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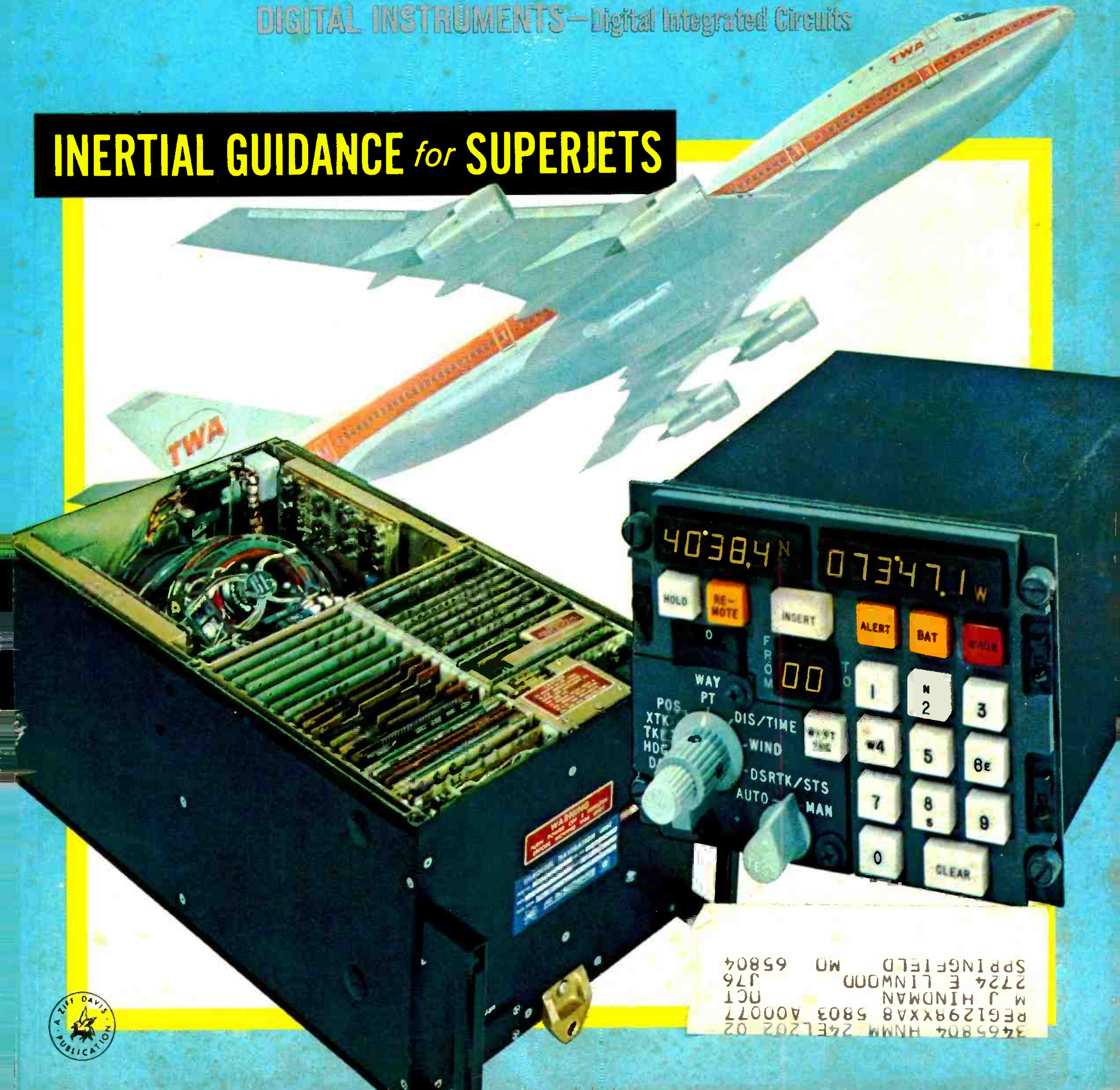

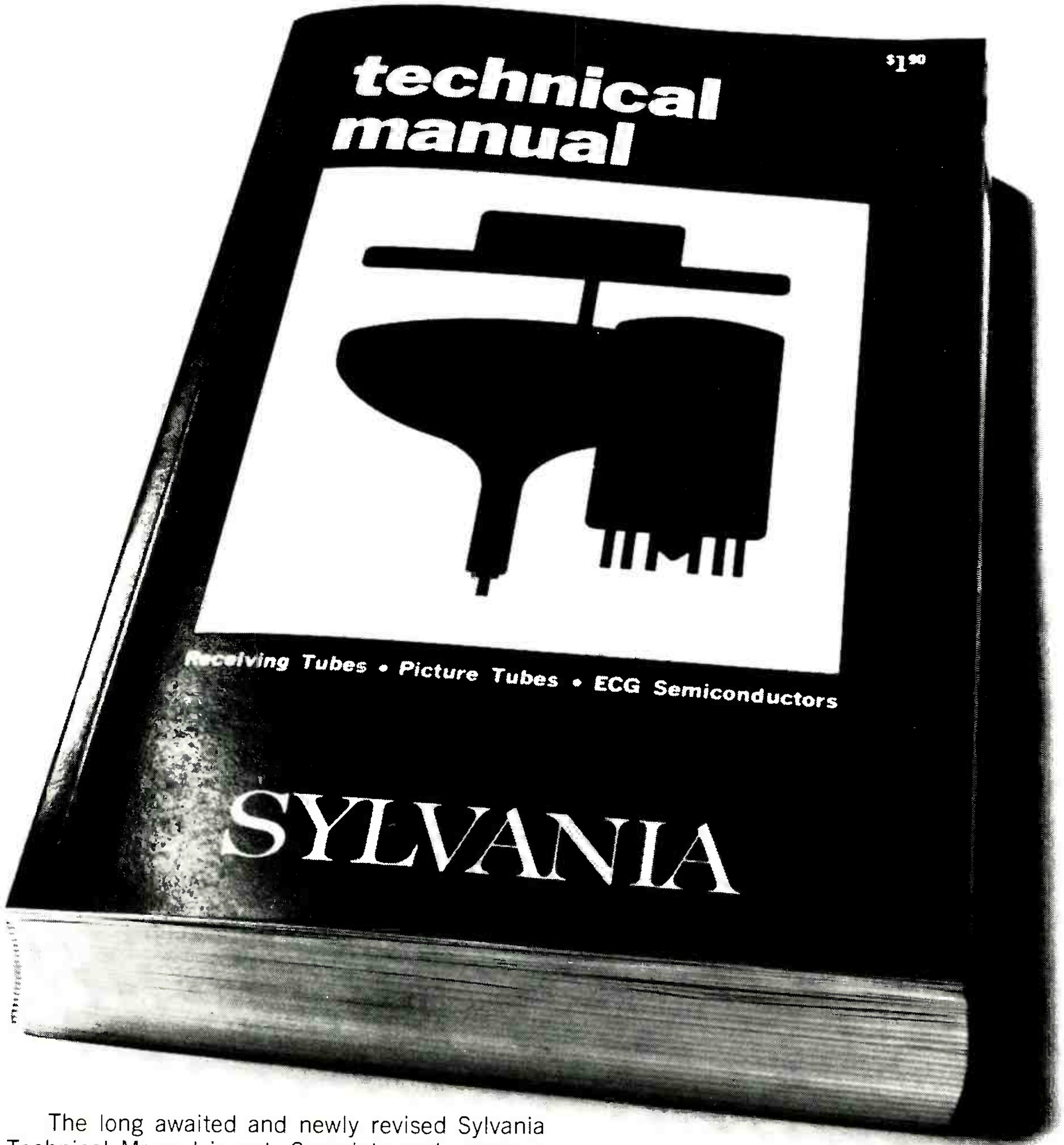
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Electronics World

SEPTEMBER 1970 VOL. 84 NO. 3

CONTENTS

THIS MONTH'S COVER shows the control and display unit (right) used by pilot and the navigation unit (with inertial platform at rear) used in the new inertial navigation system for the Boeing 747 super jet. Each plane carries three such systems which can pinpoint the plane's position without using outside signals, and can be coupled to the autopilot to guide the jet automatically across the continent or around the world. Our lead story this month covers the system, called "Carousel IV," in detail.................Cover photographs: AC Electronics Div. of General Motors and TWA.

Coming Next Month

Special Issue

COMPUTER MEMORIES

Don't miss this important issue containing a 24-page Special Section on the topic of computer memories. Specialists from seven companies cover the ground in depth. You will be guided in the intricacies by Henry T. Meyer of Burroughs, John J. Rienzo and Edwin F. Tarbox of Sylvania, Robert N. Noyce of Intel Corp., George A. Fedde of Univac Division, Di Chen and Obert N. Tufte of Honeywell Research Center, Ronald A. Hill of Ferroxcube, and Caryl A. Thorn of IBM—each man sharing his particular specialty with you. Don't miss this in-depth "must save" section.

DIGITAL VOICE COMMUNICATIONS

Sophisticated pulse techniques, employing solid-state circuits, are making possible the reliable transmission of high-quality speech in digital form. Sidney L. Silver explains how it is being done.

ADDING EXTRA CHANNEL FOR IMPROVED HI-FI AMBIENCE

A third channel, derived from the present two stereo channels, can be applied to one or two rear speakers for an extra sound dimension and greater ambience. David Hafler, President of Dynaco, explains how to make the hook-up and why it works.

GRAPHIC COMPUTER TERMINALS

The first of two-part series which explains how by displaying computer output in picture form the user is able to quickly interpret the data and act upon it. Widely used in busy air terminals, as teaching machines, and in R&D laboratories, these video display terminals permit good machine-man interfaces, thus expediting all communications.

*All these and many more interesting and informative articles will be yours in the **October** issue of ELECTRONICS WORLD . . . on sale **September 17th.***

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LETTERS

ENGINEERING CRISIS

To the Editors:

As a senior in MIT's cooperative program in electrical engineering, I must take issue with the "Engineering Crisis" item in your News Highlights column of May, 1970. The writer gives some good reasons why students are not being attracted to engineering in ever-increasing numbers today, but recommends that engineering schools undertake "exceptional public relations jobs" to help clear up the "anti-engineering atmosphere" that is springing up. Perhaps the situation of five or ten years ago, when the demand for engineering graduates was very high, could be termed an engineering crisis on the college campus; today's "engineering crisis," however, is *not* on the college campus, as the writer implies.

We are entering a period during which the growth of the engineering profession must be slowed, as industry moves away from defense- and aerospace-oriented work towards attacking problems in the social and environmental areas. To dump ever-increasing numbers of science and engineering graduates into the already saturated professional labor market would hurt the entire profession. Also, the new degree-holders would have a hard time finding the kind of position they had come to expect. This is one part of today's engineering crisis.

Engineering schools *are* bringing their curricula up-to-date, but perhaps not in the sense envisioned by the writer. Attitudes of engineering students are changing, while in many cases those of recruiters are not. Company recruiters too often look for what might be termed "old-style" engineering students. They still exist, but their numbers are decreasing. Many students who might be interested in engineering are now looking for something more appealing than the four- or five-year, highly competitive "grind" which is looked upon favorably by industry, and rewards those completing it with a position deep inside some large team effort—also not terribly appetizing to today's student. The new breed of engineering student is likely to be a broad-minded individual, with interests ranging far beyond his professional field.

Recruiters are too often interested in a student's accomplishments early in his academic career, and look with distrust on a student's indecision regarding a professional career. Many recruiters cannot properly evaluate students involved in new courses of study, pass-fail grading systems, and other innovative programs, and are more likely to pass up such students for those who have stuck to a more conventional curriculum. Some traditional standards of accomplishment have been replaced as campus attitudes have changed, while those of industry have not. This is the second part of today's engineering crisis.

KENNETH POGRAN
Class of '70, MIT
Cambridge, Mass.

* * *

SCOPES FOR TV TEST SIGNALS

To the Editors:

I was very much interested in your article entitled "TV's Built-In Test Signals" in the March, 1970 issue of ELECTRONICS WORLD. It would appear to me that observing the vertical-interval test signals would be a valuable method of checking color TV's—both in the home and in the shop—to determine whether the troubles are in the antenna or in the TV receiver. Making this determination would save valuable time.

It is my understanding that a scope should have a bandwidth of about three times that of the particular signal to be viewed. This, I understand, is to reduce the inherent errors of the scope. If this is true, it would be desirable to use a scope having a bandwidth of at least 12 MHz or better in order to view these signals.

I specialize in master-antenna systems and color-TV work. It is for this reason that I am highly interested in your article. I understand that this wide-band scope should be triggered and preferably employ a delayed sweep.

I do not know of any scope under $600 that is capable of this. May I hear from you regarding the above with any suggestions you may care to give.

L. A. HERRIED, Svc. Mgr.
Modern Electric Co.
Vermillion, S. Dak.

Requirements for the scope are not quite as stringent as Reader Herried's letter indicates. However, we do agree that it would be better to use a triggered-sweep instrument with a bandwidth of 10 MHz. There are several such units on the market at well under $600—or even under $400—both as kits and assembled *form. A few manufacturers which come to mind are* Heath, Leader, Lectrotech, *and* Telequipment. *We have reported on all these instruments in previous test-equipment product-report columns in* Electronics World.*—Editors*

* * *

ARMY RADAR TUBE

To the Editors:

Thank you for the fine article "The Tube Behind the Army's SCR-268 Radar" by Harold A. Zahl (which appeared on page 37 of your June issue). It was very interesting and enlightening on the history of the VT-127 electron tube.

Having been on active duty in the Navy before and during World War II, I first came in contact with the VT-127 while at Treasure Island, California Radio Materiél School in early 1941 and, later, aboard the *USS Biscayne*. Four of the VT-127's were used in a grid-blocking, pulsed, ring oscillator in the SC-series radar built for naval shipboard use by *General Electric*.

The installation of this radar was very evident by the placement of the large rotatable "bedspring," multi-horizontal dipole, stacked-array antenna on the main mast of the ship.

When using the VT-127 tube, I recall that we were required to decontaminate the grids after extended use. Again, thank you for the fine article.

George A. Philactos, LLDR, USNR
Western Electric Co.
New York, N. Y.

