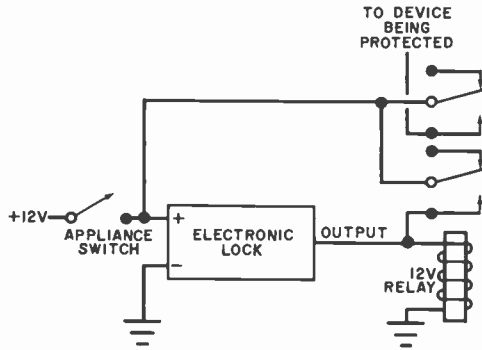
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Fig. 2. This circuit is for use with a heavy load. It is also suitable for car or boat use.



are turned off. This occurs when any pushbutton is depressed. However, when the correct pushbutton is depressed Q1 is inhibited by the charging of one of the capacitors through an SCR. Thus, "good" numbers do not cause cancellation, but any false number cancels everything. Also, if only four numbers are being used, and a fifth number is selected, the register is cancelled.

The timing circuit (SCR1) operates on the basis of the time constant of the combination of R4 and C2. When the first correct digit is entered (SCR2 is turned on), a positive voltage is applied to the anode of SCR1 and to R4. This puts a charge on C2 so that when the voltage at the junction of R4 and C2 reaches the correct potential, SCR1 is turned on. The timing can be adjusted by potentiometer R2 to vary between 5 to 15 seconds after SCR2 is turned on. Capacitor C6 and resistor R13 are an extension of the timing chain to permit proper operation of the cancellation stage.

The solenoid driver stage (Q2) is a simple transistor switch that is turned on by the final register stage (SCR5). Zener diode D15 prevents the short pulses that result from the turning on of previous stages from actuating Q2. Diode D18 protects the transistor from damaging back emf from an inductive load.

Applications. If the power requirements of the solenoid that operates the door exceed 24 volts at 300 mA, then a power relay must be used as the turn-on device.

If it is desired to use the lock in a 12-volt application (car, boat, etc.) eliminate T1 and D17 and reduce the value of R16 to about 25 ohms. Remove the lead from the 12-volt supply to the device to be protected, and add the circuit shown in

Fig. 2. When the normally used appliance switch is turned on, only the combination lock is energized. The correct combination must be entered to activate the external latching relay. The latter, in turn, applies 12 volts to the device being protected. In an ignition system, for example, substitute the ignition switch for the appliance switch so that the relay applies power to the ignition coil. Be sure the relay is wired to latch in. Otherwise, it will reopen in a few seconds.

Increasing Combinations. To increase the number of possible combinations, increase the number of keyboard pushbuttons or the number of digit register stages. The latter procedure is more effective. If the number of digit register stages is n and the number of pushbuttons is p , the total number of possible combination is p^n . It might be argued that the number of combinations is $(p^n - 1)$ but the combination 0000 is acceptable.

For 10 pushbuttons and four register stages, the number of possible combination is 10^4 or 10,000. With one more register stage, the number is 100,000, etc. By contrast, if two pushbuttons alone are added, there are 20,736 combinations.

One interesting possibility is to use 26 pushbuttons labelled A through Z. The number of combinations is then 456,976 and a four-letter word can be used as the code. At six seconds per try, it would take 761 hours to try all possible combinations.

Digit register stages identical to stages SCR3 and SCR4 can be added easily. The circuit shown in Fig. 1 can take only two more register stages without some circuit modifications to provide reliable operation. ♦

CRYSTAL CALIBRATOR FOR THE HAM and SWL

PROVIDES ACCURATE FREQUENCY CHECKS

25 and 100 kHz APART

BY WILLIAM L. BLAIR
Cubic Corporation

IN NOVEMBER OF 1969, the Federal Communications Commission completed a program of frequency reallocation in the amateur radio bands. The results created licensing incentives for Advanced and Extra class hams by providing operating privileges over wider frequency bands than are permitted to General class ticket holders. These sub-bands are defined in increments of 25 kHz.

To assure himself that he is transmitting within the limits of his class of license, the operator using narrower bands must have a calibration oscillator that works in two modes. The first mode should supply outputs every 100 kHz from 100 kHz to 30 MHz; in the alternate mode, outputs need to be spaced every 25 kHz to identify precisely the sub-band limits.

The Dual-Mode Ham/SWL Crystal Calibrator described here fulfills the requirements for a stable, precise signal source for transmitter and receiver calibration. The finished project is compact enough

to be built right into most modern receivers. And, except for the crystal, the cost of the project comes to only about \$7.25.

Theory of Circuit Design. Transistors Q1 and Q2 in Fig. 1, working with the 100-kHz crystal, constitute the series-mode oscillator stage. Trimmer capacitor C2 allows the operating frequency of the oscillator to be varied approximately 50 Hz on either side of the crystal's center frequency so that the oscillator can be accurately beat against a frequency standard such as WWV.

The output signal at the collector of Q2 is essentially a clipped sine wave. Since the harmonic content of this type of waveform is not particularly good, this circuit by itself is not especially useful for generating marker signals at the higher ham band frequencies. This situation can be compensated for by the addition of the Q3/Q4 multivibrator stage.

Both ac and dc coupling are employed

the multivibrator: dc from the collector of Q3 to the base of Q4 and ac between the emitters of the transistors. In the 100-kHz position, S1B powers all four stages, while S1A switches C4 out of the coupling circuit. The time constants provided by R8-R11 and C3 allow the multivibrator to operate at 100 kHz, and the extremely fast switching times (typically between 40 and 100 ns) provide a harmonically rich output.

When S1 is in the 25-kHz position, C4 is switched into the circuit to slow down the multivibrator so that it switches at one-fourth of the input frequency. The fast transitions are still maintained and the harmonics are quite strong to 30 MHz and beyond.

Multivibrators operate on the principle that the transistor pair is connected for

regenerative (positive) feedback. Assume that Q3 is saturated and that its subsequent low collector voltage cuts off Q4. The drop in the Q4 emitter circuit is coupled as a negative transient to the emitter of Q3 through C3/C4. This negative-going spike has sufficient amplitude to saturate Q3 further. However, since this signal is capacitively coupled, the value of the voltage holding on Q3 decreases with time as C3 and C4 charge through R8 and R11.

When the voltage level increases beyond a critical point, the next pulse from the crystal oscillator stage causes Q3 to cut off and Q4 to saturate. Since the feedback is again regenerative, the emitter-coupled signal accelerates the transition and the change in state occurs very rapidly, producing fast rise and fall

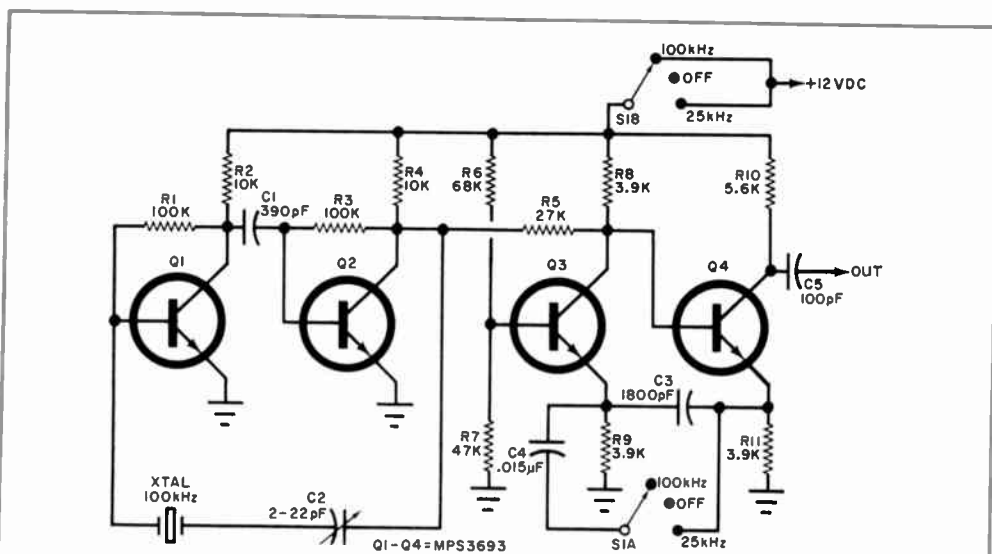


Fig. 1. Transistors Q1 and Q2, with the crystal, form a series-mode oscillator, while Q3 and Q4 are a multivibrator with switching to operate at two frequencies.

PARTS LIST

C1—390-pF, 500-volt capacitor (Elmenco No. DM-15-391J)
 C2—2.22-pF trimmer capacitor (E.F. Johnson No. 189-508-5)
 C3—1800-pF, 500-volt capacitor (Elmenco No. DM-19-182J)
 C4—0.015- μ F, 600-volt capacitor (Cornell-Dubilier No. DPM56S15)
 C5—100-pF, 500-volt capacitor (Elmenco No. DM-15-101J)
 Q1-Q4—MPS3693 bipolar transistor (Motorola)

R1,R3—100,000-ohm, $\frac{1}{4}$ -watt, 10% resistor
 R2,R4—10,000-ohm, $\frac{1}{4}$ -watt, 10% resistor
 R5—27,000-ohm, $\frac{1}{4}$ -watt, 10% resistor
 R6—68,000-ohm, $\frac{1}{4}$ -watt, 10% resistor
 R7—47,000-ohm, $\frac{1}{4}$ -watt, 10% resistor
 R8,R9,R11—3900-ohm, $\frac{1}{4}$ -watt, 10% resistor
 R10—5600-ohm, $\frac{1}{4}$ -watt, 10% resistor
 S1—Dpdt, center-off, switch (Cutler-Hammer No. 7591K4)

XTAL—100-kHz quartz crystal in HC-13[U holder

Misc.—Circuit board, mounting hardware, hookup wire, solder, etc.

times for the collector voltages. Now, the time constant that determines how long the transistors remain conducting is a function of the values of R9, R10, and C3/C4.

Again, the emitter-coupled signal desensitizes the multivibrator temporarily to the next oscillator pulse and does not allow immediate return to the initial states until the charge curve nears the threshold voltage level. When this occurs, the very next pulse does initiate a rapid transition. The desired output is available at the collector of Q4, synchronized with the 100-kHz oscillator and with the same percentage of accuracy.

The output signal is not a symmetrical square wave (on/off ratio is approximately 5/7) owing to the different values selected for the Q3 and Q4 collector load resistors. This was done intentionally because a perfect square wave contains only odd harmonics of the basic frequency, which would not have been useful in generating 25-kHz markers. The asymmetrical waveform generated by the calibrator overcomes this situation and is rich in *all* harmonics.

The waveforms in Fig. 2 show circuit operation when S1 is in the 25-kHz position. The voltage at the collector of Q2 is a clipped 100-kHz sine wave. At the emitter of Q4, two capacitor charge curves are apparent; one is positive going, the other negative. Superimposed on these curves are transients of the 100-kHz oscillator signal. These transients are of insufficient amplitude to toggle the multivibrator except as the charge curve approaches the stage threshold. The final waveform is that of the output signal present at the collector of Q4.

Construction. The use of a printed circuit board for assembling the calibrator capitalizes on the advantage of project compactness. An actual size etching and drilling guide, accompanied by a components placement photo, are provided in Fig. 3. You will note from the components placement photo that the physical layout of the parts is roughly similar to the parts layout in the schematic diagram.

Once the circuit board is etched and cleaned, use a $\frac{1}{8}$ " drill for the four mounting holes. The five medium size holes should be made with a No. 60 drill,

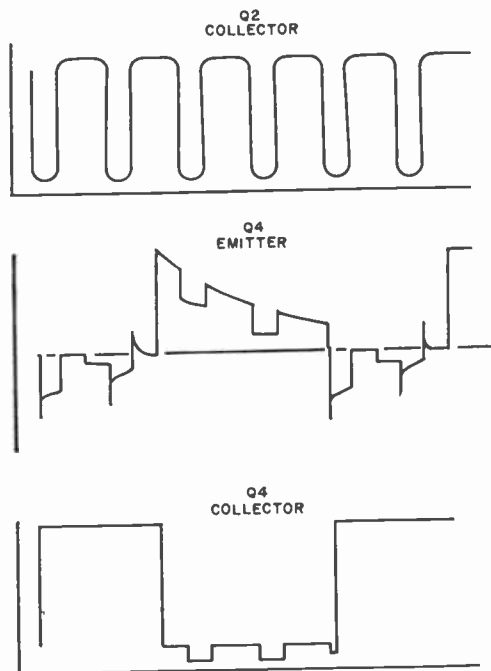


Fig. 2. Waveforms for various points in the circuit during operation in 25-kHz mode.

while all other holes should be made with a No. 66 or No. 67 drill.

If you prefer not to make a printed circuit board and would rather use perforated board, you can use the components layout diagram to help in locating the parts on the board according to the hole pattern. Wiring should be performed on the bottom of the circuit board.

Installation and Use. Installing the Dual-Mode Ham/SWL Crystal Calibrator in your equipment is simple. A single $\frac{3}{8}$ " hole, drilled through the front panel of the equipment, will accommodate S1. Before drilling this hole, however, be sure that when the switch is mounted it will not interfere with the equipment's controls and normal operation.

Locate and mount the circuit board assembly as close as possible to S1 to keep lead lengths short. Use 4-40 machine hardware and $\frac{1}{4}$ " to $\frac{3}{8}$ " spacers when mounting the circuit board.

Power is applied to the circuit via S1B from any convenient +9- to +12-volt source within the equipment in which the calibrator is used. There is no need to worry about the power drain on the

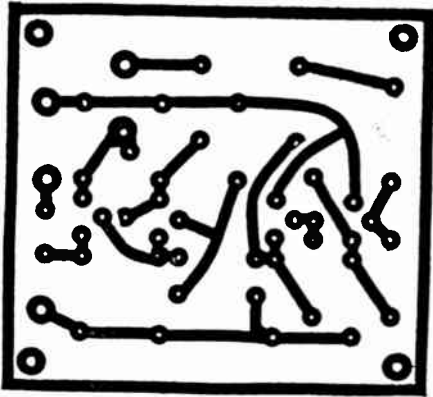
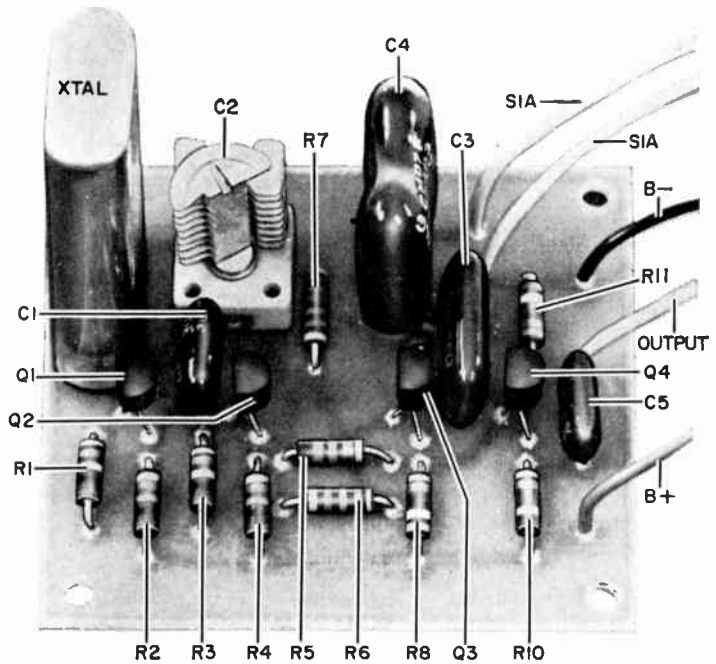


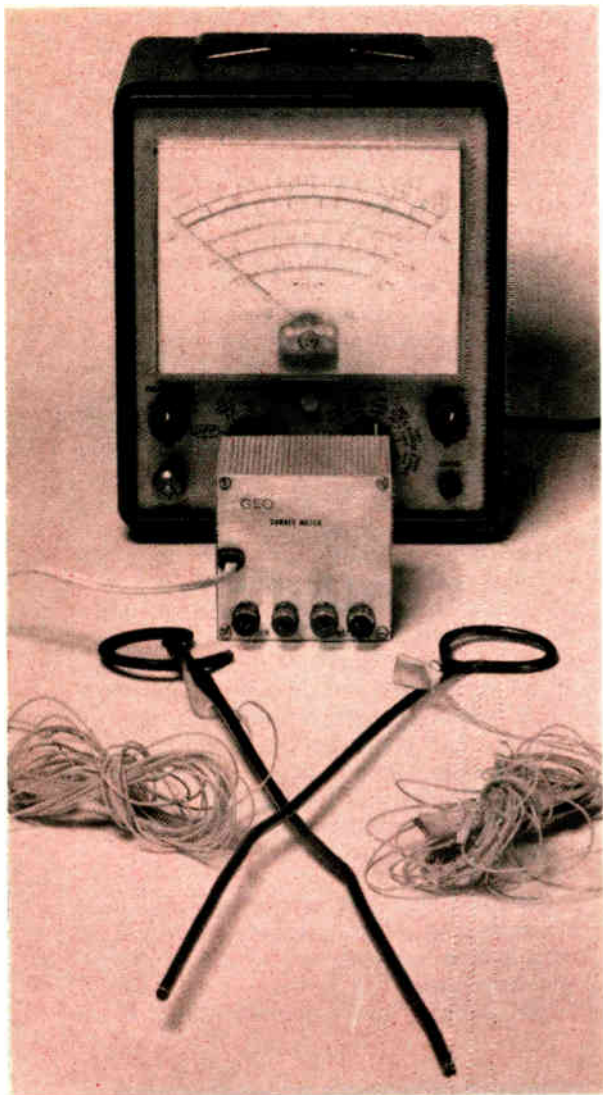
Fig. 3. If you want to make a printed circuit board, use the foil pattern at left. Lay out the components as shown above. A perforated board can be used instead of a printed circuit board.

equipment's supply since the calibrator draws very little current.