Thanks to Reader Philactos, as well as to others who have written to us commenting on the article and on their associations with the Army's version of the Eimac 100-*TL ham-radio vacuum tube. —Editors*

* * *

MATH FOR THOSE THAT HATE IT

To the Editors:

We want to thank Mr. John Frye for his excellent comments on the book "Math For Those That Hate It" by Roy Hartkopf, which appeared in his May, 1970 article. We are glad to hear that the book has created so much interest in the United States.

We would like to tell your readers that it can be ordered directly from *Tri-Ocean, Inc.*, 62 Townsend St., San Francisco, Cal. 94107. This should overcome the reluctance some people may have in ordering the book directly from Australia.

Althea Tebbutt, Export Mgr.
Rigby Limited
Norwood, South Australia

We are sorry that Mrs. Tebbutt neglected to tell us the postpaid price of the book, but we are sure our readers can get this information by sending a card directly to the above California address. —Editors ▲

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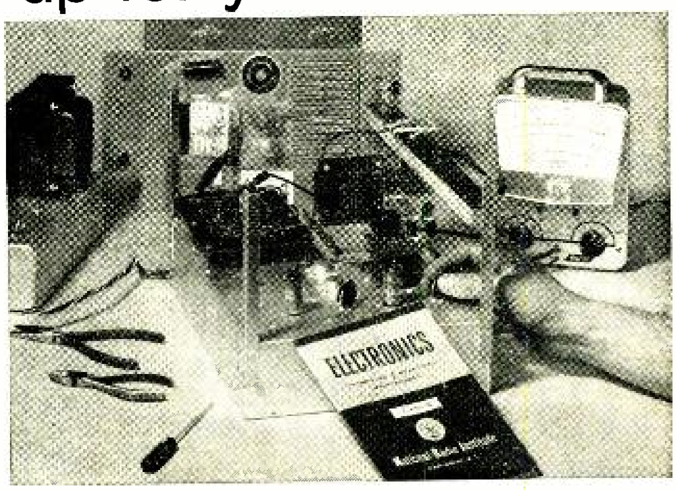

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What Should You Pay for a Hi-Fi Speaker System?

Including Lab Tests of the Complete AR Loudspeaker Line

You get what you pay for in terms of distortion, bass reproduction, treble dispersion, balance, and frequency response.

YOU can pay as little as $10, or as much as $1000 for a speaker system. At either extreme, there is little difficulty in making a choice. No one expects really high-fidelity sound from a $10 box, and if you can seriously consider one of the premium-priced systems, your field of choice is not very large. However, most of us have limited budgets, and are faced with the dilemma of interpreting the specifications (or lack of them) on a number of competing speakers, and hopefully choosing the one that best suits our needs.

The most obvious external characteristic of a speaker system is its cabinet, or enclosure. Most systems priced below $200 (and a few at somewhat higher prices) are in the so-called "bookshelf" format. There is little variety possible in the styling of a box. Indeed, the grille-cloth pattern is the major visual difference among most of them. Bookshelf systems can also be installed on the floor in a vertical position, but they will do little to enhance the appearance of a well-furnished room.

To meet the demand for speakers that are also attractive pieces of furniture, many manufacturers offer a line of styled floor-standing enclosures of various designs, sizes, and the number and types of drivers used in them. The cabinet often represents a large portion of the final selling price, without contributing to the sound in proportion to its cost. Over wide limits, there is surprisingly little correlation between cabinet size and sound, and the choice of a furniture-styled speaker system should be made with the realization that equally good sound could be bought for less in a simple box or, in many cases, better performance could be obtained for the same money by accepting a less attractive cabinet.

Two-Way Speaker Systems

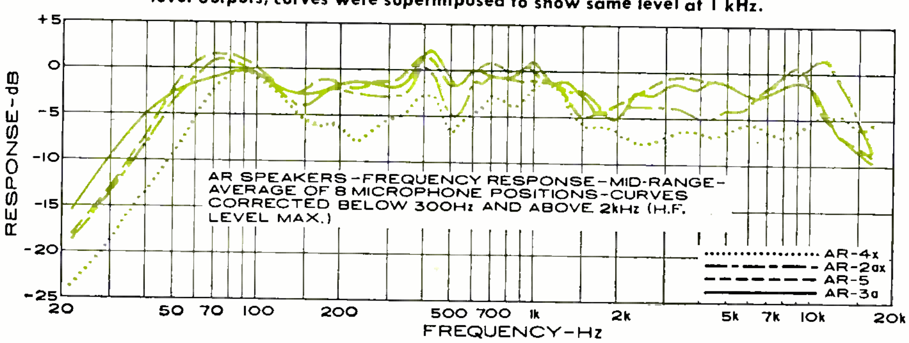
Most quality speaker systems use more than a single driver. The large radiating surface and cone excursions required for good bass performance are simply not compatible with smooth, well dispersed high-frequency output. The simplest and cheapest solution to this problem is the use of a *two-way* system, in which a relatively large "woofer" handles bass and middle frequencies with high frequencies channeled to a smaller "tweeter."

Two-way systems are available in the lowest priced range (under $40) and at prices up to $100 or more. To appreciate the reasons for this price spread, let us consider the components of the system. Although almost any speaker which is not required to handle high frequencies might be called a "woofer" (we have seen the term applied to speakers less than 6″ in diameter), a good bass speaker must be designed specifically for that purpose. Woofers are usually from 8″ to 15″ in diameter, with rigid cones suspended in a manner that allows considerable axial movement. Not only does this call for a compliant suspension of the voice coil and the cone edge, but in the interests of low distortion the magnetic circuit must be designed so that the voice coil never leaves the linear region of the magnetic flux. The size and weight of a speaker's magnet and associated structure are closely related to its performance and price.

To convince yourself of this relationship, compare the prices and weights of a number of unmounted speakers as listed in the catalogues. The weight, of course, is only a crude indication of the magnetic strength of the speaker, and tells little about the quality of its design, but the correlation with price will be apparent. The magnetic system is one of the major cost factors in a loudspeaker design.

There is no necessary relationship between magnet size and cone diameter.

Fig. 1. Comparative frequency response of the four loudspeakers tested. No attempt was made to compare efficiency of sound level outputs; curves were superimposed to show same level at 1 kHz.



MODEL	AR-4x	AR-2ax	AR-5	AR-3a
Dimensions (w x h x d)	19" x 10" x 9"	24" x 13½" x 11½"	24" x 13½" x 11½"	25" x 14¼" x 11½"
Weight (lbs)	18.5	36.5	39	53
Woofer	8"	10"	10"	12"
Mid-range	- -	3½" cone	1½" dome	1½" dome
Tweeter	2½" cone	¾" dome	¾" dome	¾" dome
Crossover Frequency (Hz)	1200	1400/5000	650/5000	575/5000
Price ($) (in walnut finish)	63	128	175	250

Table 1. Some of the important physical characteristics of the loudspeakers used as examples.

There have been 4" speakers with heavy magnets, and 15" or larger cones combined with tiny magnets that would be better suited for a portable radio speaker. A speaker with a skimpy magnet and a large cone may seem to be a good value, but this is an illusion. A powerful magnetic circuit is needed for proper control of the voice-coil movement and for good efficiency. It is more important to good sound quality than the size of the cone.

All else being equal, the size of the cone is related to the low-frequency output capability of a speaker. At one time it was widely considered that a 15" woofer was the key to good bass response. However, there are 8" and 10" acoustic-suspension speakers, capable of very large cone excursions, that can match all but the best 15" speakers at moderate volume levels. Large cones are needed when very high sound levels are required, such as in public-address and musical-instrument amplification. The same benefits can be obtained by paralleling two or more smaller speakers, but this particular arrangement may be more expensive than using a single large speaker.

The principal weakness of the two-way system is the requirement that the woofer operate well into the mid-range region. The crossover to the tweeter usually takes place between 1000 and 3000 Hz. Limiting tweeter operation to the higher frequencies allows it to be smaller and to have better dispersion characteristics. However, the woofer, if it is designed to perform well at low frequencies, will tend to have irregular response and poor dispersion in the kilohertz range. This is, unfortunately, the most critical range for good reproduction, and it is in the mid-range that much of the difference between speakers can be heard.

If the crossover frequency is lowered to 500 Hz, for example, the woofer can operate much more effectively. However, the tweeter must now be designed to operate a couple of octaves lower in frequency, which requires a larger diameter or greater excursion capability, or both. This, in turn, impairs its performance at very high frequencies, as well as increasing its cost.

Three- & Four-Way Systems

The most common solution to this problem is to use a *three-way* system. Some speaker systems selling between $100 and $135 are three-way systems, as are almost all at higher prices. In the three-way system, the lows, middles, and highs are handled by separate drivers. With each driver covering a limited frequency range, its design can be optimized. Of course, the three-way approach is inevitably more costly because of the additional driver and crossover components. A good three-way system is characterized by a smooth, uniform over-all frequency response with wide dispersion over most of its operating range.

The crossover network is a basic part of all multi-way speaker systems. Usually concealed within the cabinet, its presence may not be obvious to you, but it plays a vital role and can represent a significant part of the cost of the system. In the simplest two-way systems, the woofer is designed to have a naturally falling response above the crossover frequency and the network consists of a single capacitor in series with the tweeter voice coil to attenuate the low frequencies. Even in this basic form, the cost of the network is a function of the crossover frequency, since a lower crossover frequency requires a larger capacitor.

Better control of the woofer performance near the crossover frequency is obtained when an inductor is placed in series with its voice coil to roll off the higher frequencies. This can be a rather bulky and expensive component if a low crossover frequency is used, which is yet another reason for the relatively high crossover frequency employed in most two-way systems.

The basic crossover network has a gradual response slope of 6 dB/octave beyond the cut-off frequency. Some speaker systems employ more elaborate networks, with a 12 dB/octave slope. These use twice as many inductors and capacitors and are correspondingly more expensive. There is no clear-cut advantage to the more complex networks and it is generally agreed that, if the speaker characteristics permit, the use of the simpler network results in a smoother transition from one speaker to another. Horn-loaded mid-range speakers, in particular, must be protected from low-frequency energy, and steep crossover slopes are often necessary when they are used.

There are a few four-way speaker systems. The fourth speaker is usually a "super-tweeter," operating above 8 to 10 kHz and its chief contribution is to improve dispersion in this region, where conventional tweeters are somewhat direc-

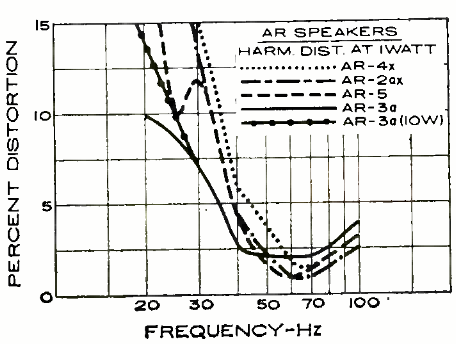


Fig. 2. Harmonic distortion of the four speakers. Note how distortion increases as frequency is lowered. Above 60 to 70 Hz, distortion remains low and differences are not significant. The higher quality, and more expensive, speakers have lower distortion at lowest frequencies and they are able to produce substantial output at these frequencies. On the other hand, if you don't require as much bass, a less expensive speaker whose distortion measures higher at lower frequencies (30-50 Hz) has reduced output at these frequencies so higher distortion figures may not be significant.

drivers, and choice of crossover frequencies, we can roughly estimate the nature of the difference among various models of a given manufacturer's line. Of course, this is not a substitute for listening to the speakers, but it may help clarify the differences that will be heard.

A Logical Approach

There are several possible logical approaches to choosing a speaker system. A reasonable first step is to decide between a floor-standing model and a bookshelf system. If you have established a budgetary limit for your speakers, try to listen to several suitably styled models priced a bit above what you expect to pay. In all probability you will prefer the sound of one make over that of the others.

Compare the features of that manufacturer's lower priced models with those of the ones you have heard. Since some manufacturers have more than one line of speakers (bookshelf, console, forward-radiating, omnidirectional, etc.) be sure to compare related models. You may find a less expensive unit with the same tweeter but a smaller woofer, or a different crossover frequency. Often the basic sound quality of an expensive speaker is available in much lower priced units from the same maker, and you may not miss the added half octave of bass or stronger mid-range of the costlier speaker system.

When you have found one or more acceptable speakers at the price you are considering, compare them to similarly priced speakers from other manufacturers. Perhaps you will find one more to your liking—if not, you will have reinforced your decision and will have confidence that you have made the best choice.

Examples of Performance and Price

To further illustrate the relationship between performance and price we have chosen the loudspeaker systems of *Acoustic Research, Inc.* and have made a complete series of measurements and listening evaluations on the AR-4x ($63), AR-2ax ($128), AR-5 ($175), and AR-3a ($250). Their physical characteristics are presented in Table 1, which shows how they are related and where they differ. The frequency response (Fig. 1) and distortion measurements (Fig. 2) for the four speakers were made under identical conditions and may be used as valid comparison of their performance. Fig. 3 shows the high-frequency dispersion of one of the speakers under test, which is fairly typical for the entire group. Tone bursts for this loudspeaker, also typical for the entire group, are shown in Fig. 4.

The AR-4x is a simple two-way system; all the others are three-way systems. It is interesting to see that the top three models use the same tweeter, a ¾" diameter dome radiator. The AR-2ax and AR-5, in addition, share the same cabinet and woofer. Their mid-range speakers are different and the woofer crossover is about an octave lower in the AR-5. The top-of-the-line AR-3a has the same mid-range and high-frequency drivers as the AR-5, but uses a much heavier 12" woofer in a slightly larger cabinet. This gives it about a half octave lower bass and lower distortion at low bass frequencies.

Note that the increased price going from one model to the next generally buys smoother or wider response in only one portion of the frequency range. The buyer who is aware of this can usually make a more intelligent selection. For example, if you are not an organ buff, you may save $75 by getting the AR-5 instead of the AR-3a. The low-priced AR-4x has a response curve very similar to that of the AR-5 or AR-3a, except in the low bass. As might be expected, it sounds very much like the more expensive speakers, but lacks the ability to shake the room with its bass output and is more directional at high frequencies. The AR-2ax and AR-5, despite their common components, sound distinctly different, with the AR-5 having more prominent and well-defined midrange.