Next, solder one end of a length of insulated stranded hookup wire to the free end of C5. Route the other end of this wire as directly as possible to the equipment's input. If the insulation is left intact and the open end of this wire is wrapped a few times around the antenna lead-in wire, the low capacity thus provided between the two wires will provide light loading on the calibrator and supply plenty of signal level across the entire band from 100 kHz to 30 MHz. This cou-

pling has the further advantage of being easily adjusted for optimum performance simply by adding or removing a few turns of the hookup wire as required.

Setting C2 for the exact frequency required is accomplished by tuning your receiver to any frequency standard station, such as WWV. While listening to the station, wait until the background tone is removed; turn on the calibrator by switching it to the 100-kHz position and adjust C2 until you hear a zerobeat. (It is well to perform this check periodically to correct for long-term aging of the crystal.)◆



An Under- ground SURVEY METER and Metal Locator

LOCATE WATER LEVELS OR BURIED TREASURE—
AT DEPTHS OF MANY FEET

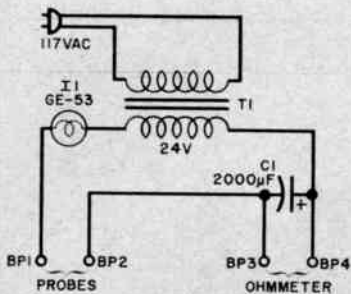
BY HAROLD PALLATZ

AT SOME TIME or other, you have undoubtedly read about or built and used an underground metal locator. Most of them work well when locating objects of a fairly good size that are not buried too far below the surface. Did you ever wonder what you would do if you wanted to find something that was really far down (say 100 feet) and perhaps non-metallic? How for instance, do geologists locate large ore deposits, underground

water sources, and oil pockets buried in the earth?

Any one of several different methods can be used—seismic shock, self potential, or resistivity profile. Obviously, each of these approaches operates in a different fashion but they are all quite capable of deep subterranean penetration.

In the seismic shock method, a series of transducers is positioned around an area and an underground shock wave is



Simple survey meter circuit can be easily assembled in a utility chassis.

initiated by conventional explosives. The transducers pick up both the original shock wave and the echoes from any underground strata having a different refraction index.

The self-potential method uses the potentials generated electrochemically in the earth to outline an ore body. A sensitive galvanometer—in conjunction with a set of conducting earth probes—measures the voltage gradients. Wooden stakes are driven into the ground at points of similar potential to outline the position of the ore body. A ground fault shows up as a sharp cutoff, or flat side, in such a pattern.

In the resistivity method, current is passed through the earth by inserting metal electrodes a known distance apart and variations in resistance are noted. The resistance can be related to the type of material existing at a certain depth (which is related to the spacing between electrodes). Water, as well as large metal pipes and ore bodies, have a low resistance, while oil has a high resistance.

Commercial geophysical equipment operating on the resistivity principle has been used to survey down to many hundreds of feet. With such equipment, four metal probes are stuck in the ground, equally spaced along a straight line and an electric current is passed between the rods. It can be shown that if two metal probes are spaced 100 feet apart, the current is a function of the average resistance 50 feet down at the center point between the two. Knowing the voltage and the current, the resistance at that point can be determined.

The survey meter described here is a

simplified version of the commercial equipment. It uses only two probes, but can locate such things as a water table 100 feet below the surface. A schematic diagram of the system is shown at left. It is assumed that the ground probes will maintain a more or less uniform resistance so that any change in resistance during measurements is due to the underground values. To eliminate the effects of polarization, an ac power source is used. However, since ac measurements made in the presence of stray fields can vary widely and are influenced by the capacitance and inductance effects in the earth, a dc metering signal is superimposed on the ac carrier. Although conventional 60-Hz line frequency is used here, any other frequency can be used, but penetration of the earth is better with low frequencies.

Resistance readings are made with a conventional ohmmeter which should be capable of indicating from less than one ohm to about 100,000 ohms. No calibration is required since all readings made at the same place and time are relative to each other. Capacitor C1 bypasses the ac current and must be of a very low-leakage type. Lamp I1 is used to limit the short-circuit current to less than two amperes. The 24-volt rms carrier voltage can vary by 25% up or down.

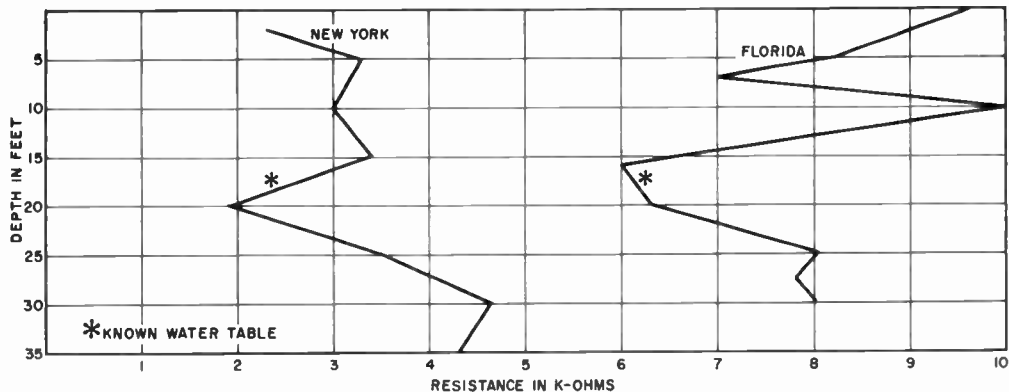
Construction. The components can be assembled in any convenient enclosure with a terminal strip to provide support and tie points. The probes can be iron, brass, copper, or aluminum (both the

EDITOR'S NOTE

Although we had no difficulty in locating a water table 20 feet underground and a water conduit 45 feet down, we did not have the opportunity of determining system "resolution"—how small an object can be detected at various depths. We leave this to the reader who is in better physical shape and handier with a shovel.

For readers in dry areas, the survey meter might be used to verify (or refute) the existence of a usable water table. It might also be valuable (more so than the metal locators that skim the surface) in locating buried treasure.

Try using a battery-powered oscillator to drive the transformer, remembering that the lower the frequency, the better.



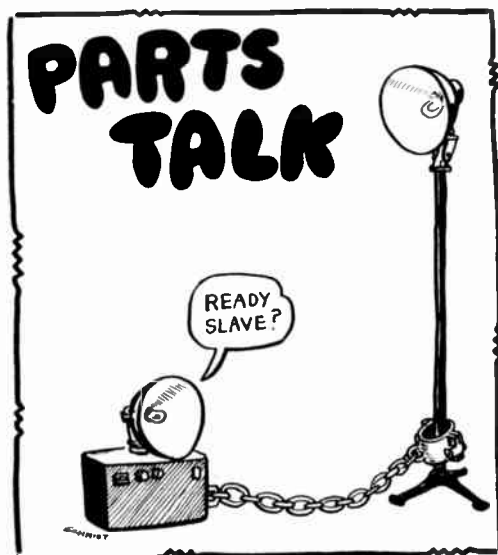
Two test recordings made in widely separated localities show striking similarities in that the resistance drops appreciably at depths where known water tables exist.

same) and should be between $\frac{1}{4}$ " and $\frac{1}{2}$ " in diameter and about 18" long. One end of each probe should be sharpened to make insertion easier. A length (50 to 100 ft) of #22 insulated (preferably plastic) wire is connected to each probe, with the other end connected to the appropriate binding post. The ohmmeter is connected (polarity not important) to BP3 and BP4.

Operation. With no ac power applied, short the two ground posts together. The ohmmeter should indicate a short circuit. When the posts are separated, the ohmmeter should deflect upscale as the capacitor charges. The maximum resistance is limited by capacitor leakage and must be over 50,000 to 60,000 ohms. Connect a known value of resistance across the ground posts and check that the ohmmeter reading indicates the correct resistance value (within tolerance). Turn on the ac power and note that the same resistance value is indicated. If it differs drastically, the problem is in the capacitor.

Use. Force the ground probes several inches into the earth in the area to be surveyed. You can start with a small separation (10 ft) or a large one (100 ft). With the ohmmeter connected and power on, record the probe spacing and the resistance value. Separate (or bring together) the rods at measured intervals (2 or 3 feet at a time) and record spacing and resistance. When you have sufficient data, plot them on graph paper.

Try to learn something about the area you want to survey. Charts and data are usually available from state or federal agencies concerned with mining and geology. Local well drilling companies also have data on land strata. Make your survey as near as possible to a location of which you have some knowledge. When you have succeeded in obtaining data of your own that checks with known data, you will begin to develop a "feel" for the system and variations in resistance will become meaningful to you. Just remember that dry rock, sand, oil, and gas have high resistance, while water shows up as a sharp low resistance. Two sample charts are shown above. ♦



COMPUTER ORGAN has virtually unlimited voicing



Card reader (shown) and alterable memories give new organ a virtually unlimited number of voices. Digital representations of musical sounds are stored on punch cards for temporary storage in computer, supplementing the organ's standard voicing.

A DIGITAL COMPUTER controlled by the keys of a conventional organ is a product of recent collaboration of North American Rockwell Microelectronics Co. (NRMEC) and Allen Organ Co. The new organ is equipped with fixed and alterable memories, giving it the capability of playing a virtually unlimited number of voices. It employs 22 NREMC aerospace-derived MOS/LSI (metal oxide semiconductor, large-scale integration) chips.

The use of MOS/LSI circuits cuts the cost of the digital music computer to a fraction of what it would have been if conventional IC/transistor circuits were used. The 22 MOS/LSI circuits contain 48,000 transistors on silicon chips whose total area is 0.5 square inch. Like all digital computers, the Allen digital musical computer has different kinds of memories and a processing unit. However, the latter is not centralized; instead, processing functions are distributed throughout the system.

The main memory is called a "specification" memory because it contains the

38 fixed voices meeting the specifications of a particular organ model. Each is stored in a read-only memory as "non-frequency" waveforms. As a time- and hardware-saving strategy, "registration" or scratchpad memories are used to temporarily store copies of the voices se-



Oscilloscope pattern at left shows digital signal within the computer; scope pattern at right is that of an analog output.

lected from the read-only memory by setting stops for a particular piece. The voices in the registration memories are also stored as non-frequency waveforms. The registration memories are time-shared, by multiplexing, by the number of notes being played on a given keyboard.

An "alterable" memory with a capacity of four non-frequency waveforms stores special voices programmed into it with punched cards. A single oscillator provides one frequency standard (4 MHz) that operates the four-phase computer system. Each manual and pedal key is assigned a frequency that is specific for the

fundamental note represented and that is derived from the frequency standard.

A look inside the organ is certainly educational. Where one would normally expect to find scores of electronic sub-assemblies and masses of wires, the space seems almost bare. The most obvious assembly is the approximately $\frac{1}{8}$ cubic-foot circuit board containing the 22 MOS/LSI chips.

Allen plans to sell the computer organs at prices ranging from about \$5000 to \$14,000. An Allen organ selling for \$14,000 will have the capability to play the sounds of a bell-rack presently costing \$25,000. ♦

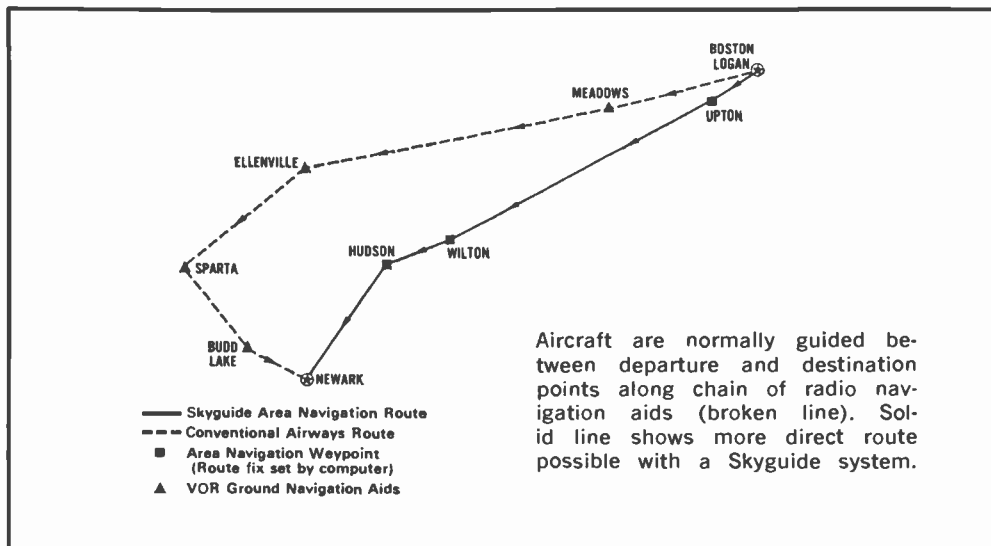
NEW AIRBORNE COMPUTER SYSTEM makes more efficient use of airways



Skyguide pictorial display is shown here installed in an Eastern Airlines DC-9-30 jet of type used in Air-Shuttle service. On rolling map, moving indicator "bug" is positioned immediately to right of a spot representing New York's LaGuardia Airport.

A NEW ERA in air navigation was recently demonstrated by Eastern Airlines as the company's "Skyguide" system now operational on the Air-Shuttle servicing Washington, Newark, New

York, and Boston. As the first installation of an area navigation system on any U.S. air fleet, Eastern's Skyguide opens up to practical use what FAA Administrator John Shaffer termed "the first major ex-



Aircraft are normally guided between departure and destination points along chain of radio navigation aids (broken line). Solid line shows more direct route possible with a Skyguide system.

pansion of the airways system since the introduction of omnidirectional radio transmitters in the early 1950's."