Although we could not test all, or even a reasonable percentage of the available speakers, the *AR* line illustrates very nicely the manner in which price is related to performance in a line of speaker systems. Other manufacturers making speaker systems in a number of price ranges include: *Acoustron, ADC, Altec-Lansing, Electro-Voice, Empire, Epicure, Fisher, JBL, Jensen, KLH, Recti-linear, H.H. Scott, University,* and *Wharfedale.*

Each of these manufacturer's products is governed by the same cost/performance relationship. Remember that the sound characteristics among speakers from different manufacturers are usually quite different even though the speakers may be comparably priced. This is an expression of their designer's philosophy as to what a speaker of given price should sound like. This emphasizes the importance of listening carefully to the products of several manufacturers before making a purchase. Once you find a manufacturer of speakers whose sound pleases you, there should be little difficulty in selecting one of his products at the right price for you. ▲

(For additional information on the AR *speaker line, circle No.* 1 *on Reader Service Card.)*

(Editor's Note: If you found this article on speakers helpful, you won't want to miss a similar treatment of phono cartridges scheduled for our November issue. Be sure to watch for "What Should You Pay for a Hi-Fi Phono Cartridge" by Hirsch-Houck Labs.)

Radio & Television news

By FOREST H. BELT /Contributing Editor

Beware Of Overkill

Although it's rarely wanted, and usually resented, a word of warning is sometimes needed. Warning advice is helpful only if it comes *before* a trouble develops. Here is one for the servicing industry to be thinking about.

The consumer electronics industry is working hard on several fronts to develop competent service technicians. We're orienting electronics instructors to teach servicing. We're attracting young apprentices with special programs that mix on-job and classroom experience. We're upgrading technicians already in the business. This activity is burgeoning mainly because of a much-touted shortage of qualified men to do the $600-million-a-year maintenance job home electronics requires.

Some manufacturers are pushing hard to create "any kind" of technician. just so he gets busy servicing right away. These manufacturers think privately that enough warm bodies fiddling with TV sets and hi-fi's, even though minimally trained, will drive the cost of servicing down. In other words, they feel (unofficially, of course) that if they glut the electronics-repair market with enough "technicians" to make competition tough, service prices will be forced back to pre-color-TV levels.

Hopefully, the service industry is too smart for that. But mistakes have been made before; they might be again. The situation bears watching. Leaders must not let happen what has happened in the fields of physics and nucleonics. Space and nuclear exploration became big things 15 or so years ago. Colleges and universities rushed to emphasize those curricula heavily, and turned out tens of thousands to fill the need. Lately, attention is shifting elsewhere—poverty, pollution, social problems. We now have an overabundance of highly trained, high-salaried physicists, engineers, and scientists. Once-popular space and nuclear experts are out of jobs by the thousands.

An oversupply of service technicians would be equally disastrous to the home-electronics servicing industry. Of course, this hasn't happened yet, nor is it imminent. But the possibility should be borne in mind as training programs continue to proliferate.

Pay-TV Keeps Hanging in There

Despite the adverse legislation over its head (this column, last month, page 6), subscription television continues to forge ahead. A new system has been filed with the Federal Communications Commission. A company called *Vue-Metrics, Inc.* wants to use its own coder/decoder system over-the-air. The firm has filed an application for channel 23 in Philadelphia.

The mischievous bill that was introduced by Representative John Dingell appears about to die its deserved death. The bill pretended to approve pay-TV, yet regulated it so strictly it couldn't possibly survive. The bill has been an effective stall, however. The FCC long ago spelled out how subscription-TV could go ahead, and with very reasonable safeguards of the public's "interest, convenience, and necessity." A suit filed to block that go-ahead was overruled by the Supreme Court.

There is no deterrent now, except the hesitancy of pay-TV leaders to proceed under the threat of being squelched by Congress. It's really high time the Congress had enough faith and courage in the American way to let the system be subjected to the public market. If it's as undesirable as its detractors say, pay-TV would wither away in a very short time. If not, the U.S. public is even now being cheated of the use of an important medium of entertainment.

More News in Color Picture Tubes

Besides the fast swing to square-cornered color CRT's, the 1971 lines sport some other special features. For example, *RCA* has available the first color set with 110-degree deflection. It's an 18-inch model which some dealers saw at the Consumer Electronics Show in June.

The Japanese are not to be outdone. *Toshiba* has a 15-inch, 110-degree version that will be in sets by the end of this year. *Sylvania* has an 18-inch set in prototype that uses a 110-degree tube. The wider angle of deflection makes the picture tubes shorter—and sets about 4 inches slimmer. One holdback has been deflection components that could sweep that wide angle with acceptable linearity and convergence; that problem is solved. Sweep-components makers showed 110-degree color flybacks and yokes earlier this year.

Another color-CRT development is an in-line gun structure *Sylvania* is experimenting with. *General Electric* already uses the principle in small color tubes for its "PortaColor" models, but no one has applied it to large screens before. A major advantage is better convergence and purity, with fewer dynamic convergence adjustments. *Sony* has such a simplified convergence arrangement in its color sets using the one-gun, three-beam Trinitron picture tube.

Tuner-Parity Rules Finally Set

The industry finally got a revised tuner-parity ruling from the FCC. In some ways, the rules are easier than they were originally: in other ways, tougher. The time element is easier to meet. The u.h.f. tuning has to be as easy as v.h.f. in 10 percent of any manufacturer's models by July 1, 1971; 40 percent by July 1, 1972; in 70 percent by July 1, 1973; and in all by July 1, 1974. Ruling applies to imports, too.

For sets with detented tuners, a 6-station detented u.h.f. tuner will be acceptable to the FCC. However, the u.h.f. stations must be adjustable by the set owner, without tools. Thus, merely providing six pretuned u.h.f. positions is not enough. Some tuners already available meet this criterion.

A set with detented v.h.f. doesn't have to use detented u.h.f. Push-buttons could be used for u.h.f. stations, but "owner adjustable" rule applies no matter what mechanical arrangement is incorporated.

Tuning aids—such as signal-seeking, automatic fine tuning (a.f.t.), or visual helps to fine tuning—must apply to both u.h.f. and v.h.f. The channel indicators must be equivalent for both bands, and the knobs must be of equivalent size and shape.

A few of the color-TV models planned for the 1971 selling season have already incorporated some principles of the ruling. Manufacturers have known for some time they'd have to do something. Electronic tuning is the simplest way—at least for the viewer.

Sharp has what seems the easiest to use. It is a signal-seeking u.h.f./v.h.f. tuner that scans both TV bands until it encounters a station. It can be made to scan in either direction—from channel 2 up through 83 or from the top down. Band-changing is automatic in the scanning process. Scanning is silent and takes about half-a-minute from one end to the other. The number of the channel on which the tuner stops flashes on a pair of Nixie tubes. Touchbuttons for up or down are operated by body capacitance.

Motorola took a different approach in some top-of-line models for 1971. The u.h.f. channels are intermixed with v.h.f. channels on a regular 13-position detented channel selector. The u.h.f.'s take the place of unused v.h.f. positions. Behind the dial, the v.h.f. tuner is conventionally mechanical, but u.h.f. is varactor-tuned in a separate tuner.

Tuner Equality Not Enough?

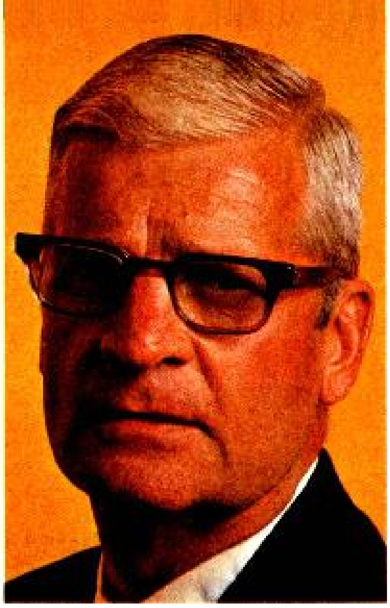
With tuner-parity rules finally laid down, set manufacturers took a deep breath of relief. The tension relaxed at last. Now they could gird for the push to meet the deadlines specified by the FCC.

But their relaxation may be short-lived. Now a new bother is shaping up in the tuner field. Cable-TV operators are making plans to ask the FCC to force television-receiver manufacturers to put 20-channel tuners on receivers for cable systems. Just what frequencies are to be involved hasn't been decided. Nor has the deadline for making 20-channel receivers.

Of course, this is so far only wishful thinking. Cable people talking about it at the National Cable Television Association convention in Chicago last June seemed to have tongue in cheek. But that doesn't mean there won't be filings and hearings on the subject. Now that the u.h.f. people have pushed tuner parity through, why shouldn't cable people try to push their own pet notion through? One difference is, a 20-channel cable-oriented tuner will do a lot more for cable than tuner parity is going to do for u.h.f. broadcast stations.

Flashes in the Big Picture

First color set to operate from 12-volt auto power comes from *Hitachi*; plugs into cigarette lighter or into regular 117-volt house current. . . . *Sylvania* joins U.S. manufacturers (*Motorola, RCA, Zenith*) producing solid-state color receivers: 1971 model is due in few weeks. . . . New Japanese name in U.S. electronics is *Mitsubishi*, selling under *MGA* label; interesting twists: some of its large-screen consoles are assembled here in the U.S. (this company has been marketing Japanese-designed U.S.-built airplanes that way). . . . Another name being used is *Sanyo*, on *Craig-Sanyo* line of TV sets: *Sanyo* has for years built private-label sets for domestic brands. . . . *Altec-Lansing*, important name in commercial sound, gets into high-tag home stereo market; unique product is equalizer with 48 individually tuned filters to allow trained hi-fi expert to adjust response of stereo speaker systems to suit acoustics of listening room. . . . Most U.S. color-TV manufacturers are now including one-year free service in warranties; plan may extend to other products in the near future. ▲



"Stop kidding yourself about your future in electronics."

Men without advanced technical education will find few opportunities in electronics in the years ahead. But industry will offer exciting work, good pay and excellent security to men who become specialists in these key areas:

- Electronic Engineering Technology
- Aeronautical & Navigational
- Television
- Communications
- Nuclear Instrumentation & Control
- Missile & Spacecraft Guidance
- Radar & Sonar
- Nuclear Engineering Technology
- Automatic Control
- Industrial Electronics
- Computers
- Digital Communications
- Electronics Systems Engineering

Take the advice of men who know the electronics industry. Make yourself a specialist in one of the key areas of electronics. Then stop worrying about how cutbacks, layoffs and contract terminations will affect you and your family. If you have up-to-date specialized knowledge of electronics, you can look forward to security and excellent earnings when men with ordinary qualifications are let go.

But to become a specialist, you must supplement your experience in electronics with more technical education. CREI Home Study Programs offer you an opportunity to get that additional education without going back to school.

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NEWS HIGHLIGHTS

Hope for Stutterers?

Preliminary test results of a simple electronic device shows promise of reducing or eliminating stuttering. Unit, called "Speech Rectifier," consists of ear pieces, pocket-size battery-powered sound generator, and throat microphone. Operates on principle of voice masking; that is, speaker is shielded from hearing own voice. For unknown reasons, most subjects stutter far less or not at all during masking. Subject's voice actuates masking sound, preventing him from hearing his own voice and automatically shuts off when he stops talking, permitting him to hear others. Of 54 subjects tested 1 to 24 times, both with and without masking, 75% had improvements of 50% or more when using Rectifier. Nearly 1/4 of subjects had improvements of 90 to 100%, that is, stuttering completely or nearly completely eliminated. After 14 to 18 sessions 47% of subjects had halt the number of blocks even after device was removed as compared to their normal speech patterns. Speech correction program is being conducted at Speech Rectification Center, 1127 Wilshire Blvd, #1500, Los Angeles, Calif. 90017 by *Dallons Instruments*, a division of *International Rectifier Corp*.

Jobs for Army Retirees

The Department of Defense has instituted a computerized job referral program designed to utilize both government and industry in locating a second "career" for military retirees. Since average retiree is between 41 and 51, an age at which most men find their family obligations greatest, it becomes imperative for him to find additional means of support. Program will provide improved means of communicating with prospective employers and *vice versa*. Computerized system will match man to job and forward resumés to prospective employer. Retirees interested in program should report to nearest military installation six months prior to discharge. Interested employers are asked to contact Centralized Referral Activity, Defense Electronics Supply Agency, Attn: DESC-R, Dayton, Ohio 45401; or Director, Transitional Manpower Programs, Attn: Referral Program Coordinator, OASD (M&RA), Room 3D271, Pentagon, Washington, D.C. 20301.

Cable TV

Recognizing growth potential of cable-TV industry, *RCA Commercial Electronic Systems* forms new Cable Systems Department. W. Thomas Collins, who has served *RCA* in various executive capacities for nearly 20 years, has been named department manager. Mr. Collins said *RCA* is currently offering cable operators a complete line of "live" film and video tape equipment for color and monochrome programs and expects to broaden its product line and extend its marketing efforts as new department's plans are activated.

TV or Not TV?

That is the question that will not have to be asked about color-TV transmission from moon if astronauts are equipped with color-TV camera recently demonstrated to press by *RCA* in N.Y. Camera weighing only 10 pounds and measuring 4 x 6½ x 16½ in. was designed by *RCA Astro-Electronics Division* specifically for use on lunar missions. Heart of camera is revolutionary Silicon Intensifier Tube (SIT), developed by *RCA Electronic Components*. Tube's imaging surface consists of almost 400,000 individual silicon diodes. SIT makes camera immune to damage from direct sunlight and highly resistant to damage from jolts or vibrations. Silicon target vidicon technology also makes possible the transmission of color pictures from the moon in dimness of sunrise to brilliance of high noon. Two of these cameras have been ordered by NASA's Manned Spacecraft Center.

Improved Tire Tester

Patent Office awards *B. F. Goodrich* patent for improved version of tire uniformity measuring machine. Original machine inspected tires for radial force variation and rejected those which failed ride-quality standards. Patent covers electronic circuit, used with computer, that enables machine to automatically locate irregularities in radial force variation and mark tire with paint as guide for later correction.

Charge 'er Up

May replace the familiar "service station" cry of "Fill 'er up" if some measure of success is obtained with one of the large number of electric powered cars being experimented with today. Recently *General Motors* demonstrated an experimental electric car powered by six zinc-air batteries and eight specially designed *Delco-Remy* lead-acid batteries. Zinc-air batteries give car a range of 90 miles at 55 mi/hr and about 150 miles at 30 mi/hr (up to six times range of lead-acid battery powerplant of same weight) while lead-acid batteries are used to accelerate car to 30 mi/hr from standing start in less than 10 seconds. Top speed of experimental car, called the XEP, is about 60 mi/hr. Although zinc-air battery car offers interesting potential for future urban vehicle applications, Dr. Paul F. Chenea, *GM* vice-president in charge of Research Laboratories, feels that, at the moment, this system is not practicable for automotive applications. Main disadvantages of zinc-air batteries are weight (1600 lbs), size (completely fills trunk), and they must be mechanically recharged (nearly 300 zinc plates and potassium-hydroxide electrolyte must be removed and replaced) as opposed to electrical recharging.

Semiconductor Sales

According to Electronic Industries Association's Marketing Servicing Department, U.S. factory sales of semiconductor products (monolithic and hybrid IC's and discrete devices) during first three months of 1970 registered a 12.3% gain over sales during same period in 1969. Leading this growth were sales of linear IC's reaching 11.7 million units at $22.9 million, up 134.0% and 80.3%, respectively, from unit and dollar sales last year.

Electronic Personalities

After ten years with *RCA*, Delbert L. Mills, senior executive vice-president, Consumer Products and Components, retired on July 1, 1970. Mr. Mills, who played key role in development and growth of color television into multi-million-dollar industry, has agreed to continue as a consultant and member of *RCA*'s Board of Directors. . . . George W. Steeves, rising from stockroom clerk for *Radio Shack* in 1948 to eastern regional manager in 1969, has been named president of *Allied Electronics*, a division of *Tandy Corp*. His goal is to make *Allied Electronics* "the largest and most profitable industrial electronics distributor in the nation." . . . Dr. Henri Busignies, senior vice-president and chief scientist of *Inter-*

national Telephone and Telegraph Corp. was given the IEEE Award in International Communications "for his outstanding leadership and technical contributions to the field of electronic technology and communications techniques." No stranger when it comes to awards, Dr. Busignies received the Pioneer Award of the Aeronautical and Navigational Electronics Group of the IRE (IEEE) in 1958 for his invention of world's first automatic direction finder for aircraft and the David Sarnoff Award of the IEEE in 1964 for outstanding achievements in field of electronics.

Home-Styled Computers

Desk size, portable (4 pounds) computer designed specifically for home market has been developed by *Compusad, Inc.*, 16 Wetmore Street, New York Mills, N.Y. 13417. Comparable in functions and performance to bulky academic computer trainers, unit, called "Compulogical Tutor," has been simplified to a point where any member of family, even an 8-year old, can readily understand its operation. Comes complete with all circuits, controls, and logic blocks and will work for months on one inexpensive dry-cell battery set (not included). Computer performs add, substract, multiply, and divide operations in microseconds. Comprehensive instruction manual is included that explains all modern computer concepts (*i.e.*, digital logic, Boolean algebra, computer circuits, etc.) and outlines hundreds of specific projects and problems (*i.e.*, accounting, economics, finance, etc.) that can be worked on it. May be ordered direct from manufacturer for only $69.95 each, postpaid and fully guaranteed.

Can You Tap This?

An electronically controlled water tap that can be turned on and off without being touched has been developed by *Venlo Sanitair* of Venlo, the Netherlands. Unit consists of chrome-plated arm (tap) with plastic sensor, a small box containing electronic equipment, two magnetic valves, and connecting wires. Any movements within 1.2 inch of tap causes signals to be developed in capacitance circuits located in sensor. These signals are amplified by electronic equipment to operate magnetic valves in water supply lines. Movements along right side of tap cause cold water to flow; along left side hot water and simultaneously along both sides a mixture. Repeating movement cuts off water supply. Temperature of mixed water can be set by stop cocks mounted in front of magnetic valves. Thermostatic control is also available. Ideal for industrial sterile rooms, laboratories, operating rooms, and wherever aseptic conditions are desirable. For further details write to Netherlands Consultate General, Commercial Division, 10 Rockefeller Plaza, New York, N.Y. 10020.

Talking Computer

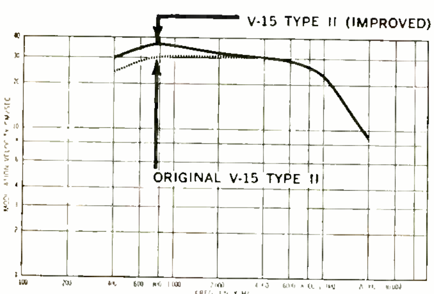
Unlike most talking computers that depend on playback of pre-recorded magnetic tapes, *Bell Telephone Laboratories'* engineers have "taught" computer to convert printed English text fed to it *via* teletypewriter into synthetic speech. Computer analyzes sentences, assigns stress and timing to each word, and finds phonetic description of each word from dictionary stored in its memory. Mathematical descriptions of human vocal-tract motions are then computed and used to generate electrical speech signals. These signals can then be heard over a loudspeaker or telephone. Realizing spoken as opposed to written words take on different meanings, depending on function or position in sentence, researchers programmed computer to distinguish between such expressions as "a name/an aim" and "a nice man/an iceman." Text-to-speech converter was devised by Cecil H. Coker, with help of Mrs. Noriko Umeda and other members of *Bell Labs'* Acoustics Research and Human Information Processing Department, at Murray Hill, N.J. Potential use of computer seen in such applications as information retrieval, aid for blind, and programmed instruction.

Coming Events

Latest in measurement, calibration, data acquisition, data transmission, control, computation, communications, etc. will be displayed at fourth 1970 Instrumentation Fair to be held in Washington Hilton Hotel, Washington, D.C. on September 15 and 16. Twenty daily one-hour workshop seminars will be presented to give attendees opportunity to learn more about application of displayed equipment (computers, microwave devices, tape recorders, IC's, etc.). There will be no admission charge for qualified persons. Contact Norm Ward, Ad-Tech, P.O. Box 475, McLean, Va. 22101 (phone 703-536-4330) for information. . . . and for those creative engineers and inventors who are looking for way to turn their ideas into money, a one-day seminar will be given at UCLA to show them how. Seminar, called "Converting Ideas into Marketable Products," will be conducted by such experts as a market analyst, a patent attorney, and production managers on Saturday, August 29, from 8 a.m. to 6 p.m. Fee for conference, including lunch, is $45. Write UCLA Extension Continuing Education in Engineering and Science, P.O. Box 24902, Los Angeles, California 90024 (phone 213-825-3344 or 825-1295) for information. ▲

EVEN A HALF-TON DUNE BUGGY SOMETIMES WEIGHS ¾ GRAM

The "Mint 400" Del Webb Desert Rally



TRACKABILITY CHART (1 GRAM STYLUS FORCE)

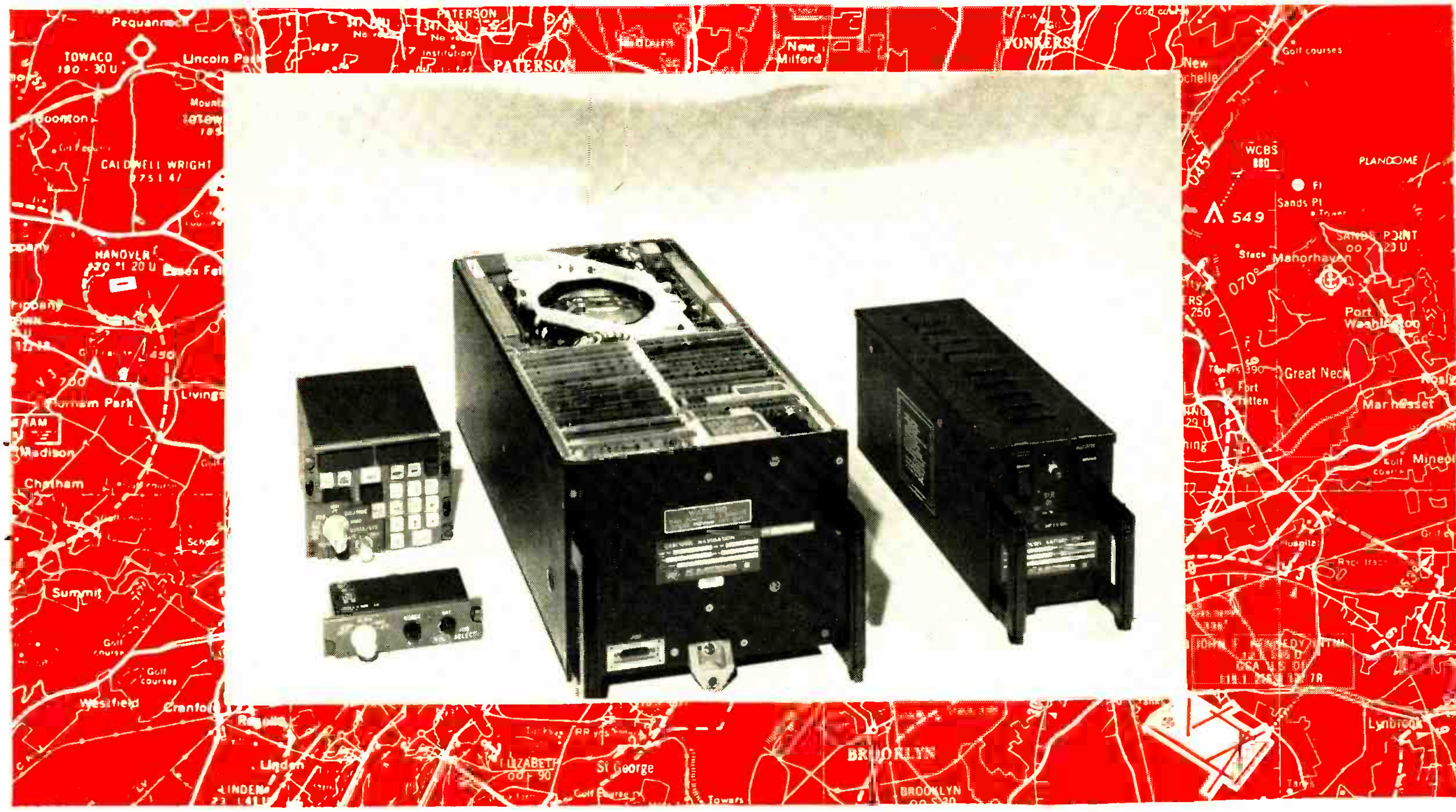
The same inertial forces that make a vehicle airborne when cresting a hill affect the tracking force of the phono stylus. Record surfaces, unfortunately, are a morass of miniscule hills and valleys. When the stylus is nominally tracking at 1 gram, this force significantly *increases* as the stylus enters a "hill," and *decreases* as it begins the downward "plunge." In addition, frictional characteristics of the tone arm or record changer mechanism may further affect uniformity of tracking forces; however, the *Shure V-15 Type II Improved Cartridge* retains its trackability throughout the audio spectrum. It accomplishes this difficult task within a critically determined latitude of tracking forces (¾ to 1½ grams) to insure continuous contact with the groove walls regardless of the varying tracking forces caused by the hills and valleys in a record groove.

Here is why fractions-of-a-gram are important to record and stylus-tip life: ¾ gram tracking exerts a pressure of 60,000 lbs. per sq. in. on the groove walls—and this rises to 66,000 lbs. per sq. in. at 1 gram, and 83,000 lbs. per sq. in. at 2 grams. At 2 grams you have added over *11½ tons* per sq. in. to the groove walls *over ¾ gram tracking!* Think about it.

SHURE V-15 TYPE II (IMPROVED)

Shure Brothers Inc., 222 Hartrey Avenue, Evanston, Illinois 60204

CIRCLE NO. 117 ON READER SERVICE CARD



These black boxes make up the inertial navigation system. At left are the pilot's links with the all-weather system, the mode selector in foreground, and the display unit. At center is the heart of the system, the navigation unit, which contains inertial platform and a high-speed digital computer. At right is the backup battery supply.

Inertial Navigation for 747 SUPERJET

By EDWIN L. HUGHES/Staff Engineer, Carousel IV Program, AC Electronics Div., General Motors Corp.

Technical details on system that automatically pinpoints jet's position and flies it anywhere in the world, in all kinds of weather, without using external radio, radar, or other navigational aids.

IF missiles and spacecraft can be guided automatically for thousands of miles with phenomenal accuracy—why can't the same technology be applied to commercial aircraft navigation? Engineers at *GM's AC Electronics Div.* pondered that question for nearly a decade and then began serious work on the problem early in 1966. Within three and one-half years they saw their dreams come true when the Federal Aviation Administration (FAA) certified their Carousel IV inertial guidance system as the primary navigation reference for the *Boeing* 747 superjet. FAA certification came late in 1969 and included use of the inertial system on the *Boeing* 747, 707 and the *Douglas* DC-8.

The automatic, all-weather inertial system is totally self-contained and is completely independent of radio, radar, or magnetic navigation aids, or man's oldest guideposts, the sun and stars. The navigator is a derivative of the company's experience in designing and building inertial guidance systems for the Mace, Thor, and Titan II missiles, the Titan III launch vehicle, and manufacturing the guidance and navigation systems for all of the Apollo command and lunar modules.

One of the three control and display units in the cockpit.

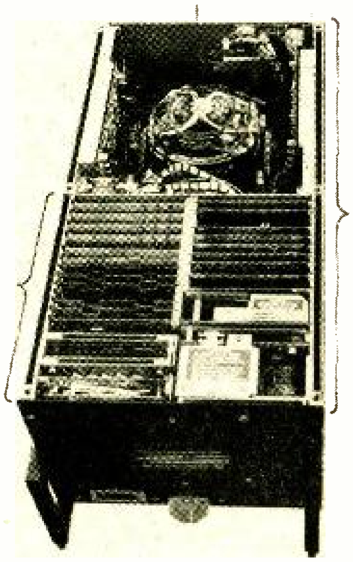
Airlines began evaluating the benefits of inertial navigation early in the 1960's, with *Pan American* pioneering the effort. Then in mid-1966, *Boeing* announced its plans for the 747 superjet, which would include inertial navigation systems as standard equipment. *AC Electronics* was ready to compete for the 747 inertial contract, having formed an engineering group earlier in 1966 to develop a commercial aircraft inertial navigation system. Carousel IV's design and performance won the 747 competition. Thus, the 747 became the first commercial aircraft to have an inertial system as an integral part of its design.