It is expected that Skyguide, a joint venture by Eastern and Decca Navigator Company Ltd. (of England), will bring greater reliability and faster flights for air-shuttle passengers. Not pointed out during the press demonstration was the fact that Skyguide, by allowing aircraft to navigate in uncongested airspace, will materially increase the safety factor in addition to reducing flying time from city to city by at least 10 percent—much more on long-distance flights.

The heart of the Skyguide system is a digital computer which takes radio signals received from existing FAA navigation aids and continually plots the aircraft's position on a rolling chart. An indicator, or "bug," traces the flight track on the chart, giving the pilot a visual reference on the progress of his flight.

The computer utilizes signals from VOR (VHF Omni-Range) stations and converts them to latitude and longitude coordinates. The result is an earth-oriented navigation system in place of the radio station-oriented system now in use.

The Skyguide tells the pilot exactly where he is, where he is going, and can direct heading or altitude changes. The computer is tied to the flight instruments and the autopilot so that the aircraft can

be flown in a narrowly defined corridor or three-dimensional "tube" between airports.

With the Skyguide, the aircraft is not restricted to flying on a radial to and from VOR navigational radio stations. Instead, the pilot can fly directly between the departure and destination points without having to thread his way from one radio station to the next.

A trip with the Skyguide is more direct, shorter, and may follow an infinite number of courses. Presently, traffic often slows down because aircraft on the same or intersecting routes must overfly the same radio stations, thus creating congestion.

Another side benefit of the Skyguide system is the fact that it can be used to land the aircraft safely under weather conditions that normally require IFR (instrument flight rules). This means that aircraft can safely land at airfields not presently equipped for "talked down" landings. Ceilings as low as 600 feet can be accommodated.

Presently, only the Eastern Shuttle employs Skyguide. But as more and more aircraft on all airlines become so equipped, air travelers will be treated to decreased flying times and an added margin of safety. According to an Eastern spokesman, the company is not keeping Skyguide a secret; the more aircraft equipped with it, the better. ♦

NEW PRODUCTS

(Continued from page 23)

FISHER'S AUTOMATIC TURNTABLES—A new line of three-speed automatic turntables incorporating many special features was recently announced by *Fisher Radio*. The three units are said to perform with extremely low wow, flutter, and rumble, and are designed to accept a full range of the finest cartridges available. Tracking is claimed to be flawless with stylus pressure as low as one gram or less. The three models offered are 502, 402, and 302 in descending price order. Each exhibits more or less the features found in most high-quality automatic turntables.

Circle No. 89 on Reader Service Card



UNIMETRICS TWO-WAY MARINE RADIO—The Minivox-IV VHF/FM two-way personal portable radio from Unimetrics is designed for ship-to-shore, ship-to-ship, and intra-ship radio communication. Weighing only 40 ounces and measuring just $8\frac{7}{8}'' \times 3\frac{1}{2}'' \times 1\frac{15}{16}''$, the Minivox-IV is intended primarily for the professional user but has features many amateur boating enthusiasts might want to look into. Powered by nickel-cadmium batteries, the unit develops 2 watts of r-f output power, has a frequency stability of $\pm 0.0005\%$, and can operate on either of two channels. Its all-solid-state circuitry is housed in a rugged water-resistant metal case. Optional coded squelch is also available.

Circle No. 90 on Reader Service Card

REALISTIC AM/STEREO FM RECEIVER—The accent in *Allied Radio Shack's* top-of-the-line Realistic Model STA-120B AM/stereo FM receiver under the Realistic name is improvement. The receiver is really an updated version of a receiver sold earlier under the same model number (minus the B). Rated output power is 150 watts, ± 1 dB into 8 ohms, with less than 0.8% harmonic distortion. An FM "Stereo Select" switch provides full interstation muting and permits tuning of only stereo signals, automatically bypassing mono signals.

Circle No. 91 on Reader Service Card

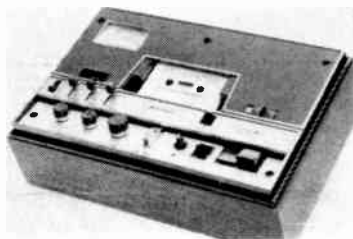


CROWN COMPACT CASSETTE SYSTEM—A compact cassette system with an AM/stereo FM receiver has been added to the *Crown Radio Corp.* product line. The system comes complete with a pair of matching two-way speaker systems. Called the Model SHC-46F, the new cassette system has piano-key operating controls, illuminated recording level meters, three-digit resettable counter, and traditional controls. Inputs are provided for microphone, remote control, and auxiliary equipment.

Circle No. 92 on Reader Service Card

ADVENT STEREO CASSETTE DECK—As in their previous cassette recorder, *Advent Corporation's* new Model 201 employs the Dolby Noise Reduction System to provide exceptionally wide frequency and dynamic range without obtrusive tape noise. In addition, the Model 201 combines a new heavy-duty transport mechanism and newly designed low-noise record playback electronics. Its recording meter circuitry is specially compensated to provide full indication of high-frequency signal strength.

Circle No. 93 on Reader Service Card





Twelfth in a Monthly Series by J. Gordon Holt

TEN HI-FI FALLACIES

AUDIOPHILES are avid readers. Unfortunately, some of what they read is incorrect—and they misinterpret some that is correct. The result is that part of the generally accepted information about audio is actually misinformation. Here are ten of the most popular misconceptions about hi-fi.

1. Solid-state equipment is better than vacuum tubes.

The inherent superiority of solid state is such an article of faith with most consumers that the term helps to sell everything from food blenders to clothes driers. Solid-state electronics has three clear-cut advantages: the units can be much more compact, they use less electricity and generate less heat, and they do not have the limited lifespan of components using hot-cathode tubes. Outside of that, one can make just as good a case for tubes as for transistors and their relatives.

In high-fidelity applications, the advantages of solid-state components are: elimination of the power amplifier's output transformer, potentially lower hum (because of the absence of the hot cathode), and usually better circuit stability due to the ease of obtaining an extremely wide bandwidth. In terms of sound, which is what most people have in mind when they cite the transistor's supposed superiority, there is no clear-cut difference. Generally, solid-state equipment produces cleaner, tighter bass than vacuum tubes can provide—mainly because it is possible to make solid-state power amplifiers with higher damping factors than can be achieved with tubes. But, it has not yet been possible to produce solid-state equipment, especially in the preamp section, that introduces as little audible distortion at high frequencies as you get in some of the very best tube-type components.

As far as durability is concerned, solid-state equipment has not yet completely lived up to its potential. Transistors do not go downhill gradually—as tubes do—but their rate of sudden failure is still higher than that of tubes. Again, this will doubtlessly be remedied; but as of now, the choice between tubes and solid-state components is more a matter of personal preference than one of clear-cut, objective superiority on either side.

2. If a musical instrument that is being reproduced through one stereo speaker is audible through the other, the reproducer has imperfect stereo separation.

This is true only for test and so-called demonstration records where it is clearly stated that *only* the left or right channel is supposed to be operating. Perfect stereo separation never occurs in nature or in live music because all sounds radiate in all directions from their source. A left-hand instrument's sound will reach the left-hand microphone first and will be loudest at that mike. But the sound continues to travel, getting weaker all the time, until it reaches the right-hand mike a fraction of a second later. Thus, the right-channel output from that left-hand instrument will be weaker and very slightly delayed in time, but it will be clearly audible. Were it not there at all, the reproduction of that instrument would be *monophonic*, from the left speaker only, and all of the sense of stereo spaciousness would be missing.

The reason a reproducing system should have the *capability* of total stereo separation is to prevent the left-hand sound (which is slightly ahead of the right-hand sound) from leaking through to the right channel and thus apparently narrowing the dimensional spread between the two channels. In fact, though, some stereo test records themselves

have imperfect separation where they are supposed to be presenting exclusively left- or right-channel signals. Even the best test records do not have enough separation to leave one channel completely dead while the other is working. As long as the "silent" channel is significantly quieter than the functioning one, the system's overall stereo separation is probably adequate.

3. Since different people hear things differently, high fidelity is more a matter of personal taste than objective reality.

This old saw dies hard! Different people react to different aspects of a complex sound —some concentrate on bass clarity, others on brilliance or overall balance, and still others on high-end richness or detail. And each evaluates reproduced sound on the basis of how well it re-creates those aspects of which he is critical. People's hearing acuities differ, also, some having response out to 20,000 Hz or beyond, while others are limited to 6000 Hz or below. But expose any group of people to exactly the same set of air vibrations as were present at a live concert, and their sonic perceptions and hearing lim-

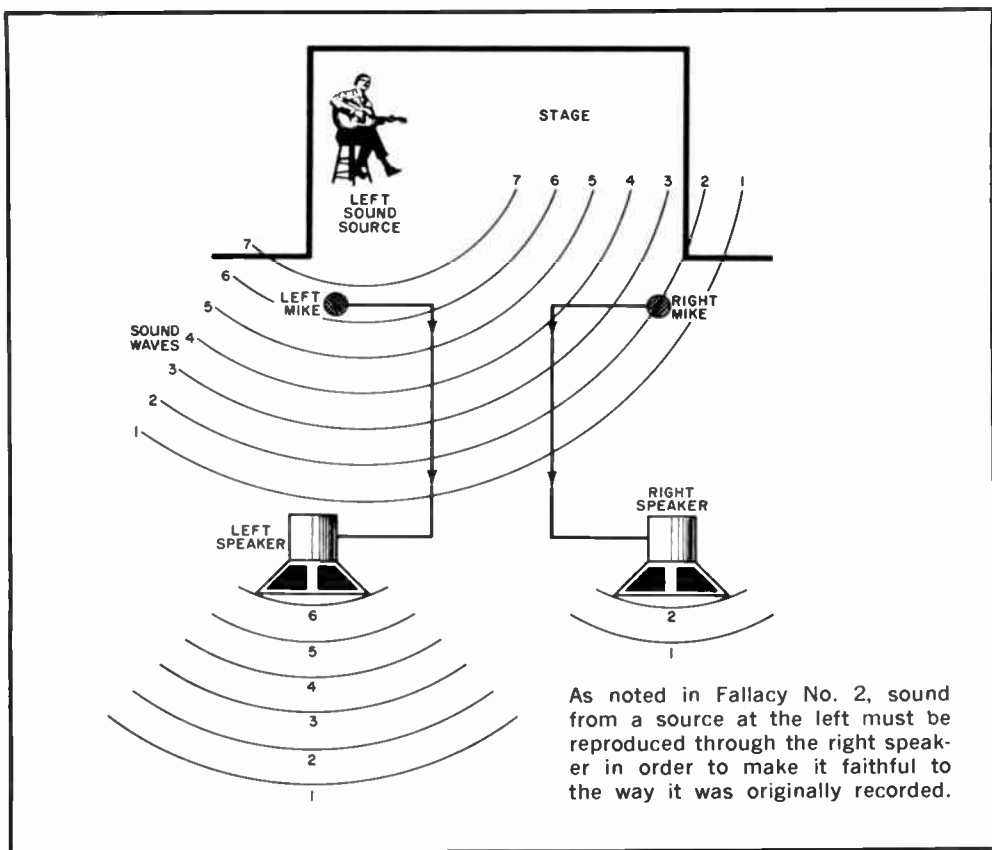
itations will react as though they were all hearing the original sounds.

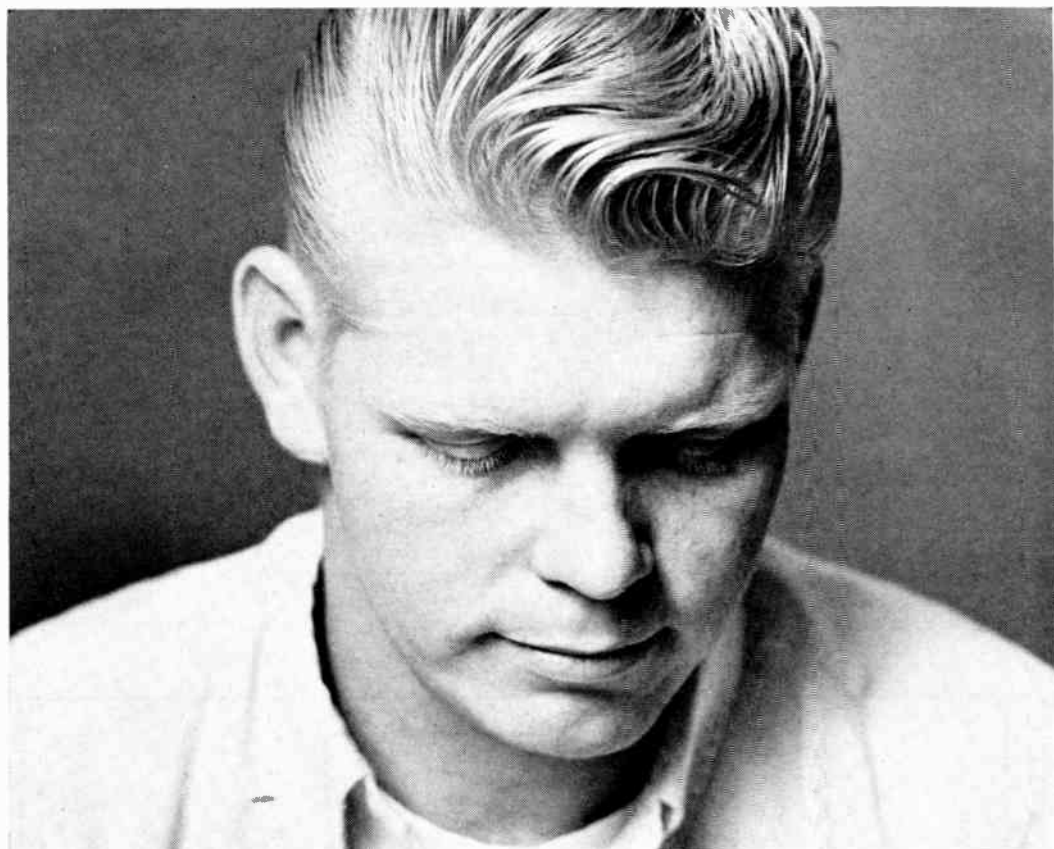
4. A synchronous drive motor has better speed regulation than a non-synchronous one.

This is a half-truth. Since a synchronous motor is "coupled" to the frequency of the ac supply, its average speed over a given period of time is as accurate as that of an electric clock (which uses a synchronous motor). In order to stay exactly locked on to the ac cycles, though, a synchronous motor must be continually speeding up and slowing down ever so slightly and this reduces its instantaneous speed regulation. Either type of motor requires special design provisions to insure that its particular type of speed variation is held to an absolute minimum for the best reproduction.