Benefits of Inertial Navigation

The benefits of inertial navigation to airlines, to flight crews, and to passengers are considerable. In the area of airline economics, inertial navigation means that no human navigator is required, a considerable cost savings. Navigation accuracy is vastly improved when compared with human computations, or even Doppler radar. One leading airline stated that the inertial navigation system is five times more accurate than other forms of navigation.

The high accuracy of the system translates into more precise flight and air-traffic control, which will ultimately provide more flight safety for passengers and crews when most aircraft are so equipped. When more direct flight paths are flown, it also means savings in time, fuel, and aircraft availability.

Looking down into the top of the system's navigation unit.



Another major advantage of an inertial navigation system is that it can provide aircraft attitude information (pitch, roll, and heading) superior to that available from standard attitude instruments. The standard attitude instruments are acceleration sensitive. In other words, if the aircraft accelerates, the attitude data is degraded. The only time the standard attitude data is accurate is when the aircraft is flying straight and level, neither accelerating nor decelerating. With the inertial navigation system the inertial attitude information is accurate at all times, irrespective of aircraft motion or acceleration. In the 747 superjet, the C-IV system acts as the primary attitude reference as well as serving as primary heading reference.

Crew convenience and workload were the other important considerations in designing inertial systems into the 747. The Carousel system makes navigation the simplest it has ever been. The automatic navigator provides the flight crew with more navigation information than they've ever had and provides it more quickly.

By rotating a control switch, different kinds of information can be selected. The most basic information, of course, is the present position of the aircraft and this is given to the pilot and co-pilot in exact latitude and longitude through a scoreboard readout. This position information is updated every six-tenths of a second.

Other kinds of information the crew can select for display are: distance and time to go to a waypoint or to destination, track angle of the flight path, ground speed, aircraft heading, aircraft drift angle, wind speed and direction, crosstrack distance from desired course, track-angle error, and the desired track angle. The system also runs a continuous self-check to review information displays for their reasonableness and to detect any malfunctions.

The system's wind computation is providing what appears to be the finest winds-aloft information that's ever been available. Using conventional methods, a navigator or pilot would figure winds by computing drift over a period of time, thereby obtaining an average wind direction and speed. Carousel IV gives an up-to-the-second reading on wind direction and speed by continuously computing the difference between the ground speed and the air speed. Using this information, it automatically compensates for cross winds, when connected to the autopilot, thus maintaining the exact ground track the crew wishes to fly.

An unexpected benefit of the inertial system is the speed indication it provides 747 pilots while they are taxiing the giant jetliners. Sitting three stories above the runway, it is difficult to judge taxi speeds. While the airspeed indicator does not work precisely at low speeds, the inertial system can give accurate ground-speed readings of as little as one knot—an important consideration when steering a 710,000-pound aircraft. Pilots also are using the ground-speed indications immediately following landing touchdown to determine if they are within safe limits for braking the aircraft.

The automatic steering features of the inertial navigation system are almost taken for granted, but have real significance. When the system is connected to the autopilot, it directs the aircraft to the desired heading, and captures that flight path in the proper direction, irrespective of the initial direction in which the aircraft was flying.

To date, Carousel IV has been sold to 24 airlines worldwide for use in 747's and for retrofitting into 707's, DC-8's, and VC-10's. FAA reliability requirements for inertial navigation systems call for an in-flight mean-time-between-failure (MTBF) of at least 544 hours. As this article goes to press, C-IV systems are accumulating some 60,000 airline operating hours per month and have an in-flight MTBF greater than 1700 hours.

In the fourth quarter of 1970, as more airlines put their 747's into commercial operation, the inertial systems will be recording more than 100,000 operating hours per month—underscoring the fact that commercial inertial has arrived.

Carousel IV is called an inertial navigator because it uses the inertias of masses to measure the magnitude and direction of the acceleration of the aircraft. That acceleration is integrated once to obtain velocity and again to get position.

Technical Description

Three *accelerometers* sense the magnitudes of the three components of the jet's acceleration, and three gyroscopes control the direction in which the accelerometers' sensitive axes point. Fig. 1 is a schematic representation of the accelerometer, which is simply a pendulum suspended in a case. The pendulum and its supporting electronics are designed to keep the pendulum mass precisely over the sensing coil. If the case is accelerated to the right or the left, the inertia of the mass will cause it to tend to lag behind the motion of the base. The sensing coil will measure this tendency of the mass to deviate from its rest position, and electronic circuits will amplify this signal, apply it to the appropriate force coil, and restore the pendulum to its normal position. The current supplied to the force coil is an accurate measurement of the acceleration of the instrument case.

If the case of the accelerometer were attached directly to the aircraft, it would be subjected to rotational accelerations and motions. While it is possible to configure a navigation system with the accelerometers so fixed, the computational problems are severe, and it is common to provide isolation of the accelerometers from the rotational motions. This is done by mounting the accelerometers on a *stable platform*. This platform is connected to the aircraft structure through a series of gimbal rings, which can move freely with respect to one another. Fig. 2 is a simplified schematic of a stable member supported by gimbal rings—the outermost ring being pivoted about the aircraft roll axis, the middle gimbal being pivoted about the aircraft's pitch axis, and the inner bearing or gimbal allowing the stable element freedom about the azimuth axis.

Maintaining the stable element immune to the rotation motions of the aircraft requires a sensor which is responsive to these rotational forces. A *gyroscope* is such a device. The functional dynamics of the gyroscope (Fig. 3) are not easy to explain; however, its operation is not difficult to understand. The gyroscope consists of a wheel which spins about a spin axis (SA) at a very high speed (24,000 r/min) inside a single gimbal or bearing which is free to rotate only about one other axis.

The physics of the spinning wheel gives it a unique response to rotational input forces. Any angular rotation of the gyroscope outer case about the input axis (IA) produces an inner case rotation about the output axis (OA). Electronic circuitry is provided which senses the location of the inner case relative to the outer case of the instrument. The output of the gyro sense coil (amplified) is used to drive a torque motor on the gimbal pivot which is parallel to the gyro input axis. Any tendency of the stable element to move relative to the set of three gyroscopes is thereby sensed and any motion is prevented, thus assuring that the accelerometer input axes always point in the proper directions.

There are different types of electronics required to support the inertial instruments (the gyroscopes and accelerometers), to perform the necessary calculations, and to communicate with the flight crew. In addition, electronic power supplies are required in support of each of these other functions.

Unusual Requirements

There are some requirements which are not commonly found in other applications. The system must work with a power input of 115 volts, 400 Hz or 28 volts d.c. This results in a fairly complex power-conversion system, shown schematically in Fig. 4. The a.c. power is converted to nominally 36 volts d.c. by a transformer/rectifier unit. The 28-volt backup battery is connected into the output of the transformer/rectifier unit through a diode. Whenever the 36-volt line goes below 28 volts, the system automatically draws power from

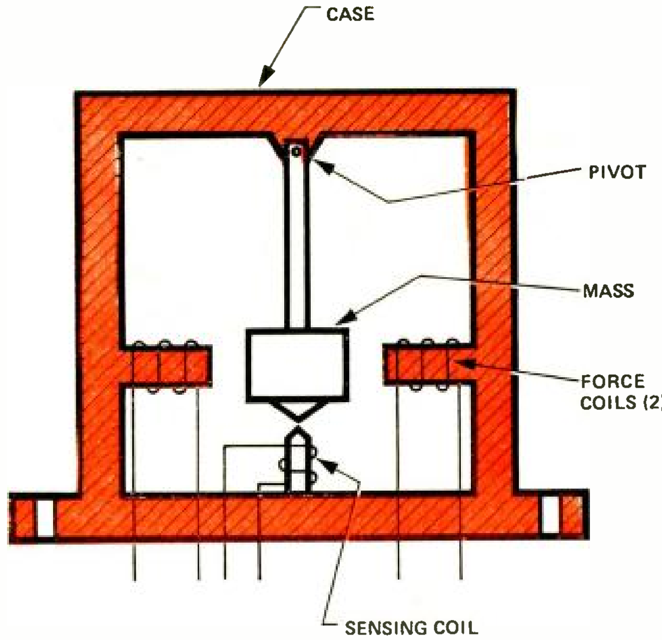


Fig. 1. Schematic representation of an accelerometer.

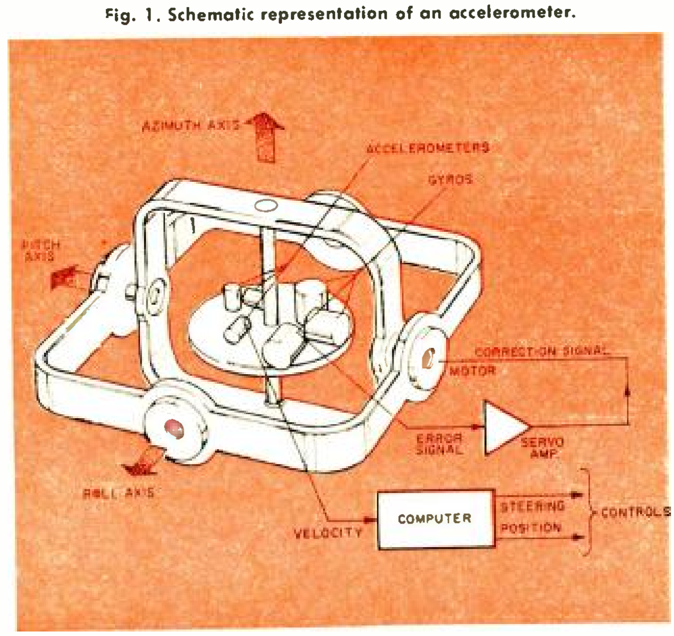
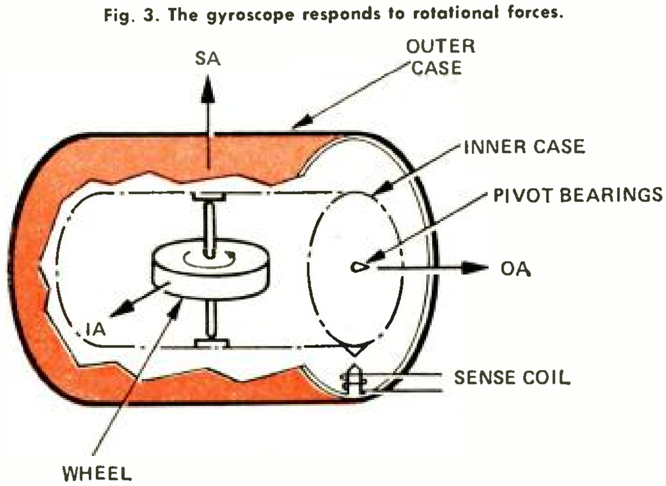


Fig. 2. This is a simplified representation of the gimbaled stable platform that is the heart of the system's navigation unit. There are three accelerometers which sense the magnitudes of the three components of the jet's acceleration, and three gyroscopes to control direction in which accelerometers' sensitive axes point.

Fig. 3. The gyroscope responds to rotational forces.



Numbers at top of display unit are current latitude, longitude.

the battery. The 36-volt bus varies as a function of load and line voltage. It is further regulated by a series switching regulator to provide a 15-volt ±1 percent output, which drives several additional power supplies.

The basic power for the inertial instrument electronics is provided from a d.c. to d.c. converter, sometimes called a static inverter; another one is used to support the computer electronics; and a third for the control/display unit (CDU). These d.c. to d.c. converters employ power-chopping transistors to turn the 15 volts d.c. into a 25-kHz signals. This is then applied to power transformers whose outputs are, in turn, rectified and filtered. Output voltages range from 5 volts to 22 volts for system use.

There are also precision a.c. power supplies which run the inertial instruments. The electric motor for the gyro wheel requires a two-phase, 1200-Hz supply which is precisely regulated in voltage, frequency, and phase. Other precision frequencies are generated for the pickoff systems for both the gyroscopes and accelerometers.

The inertial instruments must be maintained at very precise temperatures. Sensors within the instruments measure the temperature and compare it to a standard. The error signal is amplified and used to drive heater elements on the instruments.

The navigation unit provides pitch and roll attitude signals to the aircraft instrument panel. When the inertial system is first turned on, it is aligned to vertical and true north. The platform will remain so oriented for the duration of the flight and synchro transmitters on the gimbal pivots detect the aircraft pitch and roll attitude relative to the stable platform and transmit that information to the flight instruments.

The inertial instrument electronics are, in general, specialized circuits which provide unique functions, such as the gyro-stabilization electronics, the accelerometer electronics, the wheel power, and heater controls. These circuits consist of integrated operational amplifiers, discrete transistors, and other electronic components.

Computations are performed in a highly miniaturized general-purpose digital computer which is composed primarily of integrated transistor-transistor logic (TTL) circuits. It has a conventional four-wire ferrite-core memory. The memory requires that some of the outputs from the computer d.c. to d.c. converter be regulated as a function of the temperature within the computer memory. The switching electronics for this memory are both monolithic and hybrid integrated circuits.

Packaging and Components

All of the above functions must be provided within a package having a volume of 0.88 cubic foot and weighing approximately 53 pounds. This requires the best in electronic packaging techniques. The photo of the navigation unit with the top removed shows the gimbal structure, containing the inertial instruments, occupying about half the box. The inertial instrument electronics occupies one side of the electronics compartment and the digital computer unit occupies the other side of that compartment. Extensive use is made of circuit boards with IC flatpacks fixed to both sides. The memory package contains some discrete components and integrated circuits as well as 79,872 individual ferrite cores. And there's still room in the navigation unit for extra circuit boards, which could be memory cards or other circuitry.

The control and display unit, primarily a digital device, is similarly constructed of circuit boards. In addition, it contains its own d.c. to d.c. converter.