5. The better the reproducing system, the worse it makes a worn record sound.

Manufacturers of second-rate equipment have used this argument for years to explain why their stuff makes surface noise and record breakup so shatteringly offensive,





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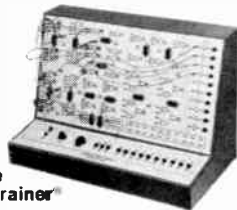
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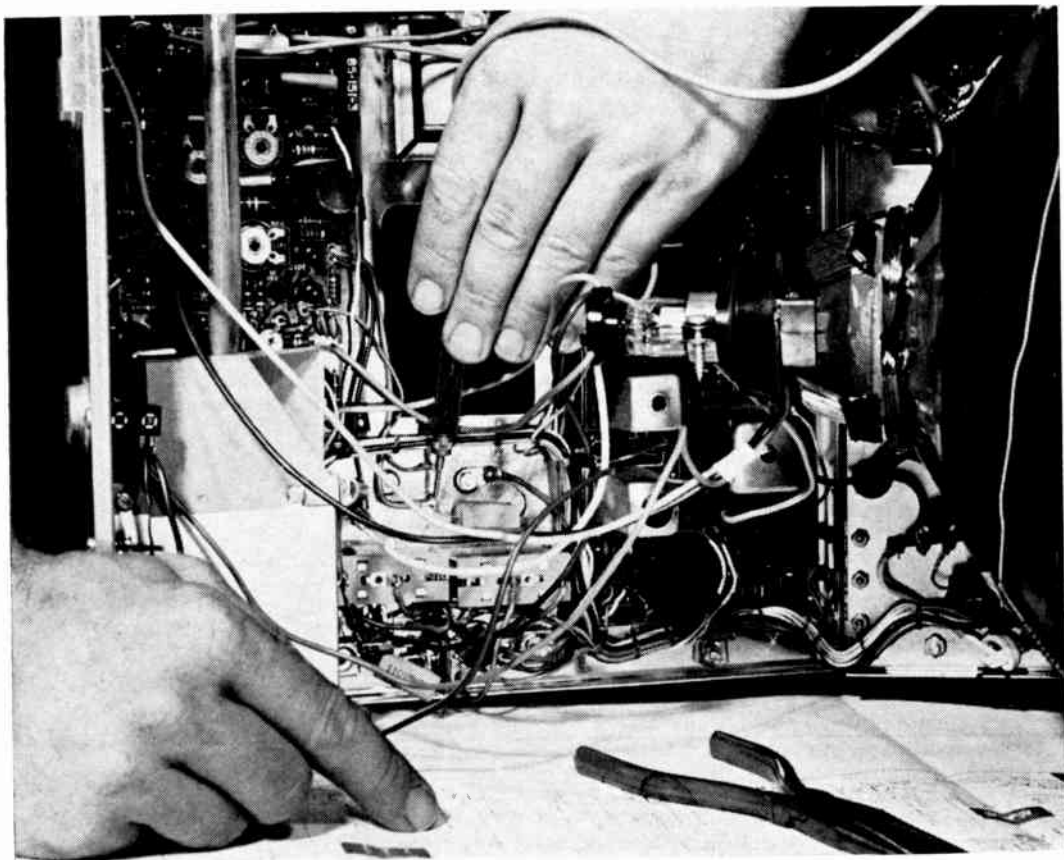
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but 'tain't so! Top-notch equipment will reproduce such distortion with embarrassing clarity—making the distortion quite audible. But the more the electrical distortion in the reproducer—the more peaky or tipped-up its high-end response—the more it exaggerates these problems.

Disc surface noise, reproduced through a low-distortion, resonance-free system, sounds rather like raindrops on pavement. Record breakup sounds like an overlay of fuzz. Both are audible, but neither is intolerable. If they are, it is a sign of a poor system rather than a good one.

6. The more power an amplifier has, the better it is.

There is a grain of truth to this, but there is no necessary relation between power and sound quality. It is generally true that low-power amplifiers are not designed to such high standards with regard to distortion as are high-power units. It is also generally true that low-power amplifiers have lower damping factors. Low distortion and a high damping factor make most loudspeakers sound better. But there have been exceptions, and these low-power amplifiers—as long as they are not driven to their overload point—have sounded as good as, if not better than, some very high-power units.

When considering power, it is also necessary to remember that a 1-dB change in volume is barely perceptible, while doubling the amount of available power from an amplifier will account for only a 3-dB increase in maximum available loudness. Thus, a change from 60 to 120 watts per channel actually represents a very small increment of volume capability. The major difference in sound between competing amplifiers is a result of their distortion at output levels of less than 1 watt—a specification that is rarely published, possibly because it provides a valid basis for comparison.

7. The human ear cannot perceive less than such-and-so amount of distortion (or phase shift or frequency response deviation or flutter or what have you).

Statements like this should be interpreted as meaning "My ears cannot perceive less than. . . ." An untrained listener can sit happily in a shower of "dreadful-fi" and not perceive anything except perhaps a vague feeling of discontent followed by a headache. Some highly critical listeners have shown their ability to detect, in reproduced music, frequency response variations as small as half a dB and distortion levels that were literally too microscopic to measure on currently available equipment. Thus, any flat statement to the effect that this or that is the smallest amount of anything that the ear can

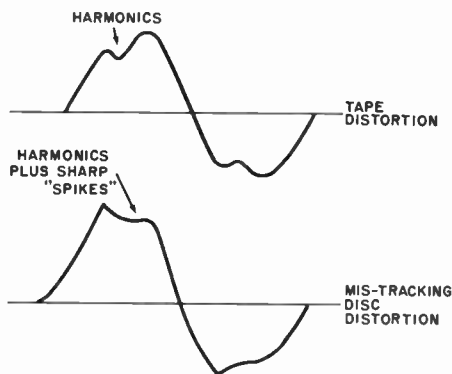
perceive must be viewed as highly suspect—if not altogether irrelevant.

8. Consistently dependable FM reception is possible only within line-of-sight distance from the transmitting tower.

This was proven mathematically several times before commercial FM transmissions showed that they did reflect from some atmospheric layer boundaries almost as readily as does AM.

9. Music sounds better on tape.

This subject was discussed in detail in this column not too long ago, but it is still a persistent hi-fi fallacy. In fact, more fidelity is lost through tape duplicating, particularly at high speeds, than is lost when cutting a disc.



Tape has built-in distortion that disc does not, but tracking distortion due to a poor cartridge can make a disc sound pretty bad.

And there are typically two more tape-copying steps involved in producing a commercial 4-track tape than in producing the discing master tape. But whereas a commercial tape is inherently worse than a disc to start with, the quality of disc playback is directly related to the quality of the cartridge used to play it back. Tracking distortion from a mediocre cartridge sounds worse than the distortion built into a commercial tape. With a top-notch cartridge, however, the disc can be very nearly as clean as the tape, and then the disc's superiority in terms of transient response, noise, and electrical distortion becomes evident. The only time music sounds undeniably best on tape is when it's from the original master tape, which we cannot, unfortunately, buy at the corner hi-fi shop.

10. Professional audio equipment is the standard by which home equipment is judged.

Manufacturers who toss the word "profes-
(Continued on page 96)



Sixteenth in a Monthly Series by David L. Heiserman

Radio Officer in the Merchant Marine

Can you tell me how to go about getting a job as a radio operator in the Merchant Marines?

● For a man who likes to travel, has no qualms about working long hours, and doesn't mind being away from home for weeks or months at a time, a job as a Radio Officer aboard a U.S. Merchant Marine vessel can be an ideal one. Radio Officers are among the most highly respected personnel aboard these ships and, with a base pay of about \$950 per month and \$400 for overtime, they are also among the highest paid. As an additional benefit, there is a 60-day paid vacation. Sounds great, doesn't it?

That's the rub. It's too great! Both Radio Officers' unions tell us there are virtually no openings for new men among their ranks. Of course, there are bound to be a few openings from time to time so, if you're really serious about it, the thing to do now is make sure you're fully prepared to jump when the chance comes. I suggest you get the following required documents right now:

1. A First- or Second-Class FCC Radiotelegraph license.
2. An officer's license from the Office of Marine Inspection of the U. S. Coast Guard.
3. A Merchant Mariner's Document validated for emergency service from the Coast Guard.

For further information about the officer's license and Merchant Mariner's Document, contact your nearest Coast Guard Marine Inspection Office. You can get a listing of these offices by writing to the U. S. Department of Commerce, Maritime Administration, Washington, DC 20235. The Maritime Administration can also send you an informative booklet called "Particulars Regarding Seafaring Employment in the U. S. Merchant Marine."

Previous experience as a Radioman in the

Coast Guard or U. S. Navy will go a long way toward getting you a Radio Officer's job in the Merchant Marine. So, if you don't have your military obligation out of the way, sign up with the Coast Guard or the Navy. By the time you've completed your first tour of duty the Merchant Marine picture might be a little brighter.

Selling Published Construction Projects

Can I legally build and sell electronic construction projects that appear in magazines such as Popular Electronics?

● This is a sticky problem from the legal point of view. An author, for instance, might unknowingly use a patented idea in a construction project. He doesn't infringe on any patent rights by publishing the circuit; and you, as a reader, can build all the circuits you want— for your own use. However, if you happen to build and sell a project that is protected by some patent rights, you may well find yourself involved in a lawsuit.

It simply isn't worth the risk or the attorney's fees to sort through the morass of rights on a published construction project. I suggest you use the basic idea for a project you like, but modify the details to such an extent that it is obviously your own design. Besides, you might be able to come up with a better or cheaper design.

Guaranteed Loans for Home Study Students

The GI Bill now helps veterans pay for a home study education in electronics. Are there any other federal programs that assist non-veterans who want to start their electronics careers with home study courses?

● The National Home Study Council, an influential independent home study accrediting agency, is largely responsible for a recent extension of the 1965 Higher Education Act to make it include home study training. This

is the Guaranteed Student Loan Program and it can help you get as much as \$7500 in tuition money for your electronics home study training.

Under the program, the government helps you borrow from a regular lending institution or, in some cases, from a home study school. The government doesn't actually give you any money and it doesn't loan you the money, either—it simply guarantees from whomever you borrow that the money will be repaid with full interest. If, for some reason, you fail to repay the loan or if you die or become totally disabled, the government picks up the tab. Banks and saving and loan institutions have been reluctant to make tuition loans, especially for home study programs. With the government backing your loan, however, the chances are better.

The Guaranteed Student Loan Program is not intended to benefit any particular social or economic group. Anyone with a fairly decent credit rating can get a guaranteed tuition loan if he is hard-pressed for money.

There are other advantages to the student loan program. You don't have to begin making payments on the loan until about nine months after you complete your training. You must, however, submit your lessons regularly enough to show that you are serious about finishing the course within a reasonable time. If you ever stop sending in lessons or fail out of the school, you have to start paying on the loan within a year after the school notifies you that you haven't met their standards. You can have your first payments deferred, by the way, as long as you are a full-time college student, a member of the Armed Forces, or a volunteer in the Peace Corps or VISTA.

Another advantage of the Guaranteed Student Loan Program is that the payments are smaller than with other types of financing. You'll have between five and ten years to pay off the loan—which helps make the payments fairly small.

A third advantage has to do with the interest on the loan. Federal laws prohibit a loaning institution from charging more than 7% on federally guaranteed student loans (instead of the usual 8% to 9%). The government pays a cash fee to make up the difference.

The home study schools that offer time-payment plans generally charge interest that amounts to more than 10%, so you'll be quite a bit ahead by borrowing from a regular bank or loan institution under the student loan program. A few home study schools are certified to act as lending institutions, but you have to check to see which ones are willing to loan you the tuition rather than sign you up for a time-payment plan.

Both you and your home study school

must be approved by the student loan program. Chances are you can qualify, but there are many home study schools that cannot. Your best bet is to stay with schools approved by the National Home Study Council. You can get a list of qualified schools and their course outlines from the NHSC at 1601 Eighteenth St., N.W., Washington, DC 20009.

Once you find an approved school, you can obtain a student loan application form from either the school or your nearest Regional Office of the U. S. Department of Education. After you fill out the application, send it to your school for certification. They will send it on to your loan institution for final approval.

For more information about the Guaranteed Student Loan Program, write to the Insured Loans Branch, Division of Student Financial Aid, U. S. Office of Education, Washington, D.C.

Little Response to Medical Electronics Poll

Since we feel that home study schools would do well to start offering courses in medical electronics—and in an attempt to get backing for our views—in last January's installment of "Opportunity Awareness" we published a reader's poll sheet. Although the responses that we got were all highly enthusiastic, we received only about 75 of them—hardly enough to make a convincing case for starting a new kind of home study course.

Unless we can gather more support from readers interested in studying medical electronics via the home study route, we'll have to shelve our present campaign.

No X-Ray Danger for TV Servicemen

Television servicemen are sometimes exposed to small amounts of x-radiation while working on color TV receivers but the significance of their exposure is "minimal." This is the conclusion of a report by the HEW Bureau of Radiological Health on findings of an x-ray exposure survey of 70 TV repair shops. Bureau Director J. C. Villforth pointed out that servicemen, unlike viewers, often must be close to operating x-ray sources without the protection of the cabinet and internal shielding. X-radiation rates inside the sets usually were below 0.5 milliroentgen per hour, the Federal limit for emissions outside the cabinet. "A Radiation Survey of Television Repair Shops in the Baltimore Area" (BRH/DEP 71-4) is available for 50¢ from the Superintendent of Documents, Government Printing Office, Washington, DC 20402.



COMMUNICATIONS

By Leslie Solomon, Technical Editor

THE RED CROSS AND REACT

There have been a lot of complaints about the misuse of CB channels. Some of them are valid in a number of areas about the country, but let's not overlook the good things. The American National Red Cross and REACT National Headquarters have jointly announced the completion of a cooperative understanding between the two public service agencies. For those not familiar with REACT, it is a national affiliation of CB operators (sponsored by General Motors as a public service) who volunteer their efforts and equipment to serve in local emergencies. REACT teams monitor the Official Emergency Channel 9 on a 24-hour basis.

The agreement will enable both organizations to render valuable aid in maintaining continuity of local communications during disasters and emergencies when normal communications facilities are disrupted or overloaded. REACT teams will be asked to contact local Red Cross chapters to establish operating procedures.

Henry B. Kreer, REACT National Director points out that the agreement with the Red Cross is one of the most significant recognitions ever accorded CB'ers, and feels that the FCC's action in designating channel 9 as an official emergency channel was instrumental in CB's gaining this confidence. So, the next time you feel like gabbing on channel 9, think twice, and remember the good guys out there who use the channel to help others. Some day, you too may need help.

Although severely disabled by muscular dystrophy, the Santin twins (that's Richard on the left and Robert at right) run a successful two-way radio service business in Fullerton, Neb. The bulk of their installations involve E. F. Johnson 30-54-MHz and 132-174-MHz equipment. On April 15, 1971, they received the President's Trophy as Handicapped Americans of the Year. The gentleman beside President Nixon is Harold Russell, World War II veteran who lost both of his arms in combat, but that didn't slow him down any either. Now Harold is the chairman of the President's Committee on Employment of the Handicapped.



(Communications continued overleaf)

COMMUNICATIONS

THE LITTLE BLUE BOX AND THE CALABOOSE

Electronics hobbyists are a strange breed. Some are readers, others are doers. The readers go about their business soaking up information, while the doers build useful electronic things to make life easier. Unfortunately, some doers go overboard. After gleaning a good working knowledge of electronics, they start to play games. One 19-year-old, in Great Neck, N.Y., used to be a real live doer. He figured he'd use his electronics know-how to fool the phone company and make long-distance calls for free.

So he built his "little blue box" found that it worked, and, lo-and-behold, he could "beat" the system. Unfortunately, he forgot that those guys "wrote the book." It wasn't long before the phone company engineers figured out what was going on and called in the local police. Our "learned" friend, along with eight others who played the same game, were arrested.

What's in a little blue box? If you or one of your buddies have one, you know—and consider yourself herewith warned. If you don't know about little blue boxes (sometimes called "cheeseboxes" in the trade) don't bother to find out. Just build your electronic gadgets for fun, and stay out here in the sunshine.