The following list indicates the approximate number of each type of electronic component in the navigation unit: 1250 monolithic and hybrid integrated circuits, 350 transistors, 370 diodes, 1850 resistors, 775 capacitors, 100 transformers and inductors, and 150 connectors—making a total of 4845 components.

To put this in a more familiar perspective, a typical solid-state color-television set has a total of about 500 electronic parts, consisting of: 50 transistors, 200 resistors, 200 capacitors, and 50 coils and transformers.

In terms of the number of solder connections, the navigation unit has about 40,000 as compared to 1250 for the television set. This makes the navigation unit approximately 30 times more complex than a color-TV set, considering only the purely electronic components and their attachments. If the synchros, torque motors, and inertial instruments are included, the complexity is increased even further.

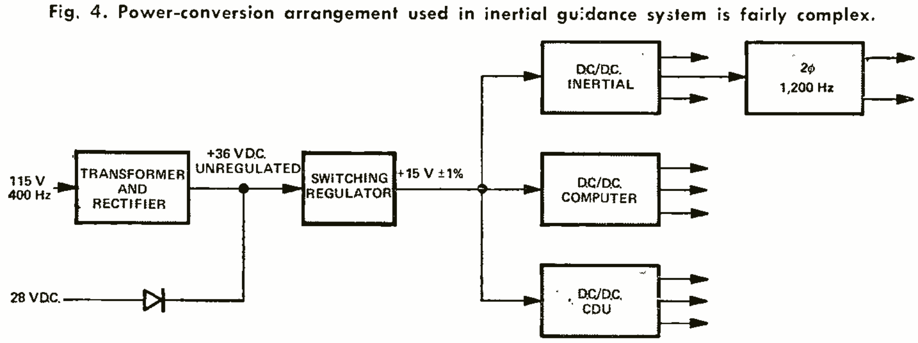
Reliability by Design

The Carousel IV in-flight reliability has been achieved by several important actions of the designers and builders of the equipment. During the design, all of the parts were rated at no more than 80 percent of their operating capability and, in some cases, 50 percent derating was used. In most cases, it was not necessary to add any parts as a result of this derating. Secondly, a worst-case analysis was performed to assure that under all possible conditions of operating temperatures, circuit voltages, and currents, the individual parts would never be operated at more than 100 percent of their rating. In other words, even in the worst possible combination of environments, line voltages, and external loads, there are no overstressed parts in the system.

The parts used in the system are not run-of-the-mill industrial-grade components but, in fact, represent the highest reliability components which can be purchased. In addition, they are given special treatment. The large number of integrated circuits in the system have

(*Continued on page* 83)

Fig. 4. Power-conversion arrangement used in inertial guidance system is fairly complex.



Calculating STRIP-LINE IMPEDANCE

By RONALD L. CARROLL

A simple, yet accurate, way of determining the impedance of various strip-line materials using graph and formulas.

ANY engineer responsible for the efficient transmission of waveforms involving low impedances (less than 50 ohms) must have a working knowledge of strip lines. There are several methods of calculating the impedance of two parallel conducting plates of equal width, separated by a uniform thickness of a dielectric material. Most of these methods involve the actual calculation of the inductance, which is re-inserted into its parent expressions, eventually yielding a resultant value for the impedance. However, the following equations will be reasonably accurate in most cases of interest.

$$Z = \frac{100d\ (17/K)^{\frac{1}{2}}}{w}$$

where: d is the dielectric thickness in inches, w is the strip width in inches, and K is the relative dielectric constant.

Since many manufacturers use materials with similar dielectric constants, we can further simplify this expression:

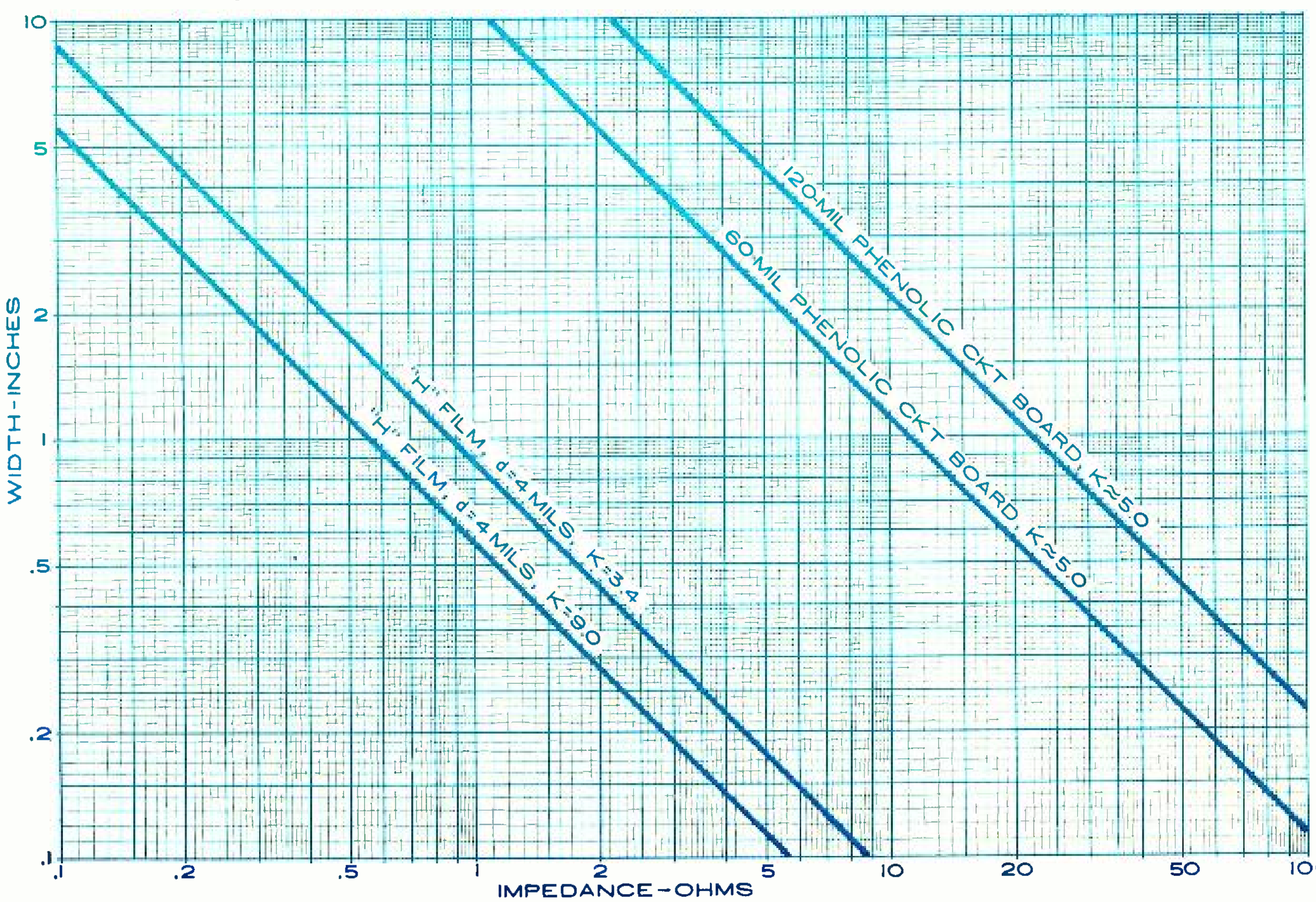
$Z = \frac{220d}{w}$ for commercial "H" film where K is 3.4.

$Z = \frac{185d}{w}$ for phenolic circuit board where K is about 5.0.

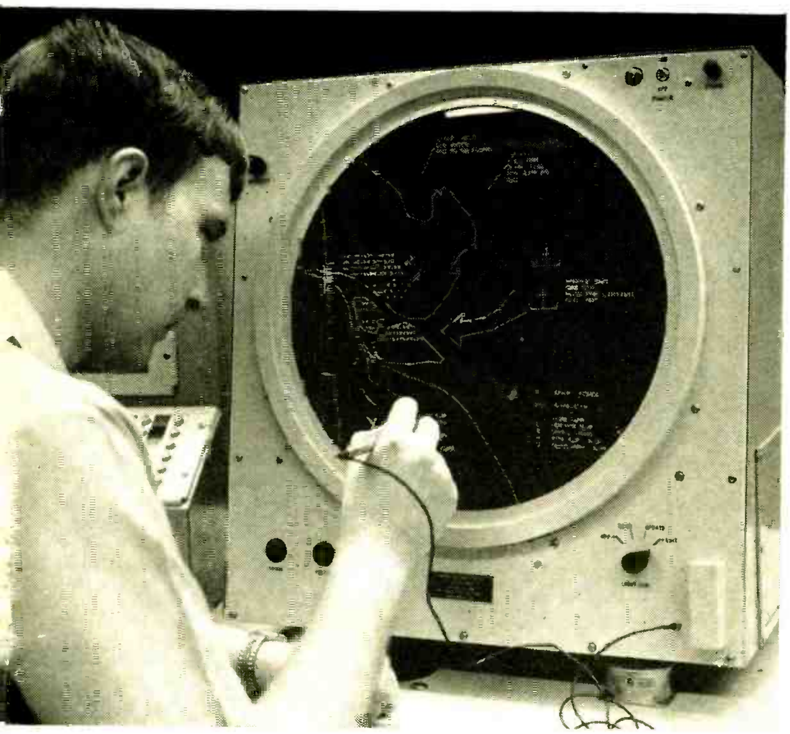
$Z = \frac{138d}{w}$ for commercial "H" film where K is 9.0.

By making a plot of Z *versus* w for your particular d and K factor strip-line material, like that shown in the graph below, you can easily determine the correct width for your required impedance. ▲

Convenient graph for determining Z vs w for various strip-line dielectric thicknesses and relative dielectric constants.

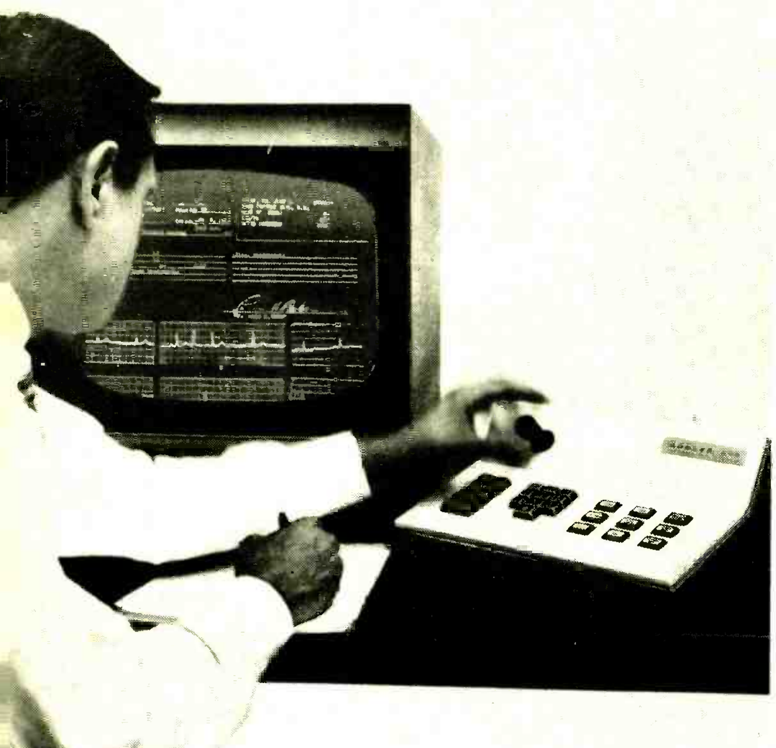


Recent Developments in Electronics



Compact Display for Air-Force Planes. (Top left) A new display unit that can be used to show radar signals or computer data is shown here. Taking the place of an existing Air-Force display, the new unit weighs about one-seventh as much and occupies one-fifth as much space as its predecessor. It also draws less power and is expected to be more reliable. The basic function of the display is as a remote radar PPI indicator. However, by easily replacing some of the printed-circuit boards, a computer output graphic-display terminal results. In this function, a high-speed character and symbol-writing capability is added and a text-editing feature, using a light pen, is incorporated. The new display unit is suitable for a wide range of airborne or ground operations. It was produced for the Air Force by Motorola.

Computer Checks 250 mi/h Test Vehicle. (Center) This sleek-looking test vehicle, built under contract to the U.S. Department of Transportation, uses a linear induction motor which should be able to propel it at speeds up to 250 mi/h. If you imagine the usual rotary induction motor cut along a radius, unrolled, and laid out flat, you can visualize the linear induction motor used. Some of the windings are laid out continuously along the track while other windings are within the vehicle. When a.c. is passed through the vehicle's windings, a strong magnetic field is set up between the windings that pulls the vehicle along the track at high speeds. Advantages are silence, a lack of pollutant byproducts, and freedom from vibration. Since thrust is provided without need for physical contact, the system should work equally well with air-suspension vehicles. Right now the test vehicle is being low-speed tested with the help of a minicomputer on a ¼-mile track at Torrance, Calif. The computer is capable of handling 32,000 readings per second from more than 100 sensors located on the vehicle. The minicomputer, a Varian 620/i, is located in an instrumentation and telemetry trailer nearby. Later this year the vehicle will be moved to a new large-scale test track near Pueblo, Colorado, for high-speed testing by the Dept. of Transportation.



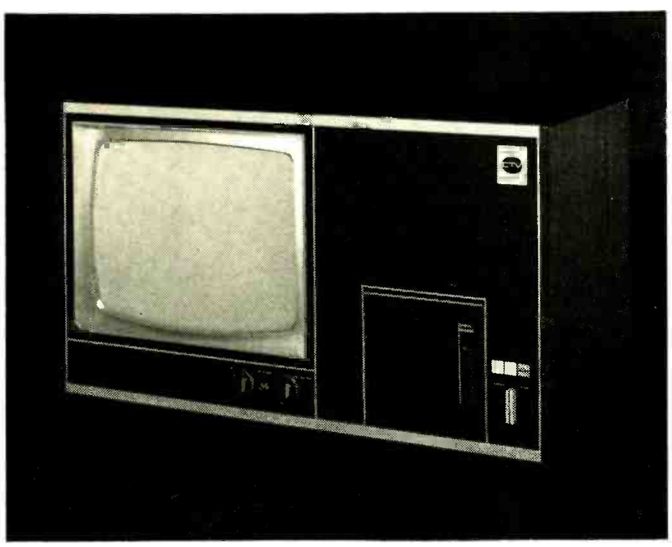
Medical Data via TV Display. (Below left) A high-speed microfilmed information storage and retrieval system that should provide the most advanced medical records system in the country is being installed at the Washington Medical Data Center. Hard-to-get information will be immediately available to remote locations merely by keying a number. The system, installed by Mosler Information Systems, will be tied in with the Center's computer. A physician who may wish to review a patient's medical records simply keys the request into the terminal. The logic and memory of the computer are used for indexing, file search, identification, and programming the request. The data is presented visually on the TV monitor within seconds. Scan and zoom controls on the remote TV camera make possible magnification and minute inspection of details. Several users can request information at the same time. The equipment will also have the ability to make hard copies. Other data will also be stored, including scientific articles from medical journals and an index of common drugs. The system is expected to be fully operational within about 8 months.