WWV & WWVH CHANGE FORMAT

Standard time and frequency radio stations WWV and WWVH, operated by the National Bureau of Standards revised their program formats at 0000 hours GMT, July 1, 1971. The most important new features are: voice announcements every minute instead of every five minutes, use of male and female voices to help distinguish between WWV and WWVH, and elimination of all Morse code signals. The carrier frequencies (2.5, 5.0, 10.0, 15.0, 20.0, and 25.0 MHz) remain the same. The formats of programs from WWV and WWVH are similar, but confusion is avoided by using alternate time

Goodyear Aerospace built this 30-foot (diameter), 32-element high-gain antenna for an earth satellite study. What makes it interesting is that this one is only a model for a 50-foot, 64-element antenna that Goodyear hopes to collapse down to fit within a satellite and then to pop open in outer space. In addition to this structure, the satellite will include an antenna pointing mechanism to aim it toward a desired area on the earth's surface. And you have trouble with a two-meter beam!



slots. Both stations broadcast standard tones and a "tick" every second. Each hour is divided into one-minute slots; each minute (except the first) begins with an 0.8-second tone of 1000 Hz on WWV and 1200 Hz on WWVH. The first minute in each hour begins with a 0.8-second tone of 1500 Hz at both stations. The minute slots are divided into a 45-second segment and two 7.5-second segments; on alternate minutes the 45-second segment contains either a standard tone or an announcement.

ERIN GO BRAGH

Ireland is one of the few countries in the world with no shortwave station. Radio Eireann's old 6-Mhz transmitter was closed down during World War II and has been silent ever since. Now rumors are circulating that the Irish government is at last considering the possibility of a shortwave voice once more for the Emerald Isle. If you think it's a good idea, drop a note to Radio Eireann in Dublin or to your nearest Irish Embassy or Consulate.

CLANDESTINE ACTIVITY

Last March 31, the Communist clandestine Radio Oggi Italia ("Radio Today in Italy") made its final transmission. During its 20-year career, it bounced around between at least five different transmitter sites in Hungary, the USSR, Rumania, Hungary, and Czechoslovakia. A mysterious jammer, transmitting very rapid A1 "beeps," is apparently emanating from somewhere in the Middle East. It has been heard on frequencies used by the Israel Broadcasting Authority (9009 kHz), R. Cairo (12010 kHz), Jordan's broadcasting service (7155), and Saudi Arabia Broadcasting (7220 and 11950). For the past few years two clandestine stations have been beaming anti-Franco programs into Spain: the Soviet backed R. Espana Independiente and pro-Western R. Euzkadi. Though it used to broadcast in Spanish only, REI is now increasing the competition by adding broadcasts in Basque as does R. Euzkadi. These can best be heard in North America on 12140 kHz around 1845 and 1945 GMT. (Contributed by Short Wave News Service.)

RADIO WEATHER

All you boating and outdoor enthusiasts will be interested to know that the National Weather Service will increase the number of weather report stations to 43 this year. Operating at 162.55 or 162.40 MHz, these stations have a nominal range of about 40 miles. The 24-hour transmissions consist of taped weather observations, forecasts, and warnings. If dangerous weather threatens, routine transmissions are interrupted and emergency warnings are broadcast. We understand that a new alerting system is being tested at some of these stations. The alert consists of a 1050-Hz tone inserted on the carrier for an interval of 4 to 5 seconds.

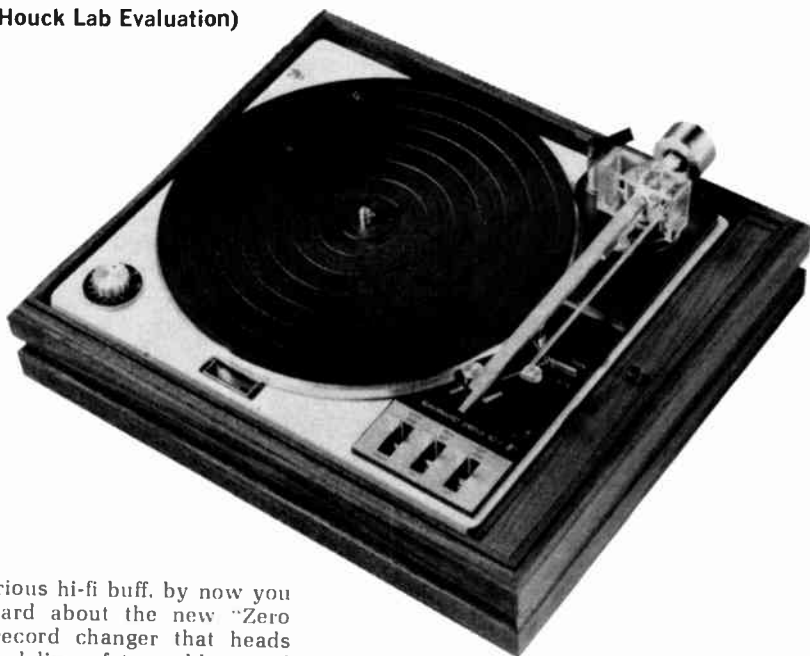
The stations are located in the following cities:

Akron, Ohio	Galveston, Texas	New York, N.Y.
Atlanta, Ga.	Honolulu, Hawaii	Norfolk, Va.
Atlantic City, N.J.	Jacksonville, Fla.	Portland, Ore.
Anchorage, Alaska	Kansas City, Mo.	Portland, Maine
Boston, Mass.	Lake Charles, La.	Sacramento, Calif.
Brownsville, Texas	Los Angeles, Calif.	San Diego, Calif.
Buffalo, N.Y.	Maui, Hawaii	San Francisco, Calif.
Charleston, S.C.	Miami, Fla.	Sandusky, Ohio
Cleveland, Ohio	Milwaukee, Wis.	Seattle, Wash.
Corpus Christi, Texas	Minneapolis, Minn.	St. Louis, Mo.
Dallas, Texas	Mobile, Ala.	Tampa, Fla.
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Ft. Worth, Texas	New London, Conn.	Wichita, Kan.
		Wilmington, N.C.

THE PRODUCT GALLERY

Twelfth in a Monthly Series by "The Reviewer"

GARRARD ZERO 100 AUTOMATIC TURNTABLE (A Hirsch-Houck Lab Evaluation)



If you are a serious hi-fi buff, by now you have read or heard about the new "Zero 100" automatic record changer that heads up Garrard's broad line of turntables. And just as likely, you are wondering what this new turntable has to offer the serious listener. Well, a fresh new approach to styling and a unique tone arm make the Garrard Zero 100 different in many respects from any other turntable on the market.

The name "Zero 100" is suggestive of the turntable's most striking feature: an articulated tone arm that exhibits essentially zero tracking error. A phono cartridge in a conventional pivoted arm can be tangent to the record groove (the ideal condition for minimum distortion) at only two points. Elsewhere, the stylus has a tracking error which can be minimized—but never eliminated—by careful arm design and installation. The distortion caused by tracking error is proportional to the playing radius divided by the

angular error. Most good arms are designed to have a low tracking error near the inner record grooves so that the degrees/inch factor is reasonably low over the entire record surface.

Articulated Arm. The tone arm of the Garrard Zero 100 consists of two parallel linkages which are pivoted in such a manner that the cartridge shell rotates slightly as it traverses the record. Even the small tracking error—typically about 0.5° /inch—remaining in good automatic turntable arms is virtually eliminated in the Zero 100. Its theoretical tracking error is less than $1/40^\circ$

(90 seconds of arc!), which is far less than other pivoted arms and too small to measure without elaborate instrumentation.

The Zero 100 arm is a straight stainless steel bar which extends beyond the front of the cartridge shell to form a finger lift. The articulating arm uses precision loaded ball bearings and a rear needle pivot bearing to minimize friction and free play. The cartridge mounts on a removable slide, and its position can be adjusted with a plastic jig for minimum tracking error. A small lever at the front of the cartridge shell tilts the cartridge to provide the correct 15° vertical tracking angle at the center of a six-disc stack, or on a single record disc.

Any pivoted arm is subject to skating force which is caused by friction between the stylus and the record material. This causes more tracking force on the inner groove wall than on the outer wall so that mis-tracking on high-level recordings will occur first in the outer wall channel. It is customary to provide anti-skating correction, an equal and opposite force on the two groove walls. Many anti-skating systems have been devised, usually involving hanging weights, levers, or springs.

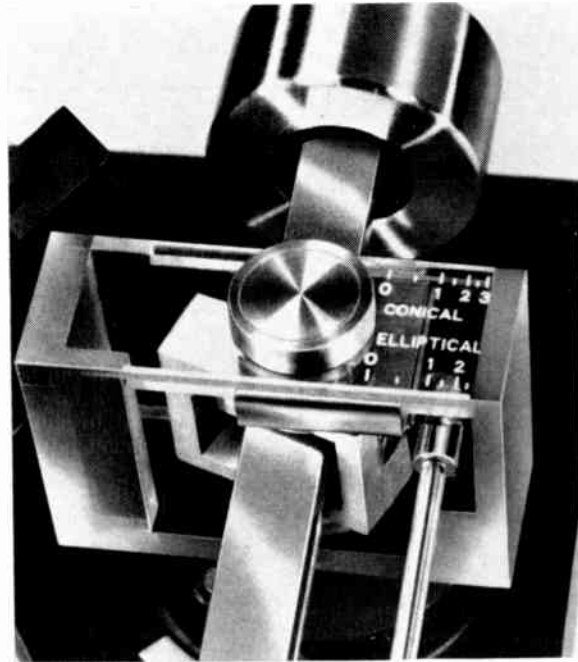
The Garrard Zero 100 employs a unique anti-skating system, with the corrective force supplied by two ceramic disc magnets mounted in opposing polarity. One is on the fixed clear plastic pivot support; the other is on the arm itself. A sliding magnetic shield between the magnets regulates the repulsive force. Two anti-skating scales, matching the tracking force, have ranges of 0-3 grams for spherical styli and 0-2 grams for elliptical styli.

The tone arm is balanced by a rotating, elastically mounted counterweight. Downward tracking force is applied by sliding a brass weight along the arm—which has on it a scale calibrated from 0 to 3 grams in 0.25-gram intervals. The arm rest has a lock which is spring-loaded so that accidentally picking up a locked arm merely extends the arm rest post without causing damage anywhere in the system.

The turntable platter of the Zero 100 is solid cast aluminum, 11½" in diameter. The platter itself is driven by a Synchro-Lab motor. This motor has the high starting torque of an induction motor but operates at exact synchronous speed, unaffected by line voltage or load. A vernier speed adjustment over a range of approximately ±3 percent is set by a ring concentric with the combined speed/record indexing selector. Stroboscope markings under the turntable are illuminated by a neon lamp and are visible through a window in the motor board, facilitating the setting of exact speed while playing a record.

As an automatic turntable, the Garrard Zero 100 can play up to six discs of the same size at 33⅓ or 45 r/min. Arm indexing is automatic for 7", 10", or 12" discs at 33⅓ r/min., and for 7" discs at 45 r/min. However, only 12" records can be stacked for automatic play without the use of optional accessories. Any size record, of course, can be played at either speed in the manual mode. When playing single records, the automatic spindle is replaced by a short manual spindle (which rotates with the disc to prevent center hole wear).

Three levers control the Zero 100: two for automatic and manual start/stop, and one for cueing. The latter raises the arm with a slightly damped motion and lowers it smoothly without any change of position on the disc.



Anti-skating system for Zero 100 has the corrective force supplied by two disc magnets—one fixed, the other on the arm. The force is varied, depending on type of stylus.

Laboratory Measurements. Our lab measurements essentially confirmed the claims made by Garrard for the Zero 100. We used a special protractor with an angular resolution of about 0.5°, and the observed tracking error was always less than this detectable amount. The tracking force calibration was accurate, within 0.1 gram over its full range. At the top of a six-disc stack, the force increased by less than 0.2 gram, which

is typical of good automatic turntable performance.

The anti-skating correction was optimum at all points on the disc (a rare occurrence among such devices, which frequently under-compensate), which suggests that the magnetic shield adjustment is compensated for the reduction in skating force near the inner grooves where the cartridge offset angle is reduced by the articulating arm design.

The turntable operated perfectly with line voltages as low as 70 volts, and the vernier speed adjustment has a range of about ± 3 percent. Wow and flutter were 0.01 and 0.025 percent at $33\frac{1}{3}$ r/min., and were 0.13 and 0.05 percent at 45 r/min. The unweighted rumble was -32 dB (by NAB standards). With CBS RRL weighting, which correlates more closely with audibility, it measured a very low -55.5 dB.

The Garrard Zero 100 operated smooth-

ly and without any mechanical "bugs." Its novel finger lift was exceptionally easy to use. And the cueing action was completely free of the "drift" that plagues many cueing devices. The pickup always returned to the same part of the disc from which it was lifted. In automatic operation, the change cycle was a relatively short 9 seconds.

The 3-gram maximum tracking force of the Zero 100 arm clearly implies the use of a compliant cartridge that is capable of operating at a low force. The benefits of the refined design of this record player, of course, can be realized most effectively with the best possible cartridge.

The Zero 100 lists for \$189.50. Available accessories include: a molded plastic base for \$6.50; a walnut base for \$19.95; a plastic dust cover for \$6.50; an automatic 45 r/min. spindle for \$3.80; and a cartridge clip holder for \$1.75.

Circle No. 94 on Reader Service Card on Back Cover

SIMPSON ELECTRONICS MODEL A 2-METER FM TRANSCEIVER



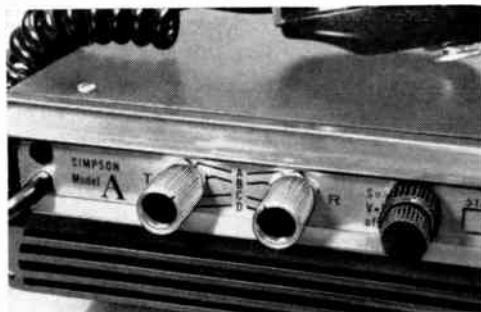
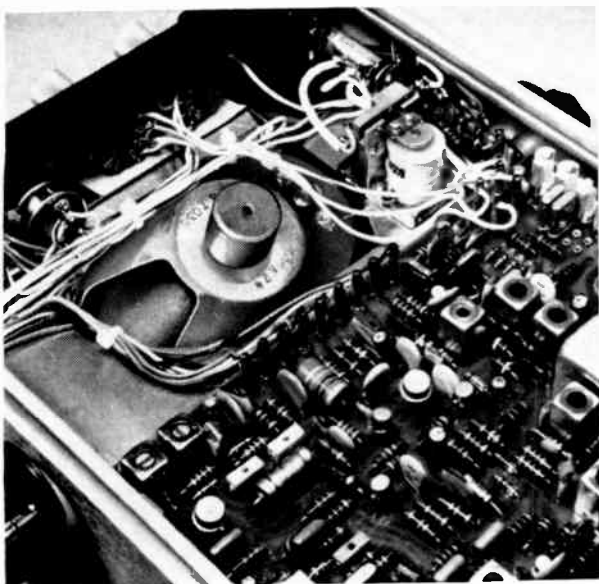
Amateur radio operators have been using narrow-band FM for years—only recently has it regained popularity with the VHF (144-148 MHz) gang for repeater operation. They have found that reliable mobile-to-mobile or mobile-to-base contacts over a radius of 50 miles or more can be made with a narrow-band FM repeater. Narrow-band FM (NBFM) is an FM signal having a deviation of 5 kHz (FCC 16F3) as opposed to conventional wide-band 15-kHz deviation (FCC 36F3).

The Simpson Model A 2-meter (144-148 MHz) FM Transceiver is an all solid-state unit (two IC's) with four transmit and four receiver channels—all crystal controlled and individually switched to give 16 different

combinations that will fit most conditions.

Test Results. On-the-air and laboratory tests showed that the small $8\frac{1}{2}'' \times 2\frac{1}{2}'' \times 11''$ transceiver not only sounded good but had excellent characteristics. The receiver had a sensitivity of $0.5 \mu\text{V}$ for 20 dB noise quieting and could be squelched down to $0.25 \mu\text{V}$. It has a ceramic filter system to produce a selectivity of 13 kHz at 6 dB and 30 kHz at 60 dB, while the receive frequency was within 0.001%. The overall frequency range was 300 to 3000 Hz with about 2 watts of audio output available. Current drain in the receive mode was 400 mA when squelched and 500 mA unsquelched.

The transmitter comes with a factory pre-



The Simpson Model A has four transmit and four receive channels individually switched as shown above. Crystals for two of each are supplied. Squelch and volume knobs are concentric and must be operated carefully to avoid moving one without the other. The 3" X 5" speaker (upper left) is tilted and has a chamber to provide sound through the front grille for mobile or table operation.

set 5.5-kHz deviation and, if desired, can easily be adjusted to 15 kHz (17.5 kHz maximum). Although specified for an output of 6 watts into a 50-ohm load, the unit actually delivered 7 watts with a 12-volt supply and 8.5 watts with 13.8 volts. Frequency stability is specified at 0.001% but, using a frequency meter, it was "tweaked" to 0.0001%. A high quality carbon mike driving a well-designed audio system with a clipper filter provides excellent voice quality over the range from 300 to 3000 Hz. The audio drives a phase-modulation system using voltage-variable capacitors. Nominal current drain is 1.4 amperes.

Reverse polarity protection is provided. If you plug the unit into the dc supply backwards, the fuse blows.

Construction and Test Points. Physical construction is excellent. The case comes with rugged extruded aluminum side rails. The top and bottom covers are vinyl-clad

aluminum, and the front panel is injection-molded Cyclolac. The receiver portion is built on a G-10 glass-epoxy board, as is the separate transmitter board. The Model A is a domestic product so servicing and parts are easily available.

Accessible test points are furnished at strategic locations, while interconnecting leads use snap fasteners to facilitate board removal. A 3" X 5" speaker, tilt-mounted within a sound chamber, provides excellent quality both in mobile and table-top operation. A mobile mounting cradle is also provided.

The manual is well prepared and contains a technical description of the transceiver, detailed alignment procedures, large two-color "X-ray" views of both circuit boards, and the usual schematic. As an added feature, the insides of the top and bottom covers carry drawings showing locations of the various adjustment controls used in alignment. The Model A is priced at \$249.

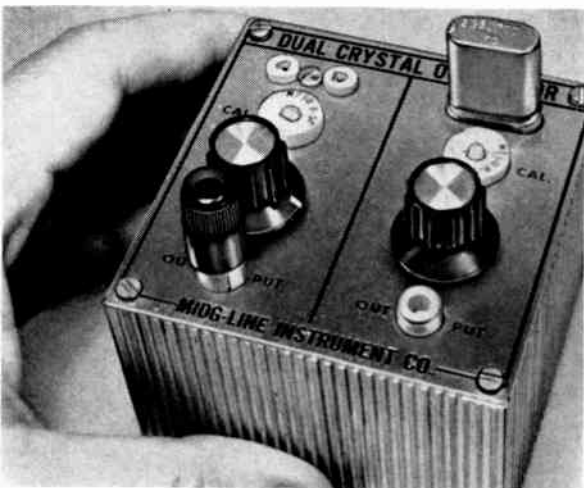
Circle No. 95 on Reader Service Card on Back Cover

MIDG-LINE INSTRUMENT CO. DUAL CRYSTAL FREQUENCY STANDARD

Useful for checking receiver tuning scales, testing unknown low-frequency crystals, and calibrating horizontal scope traces with a spiked waveform, the Dual Crystal Oscillator, made by Midg-Line Instrument Co., is unique in that crystals of two different frequencies can be plugged in at the same time and two

level-controllable outputs are available. Since there are no tuned circuits, the crystal frequencies can range from 10 kHz to 1 MHz. Both oscillators have front-panel trimmer capacitors so that any crystal can be zero beat with any standard frequency tuned in on a receiver.

Using a single IC as the dual oscillator, the unit has a zener controlled power supply. Two models are available—for either 6-



or 12-volt dc or commercial line power operation.

Operating Tests. Tests show that the frequency is "rock" steady after warmup and wide variations in the applied dc (between 6 and 24 volts in our tests) did not change the frequency by more than 2 Hz, using a 293.700-kHz crystal. In fact, total oscillator cutoff did not occur until the input voltage was reduced to 2 volts. Each output is adjustable from zero to approximately one volt rms. The waveform has a steep leading edge, creating the many harmonics required.

The Dual Crystal Oscillator is 3" X 3" X 2" and the case is fabricated from an extruded aluminum interlocking chassis. Price is \$25 for the battery-operated version and \$35 for the one that uses line power.

Circle No. 96 on Reader Service Card on Back Cover

CHAPMAN MIDGET RATCHET-OFFSET KIT NO. 6320

The quality of the tools he uses has a direct effect on the quality of the work turned out by a technician or hobbyist. First-quality tools, of course, are most preferred, while bargain basement ones should be avoided at any cost. If you look around long enough and hard enough, you will find very good quality tools at reasonable prices. An example is the "Midget Ratchet-Offset Kit" No. 6320 which sells for only \$12.95 from the Chapman Manufacturing Co.

The kit contains 21 pieces, including a padded vinyl-clad steel carrying case. There are two driver handles: one a conventional screw driver and the other a midget two-way ratchet. Twelve Allen hex-type adapters ranging from 0.050" to 5/16" across the flats are included. The driver adapter complement is rounded out with a pair of slotted head adapters (1/4" and 3/8") and a pair of Phillips head adapters (Nos. 1 and 2). The remaining two pieces are a 3 5/8" extension (into which all adapters fit and which, in turn, fits into both driver handles) and a 1/4"-square nut driver adapter.

It is evident from the list of adapters provided that this is a special-purpose set—one which will come in mighty handy for anyone in electronics. The adapters and extension are made from a tough steel alloy to withstand extra hard use. All have dual-purpose, knurled "spinner" tops for quick finger tightening and to provide a means of interchanging adapters in the ratchet. And the adapter extension has a set screw which can be



quickly tightened down on any of the adapters to provide a semi-permanent tool.

The midget ratchet is an interesting item. To make it stand up to tough usage, the handle itself is fabricated of stainless steel, while the driver head socket is made from the same steel used for the adapters. The 20-tooth ratchet has a short turning arc of only 18° for working in tight corners and it develops more than enough torque for most stubborn operations.

The case in which the drivers and adapters are supplied measures 6" X 4" X 1"—which is small enough to be tucked away in a workshop drawer or tool caddy.

Circle No. 97 on Reader Service Card on Back Cover



One Hundred Eighty-third in a Monthly Series by Lou Garner

EXPERIMENTERS, hobbyists, engineers, technicians, scientists and students can now explore the fascinating field of optoelectronics at minimum cost, thanks to a team effort by a Midwest industrial electronics distributor (Sheridan Sales Co.) and a major semiconductor manufacturer (Motorola). Working together, the two firms have introduced an inexpensive, yet comprehensive, kit of thirty semiconductor optoelectronic devices and a representative assortment of fiber optic components and accessories. The kit also includes three valuable handbooks—*Fiber Optics: Theory and Application*, *Solid State Fiber Optics Application Techniques*, and Motorola's extensive Opto Data File of device specification sheets and application notes entitled *Let There Be Light*.

Both light emitters and detectors are included in the semiconductor devices furnished with the kit. All are standard "off-the-shelf" items. Among the eleven light emitting diodes are four each of types MLED50 and MLED600 visible red light

emitters as well as two type MLED900 and one type MLED930 infrared sources. The nineteen detectors supplied in the kit include three each of types MRD150, MRD450 and MRD3054 phototransistors, together with five each of types 2N5780 and MRD14B Darlington phototransistors.

Selected for maximum application versatility, the optical components in the kit include: 40 11" long plastic fibers; a 9" long, 15-plastic fiber bundle with an end termination; a 9" long, 800-glass fiber bundle with end termination; a 12" long jacketed light pipe with both ends terminated; a 2" length of coherent fiber optic rod; an 8-foot length of PVC jacketed fiber optics; three glass lenses; a penlight; 3 penlight adaptors; and an assortment of heat-shrink tubing.

A number of interesting circuit applications are described in the Motorola handbook supplied with the kit, including a strobe/flash slave adaptor, a light-operated SCR alarm, a projection lamp voltage regulator, choppers, logic circuits, a linear ampli-



This new solid-state/fiber optic kit contains 11 light-emitting devices, 19 detectors, and a number of fiber optic materials and accessories. A complete set of application notes and a couple of handbooks are also provided in the interesting project.

fier, a pulse stretcher, a light-coupled dpst relay, a frequency sensitive photoalarm, a light-operated relay, and an optically monitored dc motor control. The featured circuits were chosen to represent typical optoelectronic applications and, in most cases, require other components in addition to those furnished with the kit.

Designated the *Solid State/Fiber Opto Design Kit*, the kit (\$39.75) will be available for a limited time only and may be ordered directly from the Sheridan Sales Co., Box 37646, Cincinnati, OH 45237. Since the kit was offered only to professional design engineers previously, readers should mention POPULAR ELECTRONICS in orders or inquiries to insure proper handling of their requests.

Reader's Circuit. The light-switched control circuit illustrated in Fig. 1 originally was developed to switch aquarium lights on and off each day, thus maintaining an established regimen while the owner was away on vacation. The designer, Thomas E. Hutchinson (33 Warrender Ave., Apt. 208, Islington 676, Ontario, Canada), suggests that it also could be used to switch any line-operated ac/dc appliance within its power handling capability of 240 watts. Typically, it might be used to provide automatic control for a small exhaust fan in an office or store, turning the fan on in the morning and off again at night after the day's business is complete.

Referring to the schematic diagram, diodes D1 through D4 constitute a full-wave bridge rectifier, supplying pulsating dc to the functional circuit. Load power is controlled by SCR1 or override switch S2, while S1 serves to switch the control circuit.

In operation, light falling on photocell LDRI reduces its resistance, increasing the dc

voltage across R2. When this voltage reaches the neon lamp's ionization potential, the lamp fires, turning on the SCR and furnishing power to the load. When the light on LDRI is reduced, R2's dc voltage is reduced by simple voltage-divider action. Eventually, this voltage will fall below that needed to maintain I1's conduction, thereby removing the SCR's gate signal. The SCR will then switch to a non-conducting state when its anode voltage drops to zero between dc pulse peaks, removing load power. Line switching transients are reduced by C1, which acts as a ripple filter in conjunction with diode D5 and series resistor R1, thus providing a smooth dc source for gate voltage.

Commercial devices are used in the design. Diodes D1 through D4 are type 1N4141, while D5 may be any standard diode with a 200 PIV rating. SCR1 is a GE type C106B1 and the photocell is a Philips type B8-731-03 (300-10 Meg). Line-isolation transformer T1 should be capable of delivering the required load current.

Although neither layout nor lead dress is critical, reasonable care should be exercised when assembling the control circuit. The SCR should be heat-sinked if used near its maximum rating, and the entire circuit should be insulated from its mounting case (or cabinet) to reduce shock hazards.

In practical installations, the light-switched control circuit is suitable for any resistance load within its ratings, such as lamps or resistive heaters, and also can be used for universal (series type) motors. It should not be used, however, to control fluorescent lamps or induction motors.

Manufacturers' Circuits. With potential applications in test equipment, electronic musical instruments, alarm systems, remote sig-

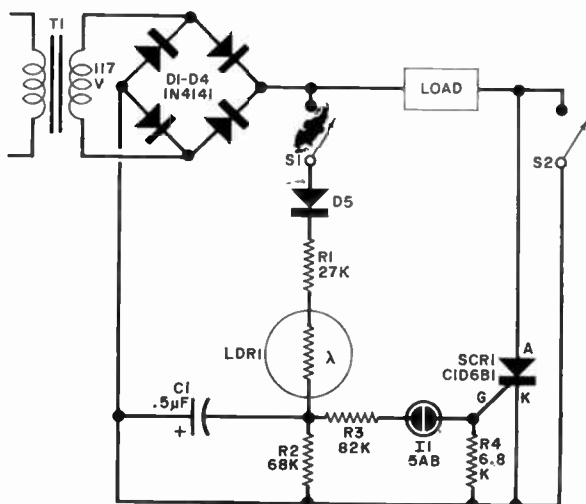


Fig. 1. Although designed to operate an aquarium heater, this circuit will switch 240 watts with a change in the light level.

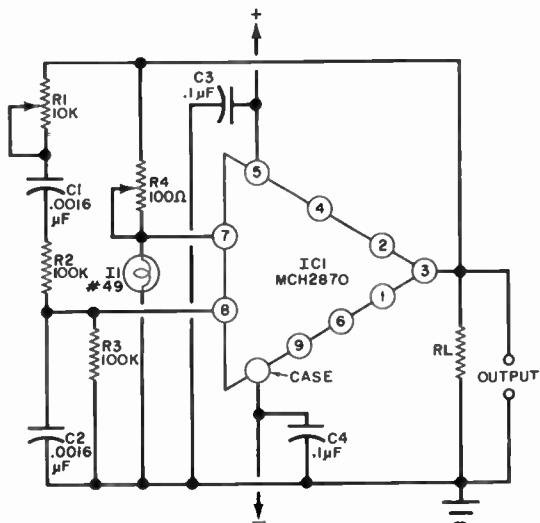


Fig. 2. Looking like a conventional op amp Wien Bridge audio oscillator, this new power circuit can deliver up to 300 mA into the output load.

nalling apparatus, and similar types of equipment, the Wien Bridge sine-wave audio oscillator circuit shown in Fig. 2 was abstracted from the technical data folder for the type MCH2870 M/C power operational amplifier. Published by Motorola Semiconductor Products, Inc. (Box 20912, Phoenix, AZ 85036), the folder describes several other useful circuits as well, including an inverting amplifier, a unity-gain voltage follower, a programmable voltage source, and a transconductance amplifier.

An interesting hybrid device, the MCH-2870 M/C consists of multiple silicon monolithic IC chips assembled in a single 8-lead metal package. With a unity-gain crossover frequency rating of 1.1 MHz, it can furnish output currents of up to ± 300 mA and has a typical open loop voltage gain of 200,000. Its open loop output impedance is a mere 10 ohms, making the device suitable for applications as a buffer amplifier, line driver, power amplifier, or servo/synchro amplifier.

Except for IC1 (MCH2870 M/C), standard components are specified for the design. Fine frequency control R1 and amplitude adjustment R4 are conventional linear potentiometers, while all other resistors are half-watt types. The capacitors are low-voltage ceramic units. The value of the load (R2) is determined by individual application requirements, but, in general, will be 50 ohms or more. A well-filtered dual ± 15 -volt dc power source is required for circuit operation.

Frequency determining components C1-C2 and R2-R3 should be close-tolerance matched pairs for optimum performance. With the values specified in Fig. 2, the nominal operating frequency is 1.0 kHz, but the circuit will operate at frequencies from 0.01

Hz to 10 kHz if proper values are chosen for C1-C2 and R2-R3. Use the formula $f=1/2\pi R_2C_1$, where R2 is in ohms, C1 in farads (assuming that R2 and R3 have equal values, as have capacitors C1 and C2).

Inexpensive as well as extremely versatile and, therefore, increasingly popular with professional equipment designers, commercial IC operational amplifiers have one serious limitation from an applications viewpoint: most require a dual (or split) dc power source. Unfortunately, doubling the power supply often doubles its cost and may, in some cases, make it more expensive than the functioning circuit. It is not surprising, then, that operational amplifiers have found relatively few applications in hobbyist projects. After all, most experimenters prefer the economy of a single-ended power source.

Happily, Motorola has suggested an inexpensive solution to this problem in their Application Note AN-420. All that is needed are a pair of Zener diodes, a couple of bypass capacitors, and a series dropping resistor, arranged as shown in Fig. 3A.