Facsimile Transceiver Uses Phone Lines. (Top right) A new facsimile transceiver that is small enough to be carried in an attaché case uses ordinary phone lines to transmit pictures. A full, letter-sized document or illustration can be sent in just four minutes; a shorter message, such as a 16-line typed memo, can be sent in only a minute. The 18-lb device is connected to the phone lines by means of an acoustic coupler. Special recording paper must be used. The new machine, the 400 Telecopier, is available from Xerox.

World's Smallest TV Camera. (Center) What is claimed to be the world's smallest commercially available TV camera is shown being inserted into boiler tube by workman. The lens, lighting unit, and ½-in vidicon camera tube are all housed within a steel case measuring about 1-in diameter and 5-in long. The companion control unit, containing power, scanning and processing circuits, weighs less than 42 lbs and can be carried by one man. Broadcast-type line-sync pulses make the camera compatible with video monitors and video tape recorders. Camera is by TV Equip. Div. of EMI Electronics, Ltd.

Cartridge Television for Home Use. (Below left) The first U.S. mass-produced home cartridge color-TV system, called "Cartrivision" has been announced by Avco. The combination unit shown, consisting of a cartridge video tape deck and color-TV receiver, is expected to sell for $800 to $900. The set will play special pre-recorded cartridges in color; it will also record TV programs off the air for later playback, without developing or processing. The set and the cartridges are expected to be available to the public early next year. It was also announced that Admiral will be using the new system in some of its new TV sets. Although we could get no technical details and were not even permitted to examine the cartridge or tape deck, color picture quality was good during a demonstration we saw.

New Control Center for Quotation Network. (Below right) We recently visited a highly sophisticated computer complex that controls the world's only international stock and commodities quotation network. The view shown here is of the control room at Ultronic Systems (subsidiary of Sylvania) new Mt. Laurel, N.J. complex. The center currently provides in-depth information to subscribers on some 9500 stocks, bonds, and commodities. Heart of the world-wide data network is a Univac general-purpose computer using two high-speed drum memories.



Can You Learn Electronics by Home Study?

BY LOUIS E. FRENZEL, Jr.

How to decide on course and select a school that is right for you. Here are some practical guidelines for making your decision.

MY answer to that question is simple, "You certainly can." A lot of people have learned electronics through correspondence courses. The question is not whether home-study courses are good or not, but rather exactly how does a person go about deciding on a course, selecting a school, then following through with it.

Correspondence courses are an effective and proven method of education. The fact that there are currently over 5 million people studying at home should clearly indicate their acceptability. Home study is a convenient means of getting some extra education.

If you have considered a correspondence course but can't make up your mind as to which course or school to choose and how to get the most from it, the seven items outlined here can help you make the right decision.

Item 1:

Decide whether you really need to take a course.

If you have considered taking a correspondence course, you must have decided that you need to get some additional education, most likely job-related. If you are even the least bit ambitious, you probably already know that more education is one way to ensure that you will move ahead on your job, do a better job, and make more money. Any investment you make in education now will certainly pay for itself later.

Perhaps you are already working in electronics but feel that you can do better if you up-grade yourself. The higher level job and pay that you desire may be out of your reach now because you do not have the education or skills to handle it. In this case, a correspondence course can help you.

Maybe you would like to change your field of specialization. Maybe you were a communications technician in the armed services but now want to get into computer electronics. A good correspondence course in this area could be the way to go. Another example is a television technician who wants to get into the mobile-radio field. While both of these jobs are in electronics, skills and knowledge demanded for one do not necessarily apply to the other. You may have to learn quite a bit of new electronic theory in the new field of specialization. A television technician changing to mobile radio would, of course, need to obtain an FCC license. The knowledge required to pass the FCC license exam is certainly not obtained working as a TV technician. For that reason, a course in the appropriate field can help you make the change.

Item 2:

Set yourself a goal.

Once you have determined that you can benefit from taking a course, you should set some kind of goal. Ask yourself exactly what you are trying to accomplish. What end result are you seeking? In the example given earlier, your goal may be to obtain an FCC commercial radiotelephone license. Look carefully at your own situation and determine what your goal will be. If you don't know where you are going, you will never get there.

Item 3:

Investigate thoroughly all schools offering suitable courses.

Before you select a home-study school, it is a good idea to send inquiries to all schools offering courses in your field of interest. You can find many of these schools by thumbing through your latest copy of ELECTRONICS WORLD or by writing to the National Home Study Council for a list of approved courses in this area. Write to all the schools and ask for their catalogues. Most home-study schools will send you a comprehensive catalogue describing their courses and the various services they offer. (See listing of schools and their addresses on this page.)

Once you accumulate the catalogues and related information, sit down and read them thoroughly. Make a table listing the advantages and disadvantages (from your standpoint) of each school. Compare the schools and courses carefully and try to determine which one, in your mind, is the best for you. There are many good schools offering courses in electronics and your job is to select the best school for *you*. One may be just as good as another, or so it seems from the information that you will receive. But keep an open mind, ask questions, and read everything you receive thoroughly. If you have questions that don't seem to be answered by the material the schools send you, then by all means write and ask for answers to your specific questions.

Some of the things to consider in comparing the schools are: *course content, price, services of the school,* and *accreditation.*

Content is important. Just what material is covered in the course? Will it help you achieve your goal? Read the lesson outlines carefully and be sure that the course contains information on the subjects in which you are interested.

Price is another important consideration. Since you are probably going to have to pay for this education out of your own pocket, you will want to be sure to get as much for your money as you can. Prices of correspondence courses vary widely depending upon just what is included in the course. While price is an important consideration, it should not be the prime factor in selecting the course. If it appears that the course you are considering will help you achieve your goal, then by all means take it, if the price is anywhere near reasonable.

Most schools provide some additional services for their students. An example is the consultation service where a student can write and get the help that he needs with his studies or with other problems related to the field. Other schools offer advice on obtaining jobs, and many publish a magazine or newsletter for their students. Some schools even have an alumni association and numerous other beneficial services. These extra services are important points often overlooked by those evaluating correspondence courses. These are quite similar to the fringe benefits you get when you take a job. Fringe benefits don't show up in the pay check, but they do provide many useful "pluses" that you might otherwise have to provide for yourself.

One of the most important things to consider when selecting a school is accreditation. The recognized accrediting body for home-study schools is the National Home Study Council. This is an organization which investigates schools that apply for accreditation and checks their ability to supply the education they offer. When a school is accredited it means that it provides beneficial education, properly written courses, and has fair business policies. If a school is accredited then, generally speaking, you can be sure that you will be getting your money's worth.

Just because a school isn't accredited, however, doesn't mean that its courses aren't any good. There may be a very good reason why a school isn't accredited. Ask about this important point if it should come up.

Item 4:

Should you select a course with or without training kits?

One of the things that will probably arise when you are deciding on a course is whether to select a course which offers training kits or an equivalent course without kits. If you are already an electronics technician and work with electronic components and equipment, you may not need to take a course that has training kits. On the other hand, if you are a beginner or are changing fields, then it might be a good idea for you to enroll in a course with kits.

Electronic training kits provide actual hands-on experience with electronic equipment. You will work with electronic components, tools, and test equipment. You will build circuits, run experiments, take measurements, and do many other things that you will have to do later on as a technician. In many cases you will build useful pieces of equipment that you can use later on your job.

Most home-study schools that supply kits with their courses will provide equipment such as v.t.v.m. (or a transistorized voltmeter), an oscilloscope, and other useful devices. In a television-servicing course you may build a color-TV set. In a communications course for an FCC license you may build a radio transmitter and other related equipment. If you would like to get actual training with equipment that you will work

HOME-STUDY SCHOOLS

National Home Study Council
1601 18th St. N.W.
Washington, D.C. 20009

Cleveland Institute of Electronics
Att: Ralph Schmotzer
1776 East 17th St.
Cleveland, Ohio 44114

Cook's Institute
Att: Wallace Cook
P.O. Box 10634
Jackson, Miss. 39209

CREI Division
McGraw-Hill Book Co.
Att: Norman Cohen
3224 16th St., N.W.
Washington, D.C. 20010

DeVry Institute of Technology
Div. of Bell & Howell
Att: Richard Chandler
4141 W. Belmont Ave.
Chicago, Ill. 60641

Grantham School of Engineering
Att: Don Grantham
1505 N. Western Ave.
Hollywood, Calif. 90027

International Correspondence Schools
Att: Roy Anderson
Oak Street
Scranton, Pa. 18515

Motorola Training Institute
Att: John Millet
1301 Algonquin Road, Dept. 19
Schaumberg, Ill. 60172

National Radio Institute
Div. McGraw-Hill Book Co.
Att: John R. Thompson
3939 Wisconsin Ave., N.W.
Washington, D.C. 20016

National Technical Schools
Att: Robert Parma
4000 S. Figueroa St.
Los Angeles, Calif. 90037

RCA Institutes
Att: Jack Friedman
320 West 31st Street
New York, New York 10001

United Technical Institute
Div. of Career Academy
Att: Terry Hueneke
611 East Wells St.
Milwaukee, Wisc. 53203

with on the job, this is certainly the way to go about it. The equipment that you build is a good investment. You are getting both theoretical education from the course lessons and practical hardware training with the kits. You will learn many valuable skills with training kits that you could not possibly obtain from textbook study alone. And it's a proven fact that you will grasp a subject better if you cover it in several different ways. Kit courses give you textbook theory, then you back it up by actual demonstration with the kits.

Keep one very important point in mind when selecting a school that offers kits. Some kits are simply add-ons, that is, you get pieces of equipment to build and that's it. You may not actually learn how they work or demonstrate their internal circuits. This is fine as far as it goes but then again other kits permit you to build a piece of equipment a step at a time, learning each of its internal circuits in detail. The end result is still a useful piece of test equipment but you have learned how it works. Such kits are usually coordinated with or keyed to the regular course texts so that they reinforce one another. If it's real educational value you want, as well as a useful end product, choose this type of kit over the add-ons.

Item 5:

Enrolling for the course.

Once you have carefully evaluated all the schools, you will now select one and proceed to enroll. Many times the enrollment procedure is as simple as filling out your name and address on a form and returning it to the school, with a very low down payment, in a prepaid envelope. As easy as it seems, there is more to it than meets the eye. Most of the enrollment forms are, in reality, contracts that obligate you to pay the full price of the course even though you may decide later that you don't wish to complete it. This is only a means of protecting the school. Most home-study schools are businesses and cannot afford to lose money on those people who are not truly interested in taking the courses for which they enroll. As you fill out the application for the course, read it carefully to be sure that you understand what it involves.

In any case, don't let this scare you away. Most home-study schools are ethical, meaning that if a person should legitimately decide later that the course is not for him, they offer a means of settling the contract. These settlements are usually quite reasonable. If you give full consideration to your decision prior to enrolling and you know what you want, you will never really need to bother with such refunding policies.

Many home-study schools employ salesmen. If a school uses salesmen, then you will no doubt be personally contacted when you inquire about a course. Most of these salesmen will want to visit you to describe their courses in detail. The salesmen are also representatives of the schools who are authorized to enroll you. Some of these salesmen can be quite persuasive so be careful not to be talked into a course until you are absolutely certain that it is what you want and need.

Another point to consider, and an important one, is that if a school does employ salesmen it means that the course will probably cost more than an equivalent course from a school that does not. Salesmen must be paid for their work and the student pays their commissions through the higher price of the course. (*On the other hand, schools that employ salesmen say that the additional business they get this way permits them to keep their prices down.—Editor*)

This is not to say that the salesmen should be avoided or that schools that use them should not be considered. But you should be aware of these facts so that you can make a proper decision. In most cases, the salesmen are honorable and quite useful in helping you to reach a conclusion about enrolling in a course. Feel free to call upon them for any additional information or help you may need before or after enrolling.

Item 6:

Decide for yourself whether you really want to obtain the education you are thinking about.

A home-study course can be not only an important key to your future success, but also an enjoyable experience. The course will be worthwhile in preparing you for a better job or some other beneficial end results. It can also be worthwhile if you are especially interested in the subject matter and approach it with the right attitude But let's be honest about it. Your success with the course is going to be directly related to your desire to obtain this education. In other words, your decision to take a course should not be based on whether or not you can do it, but rather do you really *want* to do it.

A lot of students find that there is more to a home-study course than they originally imagined. You'd better know this before you enroll. You are going to have to study to get through the course. If you could get through the course in a few weeks with some simple reading, it certainly wouldn't mean anything. There is more involved in getting a worthwhile education.

The home-study schools can prepare excellent, easy-to-read textbooks that contain just the information you want. You will need to read these textbooks, work the problems, and do the studying required to take and pass the exams. Schools prepare excellent training kits, but you must build them and make every effort to absorb the information that they are designed to provide.

For some home-study courses in electronics, you could possibly face a two-year period of study if you work at it irregularly. However, remember that you are on your own and you must set yourself a study schedule and have the perseverance to stick with the program until it is completed. If you have the self-discipline to study regularly every day, then you can complete most courses in a surprisingly short period of time, usually in less than a year. If you are really interested in the subject matter, it won't be work for you at all. Prepare yourself mentally now before you enroll in the course and then you can tackle it with the right attitude. Look at the course as a challenge that will prepare you for many good things in the future. Most employers are quick to recognize the fact that anyone motivated enough to put himself through a good correspondence course must really have something on the ball.