In operation, the voltage supplied by a "floating" single-ended dc source is reduced, split, and balanced to ground by zeners D1 and D2. Capacitors C1 and C2 provide ac bypass, while Rs acts to limit the maximum zener current.

Naturally, the basic dc source must supply a higher voltage than the total required by the split load. A 40-45-volt original source for example, might be used for a ± 15 -volt supply (30 volts total).

While the zener diode ratings depend on the circuit's voltage and current load requirements, the capacitor values (C1 and C2) are not critical and, typically, might range from 0.1 to 1.0 μ F. Ohm's law can be used to

compute the series resistor's value (R_s)—simply divide the difference between the source and total load voltages by the total load current added to the zener bias current.

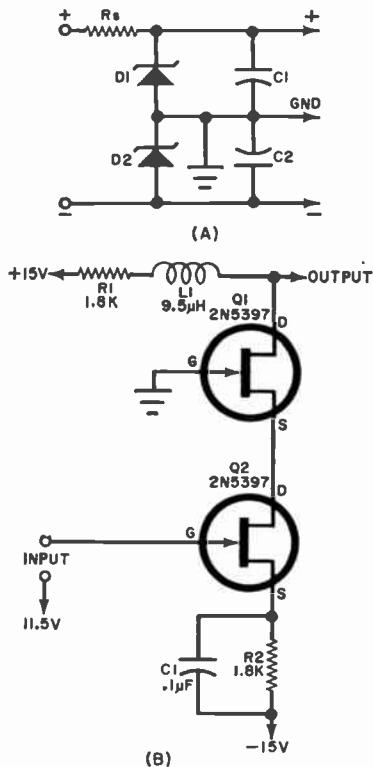


Fig. 3. If you need bipolar voltage from a single-ended power supply, Motorola suggests the circuit at A. If you need a really wide-band scope or instrument preamplifier, then Siliconix suggests you build the circuit at B. It has 18-dB gain and a 47-MHz bandwidth.

Abstracted from "FET Cascode Circuits Reduce Feedback Capacitance," an *Application Tip* published by Siliconix, Inc. (2201 Laurelwood Road, Santa Clara, CA 95054), the circuit illustrated in Fig. 3B should be useful in oscilloscopes, TVM's, receivers, R/C systems, and comparable projects. According to Siliconix, the design can furnish over 18-dB voltage gain with a 47-MHz bandwidth.

The relatively few components required by the circuit should be available through most larger distributors; Q1 and Q2 are both type 2N5397, R1 and R2 are half-watt resistors, and C1 a small ceramic capacitor. Peaking coil L1 has a nominal rating of 9.5 μ H, and a small adjustable rf coil similar to the J. W. Miller type 20A105RB1 could be used here.

As in any wideband amplifier, layout and lead dress are reasonably critical and, there-

fore, good wiring practice should be observed when duplicating the circuit. All signal carrying leads should be kept short and direct to minimize lead inductances, while the wiring should be dressed to reduce distributed capacitances.

Device News. A unique electronic timing circuit capable of operating on any dc power source from a 1.3-volt mercury cell to a 15-volt battery is now available from RCA's Solid State Division (Route 202, Somerville, NJ 08876). Intended for use in wrist watches, wall clocks, automobile clocks, digital readout clocks, and similar timing applications, the 23-stage static frequency divider circuit has many timing applications.

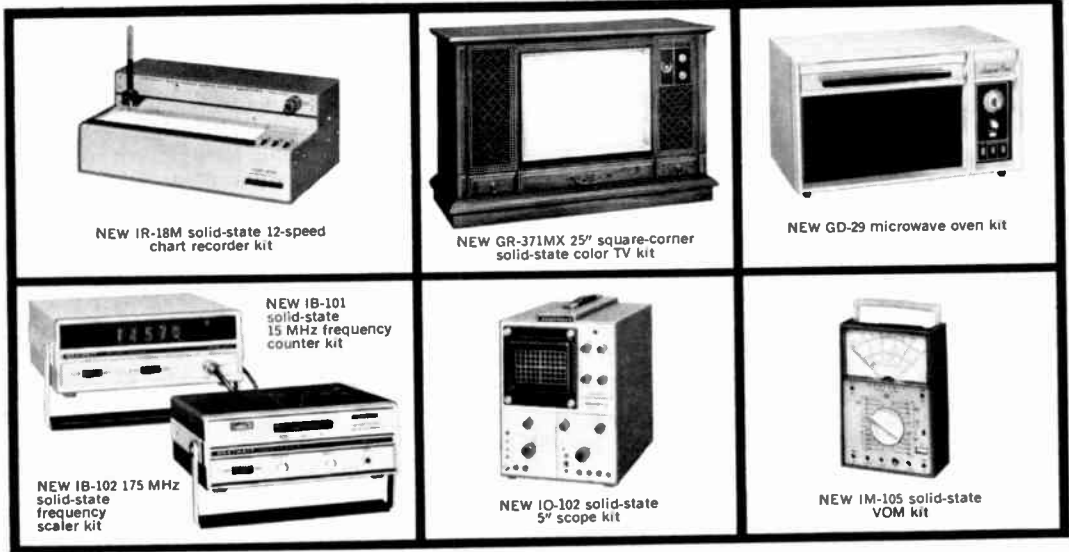
Designated type TA6030, the device utilizes COS/MOS technology to achieve the low power, high logic speed, and noise immunity characteristics essential to optimum performance. The initial version of the device contains two inverter output drivers, three zener diodes for voltage regulation and transient protection, and input inverters for use with crystal or RC oscillators as well as 23 flip-flop stages.

RCA also has announced a new series of five multi-transistor IC arrays, each on a common monolithic substrate. Three arrays, types CA3081, CA3082 and CA3083, are designed for high current applications, while the other two, types CA3084 and CA3086, are intended for general-purpose applications in signal-processing systems. All five devices are offered in standard DIP packages

The CA3081 and CA3082 consist of seven high-current (to 100 mA) silicon npn transistors in common-emitter and common-collector configurations, respectively. The CA3083 is a versatile array of five independent high-current (to 100 mA) silicon npn transistors, with two matched at low currents for applications requiring offset parameter controls. The CA3084 is a general-purpose array of low-current, high-voltage silicon pnp transistors, consisting of two independent matched transistors, a Darlington connected pair, and a "current-mirror" pair with a shared diode. Finally, the CA3086 is an array of five 50-mA silicon npn transistors arranged as a differentially connected pair and three independent transistors.

Two new microwave stripline transistors have been introduced to complement its line of coaxial microwave devices by RCA's Solid State Division (Somerville, NJ 08876). Designed primarily as UHF/microwave power amplifiers, developmental types TA7994 and TA7993 are intended for use in microwave communications, S-band telemetry, microwave relay link, phased-array radar, distance-measuring equipment, transponder, and collision-avoidance systems.

The TA7994 is rated at 5 watts output with



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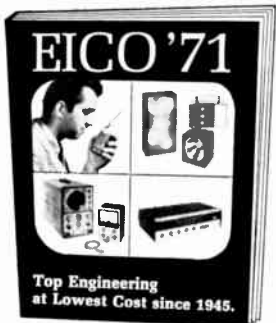
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7 dB gain (min.) at 2 GHz, and 13.5 watts output with 11 dB gain at 1 GHz. Suitable for use as a driver for the TA7994, the TA7993 is rated at 2 watts output with 8.2-dB gain (min.) at 2 GHz, and 3 watts with 12-dB gain at 1 GHz. Both units are epitaxial silicon npn planar devices and both are packaged in hermetically sealed ceramic-metal cases which feature low inductance and parasitic capacitance.

Subminiature passive components are needed to take full advantage of the small size and high performance characteristics of the new IC's introduced over the past few months. Recognizing this, the Sprague Electric Co. (395 Marshall St., North Adams, MA 01247) has introduced a new line of ultra-small solid tantalum capacitors. Designated types 188D and 189D, the new capacitors are no larger than the head of a paper match. Standard working voltages range from 2 to 20 volts, dc, while capacities range from 0.01 to 15 μ F. Not all capacitance values are available at every working voltage, of course. Full technical details and specifications are given in Engineering Bulletin No. 3516, available on request from Sprague's Technical Literature Section.

Two dual 100-bit dynamic shift register IC's are now available from the Signetics Corporation (811 E. Arques Ave., Sunnyvale, CA 94086). The type 2506 and 2507 devices can operate at relatively high frequencies and are intended for use in low-cost buffer and sequential access memories. Using low-threshold silicon gate MOS technology, the registers can operate at typical clock rates of 5 MHz. Their power dissipation at 1 MHz is only 400 microwatts per bit, while their clock capacitance is less than 40pF. The two devices are available in both 8-lead TO and DIP packages.

TRW's Semiconductor Division (14520 Aviation Blvd., Lawndale, CA 90260) has introduced a new operational amplifier with a 4-kHz bandwidth and 80-dB gain when operated on a mere \pm 2-volt dc source. Satisfactory operation can be obtained with current drains of as little as 20 microamperes. Identified as type MP112, the unit is intended for use where low potentials and low battery drain are mandatory requirements. Available in both TO99 and 14-pin DIP packages, the device can be used in active filters, audio amplifiers and similar linear applications.

Good news from Motorola! Price reductions on eight of its popular small-signal plastic transistors, types 2N3903 to 2N3906 and 2N4123 to 2N4126. These devices include low-noise, general-purpose, switching, with amplifier transistors useful to 300 MHz, with all rated at 310 mW power dissipation. The new unit prices range from 39 cents for

the 2N4123 to a high of 55 cents for the 2N39—series.

Motorola Semiconductor Products, Inc. (P.O. Box 20912, Phoenix, AZ 85036) has released the first standard integrated circuits belonging to a brand new logic line trademarked "MECL 10,000." With more than two dozen devices scheduled to be included in the new series this year, the first four are: the MC10181 4-bit arithmetic/logic unit, the MC10109 dual 4-5 input OR/NOR gate, the MC10119 4-wide 3-3-3-4 input OR-AND gate, and the MC10131 dual "D" master-slave flip-flop. Unit prices range from \$2.40 for the MC10109L to \$24.00 for the MC10181P. The MC10181 is offered in a 24-pin dual in-line plastic package (type "P"), while the other three new devices are furnished in 16-pin type "L" dual in-line black ceramic packages.

As illustrated in Fig. 6, Motorola's new MECL 10,000 gate features a differential input amplifier, an internal temperature compensated bias network, and complementary (OR/NOR) emitter-follower outputs. In the circuit, high speed is combined with very low power: 2.0-ns propagation delay and 25-mW power dissipation are typical for the basic gate, with the power dissipation remaining constant at all operating frequencies.

TRW Semiconductors (14520 Aviation Blvd., Lawndale, CA 90260) has announced the addition of a new device, the SVT450-3,

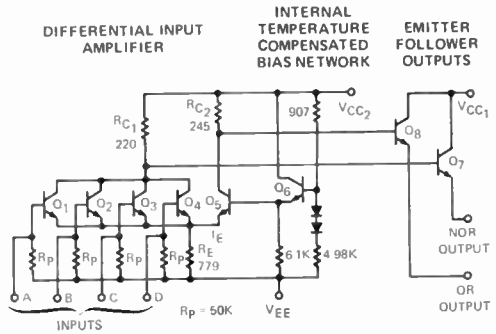


Fig. 4. This new Motorola MECL 10,000 gate features OR/NOR output and built-in temperature compensation. Like the other MECL devices, this is also a very fast switcher.

to its line of power transistors. Packaged in a TO-3 case, the new device features an I_c of 3 amperes with a saturation voltage of less than 1 volt and a beta greater than 10. Designed primarily for switching power supply and modulator applications, the SVT-450-3 is capable of switching 450 volts at 3 A in less than 100 nanoseconds.

A new high-speed dual voltage comparator for analog-to-digital conversion has been introduced by Siliconix, Inc. (2201 Laurelwood Road, Santa Clara, CA 95054). Identified as type L132, the device consists of two isolated comparison channels, each with a

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separate strobed latch on the output capable of driving TTL logic inputs. Other features include a low typical input current of only 3 μ A and a 10-volt maximum differential input voltage. The L132 is offered in both TO-86 flat packs and TO-116 DIP packages.

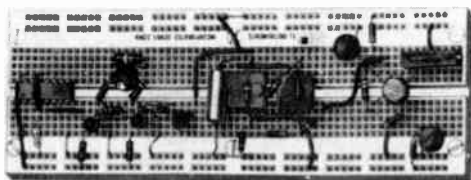
The Amazing EL Socket (Breadboard)?? If you've seen the famous TV commercial featuring a dish detergent which "thinks it's a hand lotion," you'll appreciate EL Instruments, Inc.'s (61 First St., Derby, CT 06418) No. SK-10 Socket—a socket which, with good reason, "thinks it's a solderless breadboard."

The SK-10 "socket" measures 6.5 x 2.2 inches overall and is about 1/8 inch thick. It is

equipped with 128 5-point terminals and 8 25-point bus bars. The 5-point terminals are arranged in parallel rows of 64 pairs, spaced to permit the easy direct insertion of DIP IC's while TO-type IC packages, transistors, and other discrete devices may be plugged in simply by shaping their leads with a pair of long-nosed pliers. The SK-10's nickel-plated beryllium copper contacts will accept solid wire and component leads from #22 to #26 gauge.

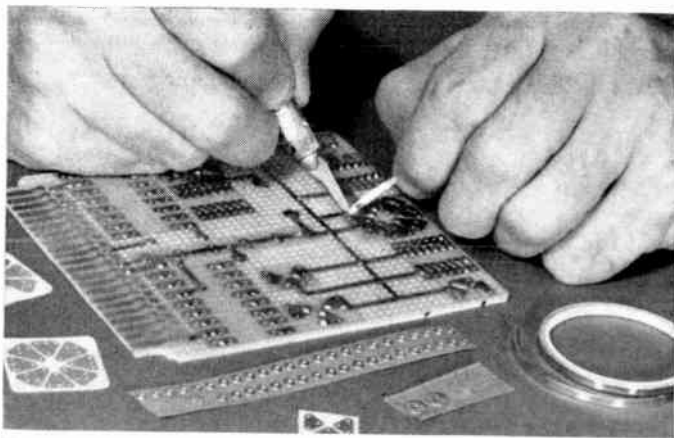
With a total capacity of up to eight standard 14-pin DIP IC's in addition to the necessary external components, a single SK-10 can be used for breadboard assembly and tests of fairly complex equipment designs. Since its terminals will accept small gauge standard hook-up wire, special patch cords are not needed for circuit interconnections.

Designed to mount on any flat insulated surface with six #4 flat-head machine screws, the SK-10 is suitable for permanent construction as well as breadboard experiments. After exhaustive tests in our own laboratory, we feel the unit is well worth its \$18.00 price tag.



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For prototyping circuits the "breadboard" shown above is completely solderless. If you have troubles making PC board, or don't like messing around with etchant, then you can stick a circuit down as shown at the right. Each element is a complete copper foil on a sticky back. All you do is stick 'em down, where you want 'em, and put in the parts. You can solder to the copper pads and foil.



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and different meaning for electronics engineers, hobbyists and experimenters as the result of an interesting product line introduced by Circuit-Stik, Inc. (1518 W. 132nd St., Gardena, CA 90249). Consisting of a series of conductive foil elements bonded on thin, flexible epoxy-glass substrates backed with a strong, pressure-sensitive adhesive, Circuit-Stik components may be used to assemble functional circuit boards in a matter of minutes. The only tools needed are a razor knife and a small soldering iron or gun.

The circuit element patterns that are offered meet virtually every design requirement, including TO-3, TO-5, and TO-18, 3- and 4-lead transistor configurations; stud and plastic style SCR connections; and TO, DIP and flat-pack IC terminal arrangements. Also there are individual donut pads, discrete component strips, connector patterns, and bus bars. Various widths of adhesive-backed copper foil tapes are available in rolls for other wiring.

Almost any desired circuit may be made up simply by selecting the required component terminal patterns, removing the backing paper, and applying directly to an insulating substrate, just as one might apply a pressure-sensitive label to an envelope or parcel. Component element interconnections and other circuit wiring can be added by using the adhesive-backed copper foil tape. When the circuit elements and foil are burished in place and butt joints secured with a drop of solder, the completed design is equivalent to a conventional etched circuit board.

Although practically any substrate may be used (including ceramic plates and glass-epoxy or phenolic paper boards) the manufacturer also offers a special perf board pre-punched with a 0.100" grid hole pattern compatible with his "1000 Series" component elements. Used together, the special perf board and corresponding circuit elements permit the fabrication of circuits complete with integral mounting holes for devices and components, thus reducing or eliminating the need for additional machine work before final circuit assembly.

While the manufacturer will honor requests for literature or catalogs and will fill quantity orders directly, small orders for Circuit-Stik materials should be sent to a supplier such as the Circuit Specialists Co. (Box 3047, Scottsdale, AZ 85257). The latter offers a basic kit of Circuit-Stik elements, foil tape and circuit board for only \$5.50 (plus 30¢ for Air-Mail shipment, if desired). Identified as the CS-20 Kit, the package includes a small piece of 0.100" grid perf board, a roll of copper foil tape, and a comprehensive assortment of component elements for transistors, and both TO and DIP IC's, as well as a number of donut pads. ♦

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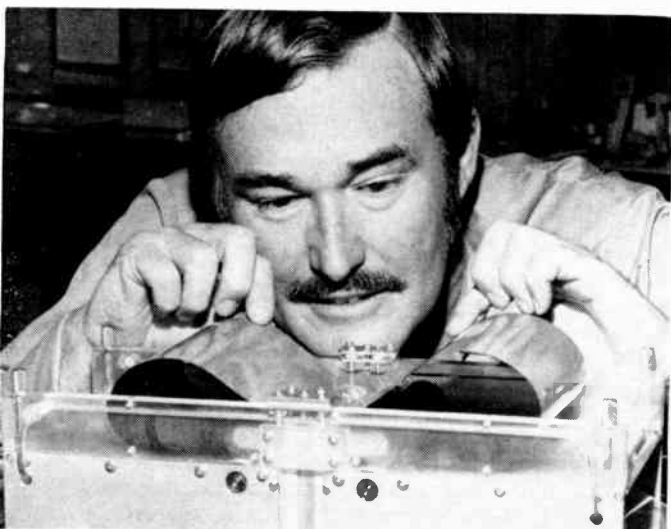
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STEREO SCENE

(Continued from page 76)

sional" around in describing their home hi-fi equipment would do well to examine the implications they are making, because in terms of performance specifications, professional equipment is generally inferior to home-type equipment. Disc reproduction, with its attendant tracking-distortion tendencies, puts much more stringent standards on its operation than is done for the professional recording engineers' equipment. Some audiophile tape recorders have responses that extend out to 20,000 Hz at 7½ ips; professional machines will rarely make it to 15,000 at that speed (since they are designed primarily for 15 ips). Most audiophile amplifiers produce less than 0.2% distortion at

operating levels below overload; professional disc-cutting amplifiers often generate 0.5 to 1.0% distortion at equivalent levels. Many audiophile speaker systems are good to 35 Hz at the bottom and beyond 15,000 at the top (within 3 dB over most of the range); the typical recording studio monitor speaker cuts off at 50 Hz or higher and 12,000 Hz or lower and the response in between may deviate by as much as 6 dB either way. Equalization accuracy for professional equipment is rarely better than ± 1 dB; but it is within ± 0.5 dB in some audiophile preamps. Professional turntables and tape machines are considered to be excellent if their wow and flutter is below 0.15%; audiophile units aim for, and often achieve, figures below 0.1%. The main points of superiority in professional equipment are ruggedness and ease of servicing and maintenance—which don't usually show when the shopper is comparing prices of professional and audiophile lines. ♦



PRECISION SOLID-STATE FILM TRANSPORT developed by Teledyne Ryan Aeronautical for U.S. Air Force utilizes piezoelectricity to advance film instead of rotary mechanisms. Project engineer Dr. Charles M. Davis (left) says the patented principle involving piezoceramic materials provides precise film advance accuracies of one micrometer, essential in high-quality recorders which build up imagery from a succession of evenly spaced scan lines. The precision film transport is capable of moving film continuously or in discrete steps over wide speed ranges, yet is compact and relatively simple in design. Feasibility testing is being accomplished at the Air Force Avionics Laboratory at Wright-Patterson AFB, Ohio.

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FISH FINDER

(Continued from page 49)

EDITOR'S NOTE

The underwater fish detector was tested in various tanks at the New York Aquarium (with the aid of a helpful curator). Of course, the dolphins made the wildest underwater sounds, but the white Beluga whales came in a close second. Tests in some tanks did not reveal much noise, possibly, as the curator explained, because the fish had been there for some time and had few hunting instincts since they are fed on a schedule. The barking of a seal underwater is not to be believed, but these creatures tend to play with the transducer, which causes painful shocks on the ears.

Tests in the Great South Bay off Long Island, New York, revealed some strange noises (possibly flounder or mackerel, which were in at the time), but the noises from boats were usually overpowering.

Try the detector in your home fish tank, but be sure to turn off the aerator or pump while doing so.

Construction. The circuit, shown in Fig. 1, consists basically of an underwater transducer coupled to a high-gain audio amplifier (IC1). The response of the amplifier is down 3 dB at 200 Hz and 13 kHz, while maximum gain is 100,000. The output impedance is 0.5 ohm, making the system suitable for use with almost any type of speaker or earphones. It can also be used with another amplifier. Gain is controlled by R5 and there are two parallel output jacks—one of which can be used for a tape recorder.

It is recommended that a printed circuit board be used to prevent oscillations. A foil pattern and component layout are shown in Fig. 2. The board, with the battery, should be mounted in a small, metal shielded enclosure to prevent external electrical noise pickup. It is also suggested that the case be anodized to prevent corrosion when the detector is used near salt water. ♦

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(Continued from page 16)

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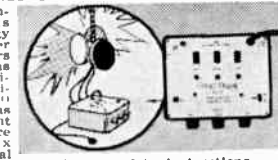
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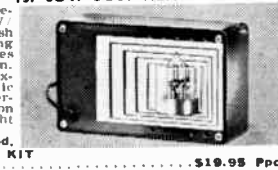
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P-71,342AV \$24.95 Ppd.
BUILD-IT-YOURSELF STROBE KIT
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THE KIT FOR EVERYONE

You do not need the slightest background in radio or science. Whether you are interested in Radio & Electronics because you want an interesting hobby, a well paying business or a job with a future, you will find the "Edu-Kit" a worth-while investment. Many thousands of individuals of all

ages and backgrounds have successfully used the "Edu-Kit" in more than 79 countries of the world. The "Edu-Kit" has been carefully designed, step by step, so that you cannot make a mistake. The "Edu-Kit" allows you to teach yourself at your own rate. No instructor is necessary.

PROGRESSIVE TEACHING METHOD

The Progressive Radio "Edu-Kit" is the foremost educational radio kit in the world, and is universally accepted as the standard in the field of electronics training. The "Edu-Kit" uses the modern educational principle of "Learn by Doing." Therefore you construct, learn schematics, study theory, practice trouble shooting—all in a closely integrated program designed to provide an easily-learned, thorough and interesting background in radio, function, theory and examining the various radio parts of the "Edu-Kit." You then learn the and trouble-shooting. Then you begin by listening to regular broadcast stations, learn theory, practice testing and techniques. Gradually, in a progressive manner, and at your own rate, you will find yourself constructing more advanced multi-tube radio circuits, and doing work like a professional Radio Technician. Included in the "Edu-Kit" course are Receiver, Transmitter, Code Oscillator, Signal Tracer, Square Wave Generator and Signal Injector Circuits. These are not unprofessional wiring and soldering on metal chassis, plus the new method of radio construction known as "Printed Circuitry." These circuits operate on your regular AC or DC house current.

THE "EDU-KIT" IS COMPLETE

You will receive all parts and instructions necessary to build twenty different radio and electronics circuits, each guaranteed to operate. Our Kits contain tubes, tube sockets, variable, electrolytic, mica, ceramic and paper dielectric condensers, resistors, tie strips, hardware, tubing, punched metal chassis, Instruction Manuals, hook-up wire, solder, selenium rectifier, coils, volume controls and switches, solid state materials, etc. In addition, you receive Printed Circuit materials, including Printed Circuit chassis, special tube sockets, hardware and instructions. You also receive a useful set of tools, a professional electric soldering iron, and a self-powered Dynamic Radio and Electronics Tester. The "Edu-Kit" also includes Code Instructions and the Progressive Code Oscillator. In addition to F.C.C. Radio Amateur License training, you will also receive lessons for servicing with the Progressive Signal Tracer and Signal Injector, High Fidelity Guide and a Quiz Book. You receive Membership in Radio-TV Club, Free Consultation Service, Certificate of Merit and Discount Privileges. You receive all parts, tools, instructions, etc. Everything is yours to keep. Progressive "Edu-Kits" Inc., 1189 Broadway, Dept. 704D, Hewlett, N. Y. 11557.

UNCONDITIONAL MONEY-BACK GUARANTEE

- Please rush my Progressive Radio "Edu-Kit" to me, as indicated below:
Check one box to indicate choice of model
- Deluxe Model \$31.95
 - New Expanded Model \$34.95 (Same as Deluxe Model plus Television Servicing Course and valuable Radio & TV Tube Checker).
- Check one box to indicate manner of payment
- I enclose full payment. Ship "Edu-Kit" post paid.
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 - Send me FREE additional information describing "Edu-Kit."

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- MEMBERSHIP IN RADIO-TV CLUB:
- CONSULTATION SERVICE ● FCC AMATEUR LICENSE TRAINING
- PRINTED CIRCUITRY

SERVICING LESSONS

You will learn trouble-shooting and servicing in a progressive manner. You will practice repairs on the sets that you construct. You will learn symptoms and causes of trouble in home, portable and car radios. You will learn how to use the professional Signal Tracer, the unique Signal Injector and the dynamic Radio & Electronics Tester. While you are learning in this practical way, you will be able to do many a repair job for your friends and neighbors, and charge fees which will far exceed the price of the "Edu-Kit." Our Consultation Service will help you with any technical problems you may have.

FROM OUR MAIL BAG

J. Stataltis, of 25 Poplar Pl., Waterbury, Conn., writes: "I have repaired several sets for my friends, and made money. The "Edu-Kit" paid for itself. I was ready to spend \$240 for a Course, but I found your ad and sent for your Kit."

Ben Valerio, P. O. Box 21, Magna, Utah, writes: "The Edu-Kit are wonderful. Here I am sending you the questions and also the answers for them. I have been in Radio for the last seven years, but like to work with Radio Kits, and like to build Radio Testing Equipment. I enjoyed every minute I worked with the different kits; the Signal Tracer works fine. Also like to let you know that I feel proud of becoming a member of your Radio-TV Club."

Robert L. Shuff, 1534 Monroe Ave., Huntington, W. Va., writes: "Thought I would drop you a few lines to say that I received my Edu-Kit, and was really amazed that such a bargain can be had at such a low price. I have already started repairing radios and phonographs. My friends were really surprised to see me get into the swing of it so quickly. The trouble-shooting Tester that comes with the kit is really swell and finds the trouble, if there is any to be found."

PRINTED CIRCUITRY

At no increase in price, the "Edu-Kit" now includes Printed Circuitry. You build a Printed Circuit Signal Injector, a unique servicing instrument that can detect many Radio and TV troubles. This revolutionary new technique of radio construction is now becoming popular in commercial radio and TV sets.

A Printed Circuit is a special insulated chassis on which has been deposited a conducting material which takes the place of wiring. The various parts are merely plugged in and soldered to terminals.

Printed Circuitry is the basis of modern Automation Electronics. A knowledge of this subject is a necessity today for anyone interested in Electronics.

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4-CHANNEL SOUND

Electro-Voice
takes the first practical step:

EV STEREO-4™
compatible four channel

{ Being more a progress report than an advertisement }

The Promise

Thousands of people have heard 4-channel stereo reproduction at hi-fi shows and special demonstrations in the last few years. Others have read about this fascinating and rewarding technique that promises more faithful reproduction of musical performances. Early experiments have also shown 4-channel to be an effective tool in creating new sonic environments for both serious and popular musical forms. The concept has met with almost universal critical acclaim, and strong general approval.

The Problem

But alas only a handful of enthusiasts can actually enjoy this advance today. Because only a few 4-channel tapes have been produced for sale. The problem is simple, but basic: 4-channel means just that—four separate signals. And to reproduce it properly demands four of everything, right down the line.

Using four amplifier channels and adding four speakers is easy. Even creating a 4-channel tape recorder is practical (although expensive). But the stumbling block has been finding a way to put four completely independent signals in a record groove, or broadcast them over a standard stereo FM station.

And if you can't buy a 4-channel disc, or hear it on FM, the market is limited to a precious few 4-channel tape owners. But their numbers are so small that record companies just can't afford to release four

channel material. So they continue to produce 2-channel stereo that you *can* play (and that they can sell in volume).

The Way Out

Now Electro-Voice has moved to break the impasse. With a system that can offer the significant advantages of discrete 4-channel, yet is compatible with present record playing equipment and present FM broadcasting. It is called STEREO-4.

STEREO-4 is a system that encodes four channels into a stereo signal that *can* be transmitted over FM or recorded on a disc. In the home you add a STEREO-4 decoder, plus another stereo amplifier and a pair of rear speakers. The result is reproduction that closely rivals the original 4-channel sound. Four different signals from your speakers, with a feeling of depth and ambiance you have never before heard from any record.

Admittedly, STEREO-4 is not quite the equal of 4 discrete signals. But while there is some loss of stereo separation, there is no reduction in frequency response or overall fidelity. We might note that this reduced separation actually seems to aid the psycho-acoustic effect for many listeners in normal listening situations. And on the plus side, STEREO-4 offers an advantage that even discrete 4-channel cannot provide.

The Remarkable Bonus

Playback of almost all of your present 2-channel stereo library is greatly enhanced when fed through the STEREO-4 decoder. It's the result of multi-microphone recording techniques that include a remarkable amount of 4-channel information on ordinary stereo discs and tapes. Adding STEREO-4 releases this hidden information for you to enjoy.

The Details

A STEREO-4 Model EVX-4 Decoder costs just \$59.95. And with it, plus 4 speakers and dual stereo amplifiers,

you're equipped for almost any kind of sound available. Encoded 4-channel, enhanced stereo, regular stereo, and discrete 4-channel (assuming suitable source equipment). Even mono. So you have the only system that is completely compatible with the past, present, and foreseeable future.

The Present

And what about encoded 4-channel discs and broadcasts? Well, recording companies have already started mastering STEREO-4 records, and more are joining in. And STEREO-4 is now being broadcast in many major cities around the country.

The Future

Like you, we hope for the day when discrete 4-channel sound will be commonplace on records and FM, and your STEREO-4 decoder will be relegated to enhancing your present library. But that day will have to wait until some very knotty design problems are solved. And probably after a host of new FCC regulations define an utterly new system. Indeed there is serious question whether the problems can be solved at all.

In the meantime, the STEREO-4 system is getting 4-channel recordings into the marketplace in increasing numbers, in form that people can enjoy. Hear STEREO-4 at your E-V soundroom soon. And at your local FM station for a scheduled STEREO-4 broadcast. Or write us for complete information. It's not too soon start planning for tomorrow.

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EVX-4 Stereo-4 Decoder

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