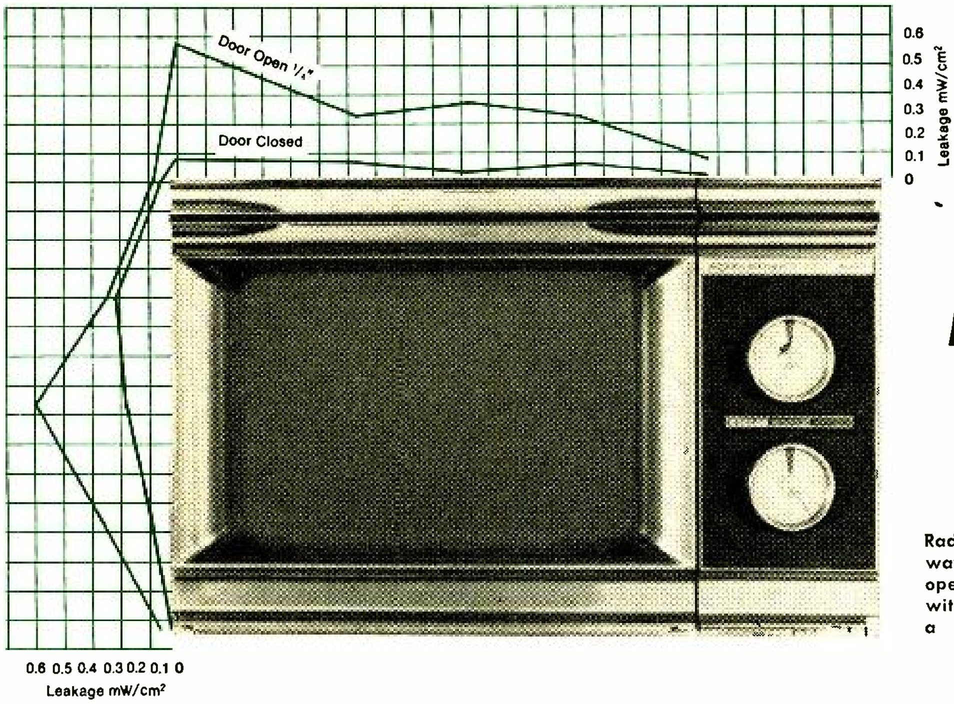
Item 7:

A home-study course is a good investment.

In these days of soaring living costs, inflation, and higher taxes, it is increasingly difficult to obtain many of the things we really need. For that reason you may find it hard to justify spending your hard-earned money on something like a correspondence course. However, education is one of the best investments you can make, maybe *the* best. Any money you spend now obtaining training for your job will earn worthwhile dividends in the form of higher pay and a better job in the future.

If you compare the cost of home-study education with other conventional forms of education, such as resident technical schools and colleges, you will find that the cost of a home-study course is only a fraction of what you might have to pay for other methods of training. You get a tremendous amount of education for your money in a carefully chosen home-study course. ▲

MICROWAVE OVENS -Revolution in Cooking



Part 2— Radiation & Safety

Radiation profile showing typical microwave-oven leakage after 100,000 door openings. Oven is an Amana RR-2 with a choke absorber door seal and a 275-cubic centimeter water load.

By DAN R. McCONNELL / Product Planning Manager, Microwave Ovens, Amana Refrigeration, Inc

Description of the various design features that minimize radiation and result in a safe and reliable product which does its job well.

LAST month, in Part 1 of this article, we covered the operating principles and basic designs of microwave ovens, including the mechanism and techniques of cooking. Now let us consider the radiation problem and the various safety features that have been built into the ovens.

In October of 1968 Congress passed the Radiation Control for Health and Safety Act, Public Law 90-602. This Act authorized the Secretary of Health, Education, and Welfare to develop safety standards for commercial devices that emit radiation of any kind, including television receivers, diathermy equipment, and microwave ovens.

X-rays vs Microwave Radiation

Color-TV receivers emit very low-level x-radiation as an unwanted by-product of the use of very high-voltage tubes (to 30,000 volts). Microwave ovens emit no measurable x-radiation, simply because the voltages involved are much lower (to 6000 volts). Instead, microwave ovens may "leak" some of the microwave energy used in the cooking of food. This microwave-energy leakage is "radiation" in the sense that all electromagnetic waves are "radiation," whether they are AM or FM radio, v.h.f., u.h.f., microwave, infrared, visible light, ultraviolet, x-rays, or *gamma* rays. Microwaves are that part of the spectrum where the wavelengths are on the order of the size of ordinary objects.

In the minds of the general public, radiation generally is identified with x-rays and *gamma* rays. The biological hazards associated with x and *gamma* rays are vastly different from those associated with the lower frequency radiation and should not be confused.

X-radiation is classed as *ionizing* radiation, which is *cumulative* in effect, and possesses *no threshold* of injury. X-rays are of such enormously high energy that they break molecular bonds when absorbed by biological tissue. They ionize molecules causing a destruction of tissue that is neither wholly repairable nor reversible. Not being repairable means that each successive dose simply increases the amount of tissue destroyed. In effect, the damage is cumulative. There is no level of x-radiation intensity below which there is no damage. There are only levels low enough so that accumulation will not be dangerous. X-rays have no threshold.

Microwave radiation, however, is non-ionizing, as is infrared, radio waves, and other lower-frequency radiation. The lowest energy x-rays, for instance, have quantum energies 100,000,000 times greater than that of one quantum of 2450-MHz microwave radiation. In effect, microwave radiation does not possess sufficient quantum energy to ionize the molecules of biological tissue, and does not, therefore, produce irreversible damage. With no irreversible damage there is no cumulative effect. Present knowledge indicates that damage due to microwaves in biological tissues occurs through the thermal effects; *i.e.*, results of heating. Such thermal effects do have a threshold intensity below which no biological damage is incurred.

In terms of microwave-radiation safety, one can there-

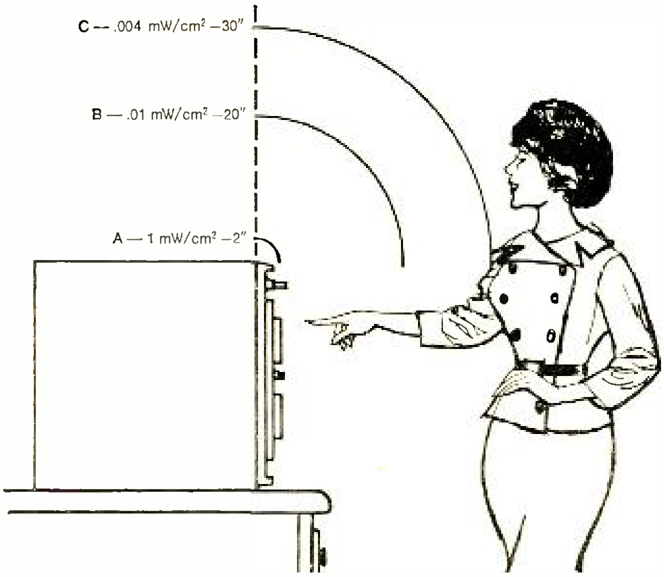
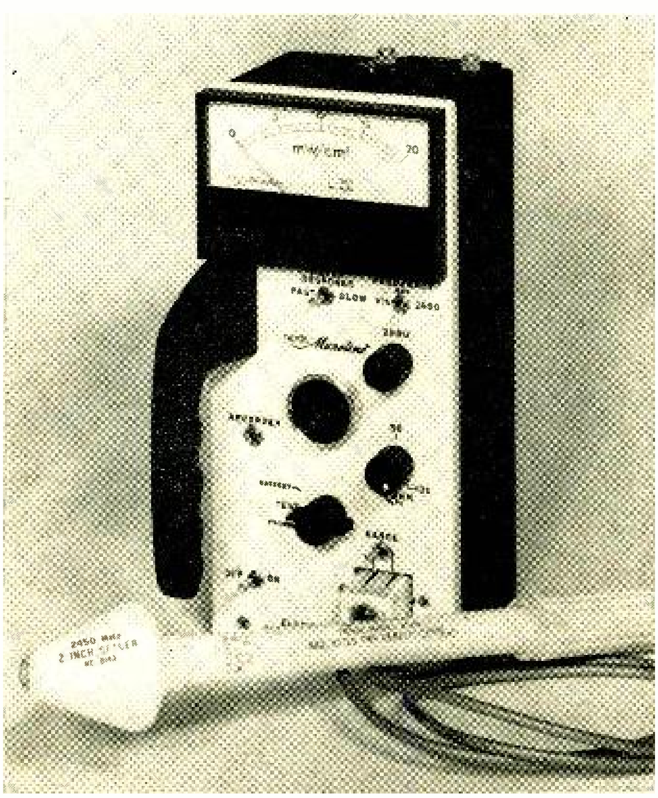


Fig. 1. Examples of microwave-radiation power densities at various distances. Leakage occurs only around the door seal.

fore define a maximum permissible exposure level at a level lower than the threshold by a suitable safety factor, such as 10. It should be possible, in principle, to design a microwave oven so that no one could be reasonably expected to be exposed to a hazardous level of microwave radiation. Before discussing safety levels and the principles of safety design, hazards of high-intensity fields should be identified.

The most important high-intensity hazard is that of cataracts of the eyes. A number of researchers have demonstrated the ability to produce cataracts in the eyes of laboratory animals. The lowest recorded level of power density producing a cataract in one dose is 120 mW/cm² maintained at the surface of a rabbit's eye for 35 minutes. The lowest multiple-exposure level ever claimed for producing a cataract is 80 mW/cm². In all cases, levels of more than 100 mW/cm² require long exposures to produce cataracts. In fact, the HEW summary report "Biological Aspects of Microwave Radiation" (TSB-68-4) states: "It has been established that a power density of 100 mW/cm² applied directly to the eye can be tolerated for hours at a time." Since any competent microwave-oven design can limit leakage to a few mW/cm², measured 2 inches (5 cm) from the unit, it is clear that there should be no risk of cataract production.

Fig. 2. Narda 8100B electromagnetic radiation meter recommended for microwave oven leakage measurements. The probe of the instrument has 2-in spacer for checks at this distance.



The second so-called hazard is the heating of testes. The lowest level at which a heating effect has been noted is at 10 mW/cm², requiring 60 minutes to observe a temperature change of 1°F. This low-level effect cannot be interpreted as a hazard to health. The effects are roughly comparable to those resulting from a hot bath or restrictive clothing.

An *alleged* third hazard includes effects upon the central nervous system (headaches, nausea, dizziness), as claimed by Russian, Czech, and Polish researchers. The adverse effects are subjective and psychological and occur only for long-duration (such as 8 hours) exposures. The belief in the existence of these effects is based mostly on epidemiological studies. No mechanisms for these effects are known.

This research has been the subject of extended controversy in this country for several reasons. The experiments have been criticized for a lack of statistical control. Reports have been incomplete to the point that many important procedural details are unknown. Russian instrumentation is suspect. Measurement standards and simple definitions are unknown. The result is that Russian work has been impossible to duplicate in this country, and their claims remain controversial and unaccepted. Many Western researchers are investigating the same area now, and it is hoped that some of the confusion will be eliminated.

Safety Standards

Safety standards must take into account the thresholds for damage and add some safety factor to allow for other thermal stresses and for uncontrolled populations. In 1961 the three U.S. Military Services enacted a safety standard of 10 mW/cm² for prolonged whole-body exposure. This standard specifically incorporated a safety factor of ten from the approximately known threshold of cataract hazard. In 1966 the U.S.A. Standards Institute recommended a safety level of 10 mW/cm², whole-body radiation (entire body immersed in the field), as averaged over any 0.1-hour period. In effect, this means that for prolonged exposure (greater than 0.1 hour) the radiation-protection guide would be 10 mW/cm². For a shorter period of exposure, higher levels are permitted.

(Editor's Note: Federal public health officials, taking a very cautious approach, have proposed a tighter standard maximum limit for radiation. This new standard, for ovens made after July 1, 1971, is one-half the present value, or 5 mW/cm² at any time for ovens in the consumer's hands and a maximum of 1 mW/cm² at the point of manufacture.)

Certain special conditions relate to the nature of the leakage of microwave energy and the nature of the use of the oven. The only significant leakage occurs around the door seal so that the energy radiates from a slit. A person standing in the radiation field is essentially exposed only in "partial body" rather than whole body. Furthermore, the fields diminish in intensity approximately by the square of the distance from the source. The duration of a person's presence in the field is normally very short. The normal position of a person in relation to the range means that the sensitive areas (the eyes and testes) are much more than 5 cm (2 inches) away from the door seal.

In the example in Fig. 1, suppose that the power density, as measured 5 cm from the door seal, is 1 mW/cm². A person's head would be approximately 50 cm from the seal or 10 times the distance at the point of measurement. Applying the inverse-square rule would mean that the power density at head height would be about 0.01 mW/cm^2, a negligible amount.

The Russian standards for radiation safety in fact limit the power density to 0.01 mW/cm^2 for prolonged exposure, to 0.1 mW/cm^2 for periods up to two hours daily, and to 1.0 mW/cm^2 for periods up to 20 minutes per day. It is interesting to note, however, that the Russians do not possess instrumentation capable of measuring the fields at 5 cm and relate their standards to typical average immersion in a field. Under their interpretation, the person in our example whose head is 50 cm from the U.S. point of measurement, would be considered to be subjected to an acceptable field of 0.01 mW/cm^2 even for eight hours continuous exposure. If the exposure is only for ½ hour, a level of 1 mW/cm^2 would be permissible at the head location. This corresponds to levels of leakage far above present industry standards.

To the author's knowledge there is, at present, only one commercially available instrument that is capable of measuring, with reasonable accuracy, in the "near field," close to the radiating aperture, and only one instrument that meets the measurement requirement of the proposed government standard. This instrument is the *Narda* 8100B electromagnetic radiation meter shown in Fig. 2. This instrument is strongly recommended for use in accurately measuring the leakage levels from a microwave oven. (*For more details on this instrument, see the "Test Equipment Product Report" in last month's issue.—Editor*) The use of neon lights or similar devices is not recommended for even the crudest of measurements.

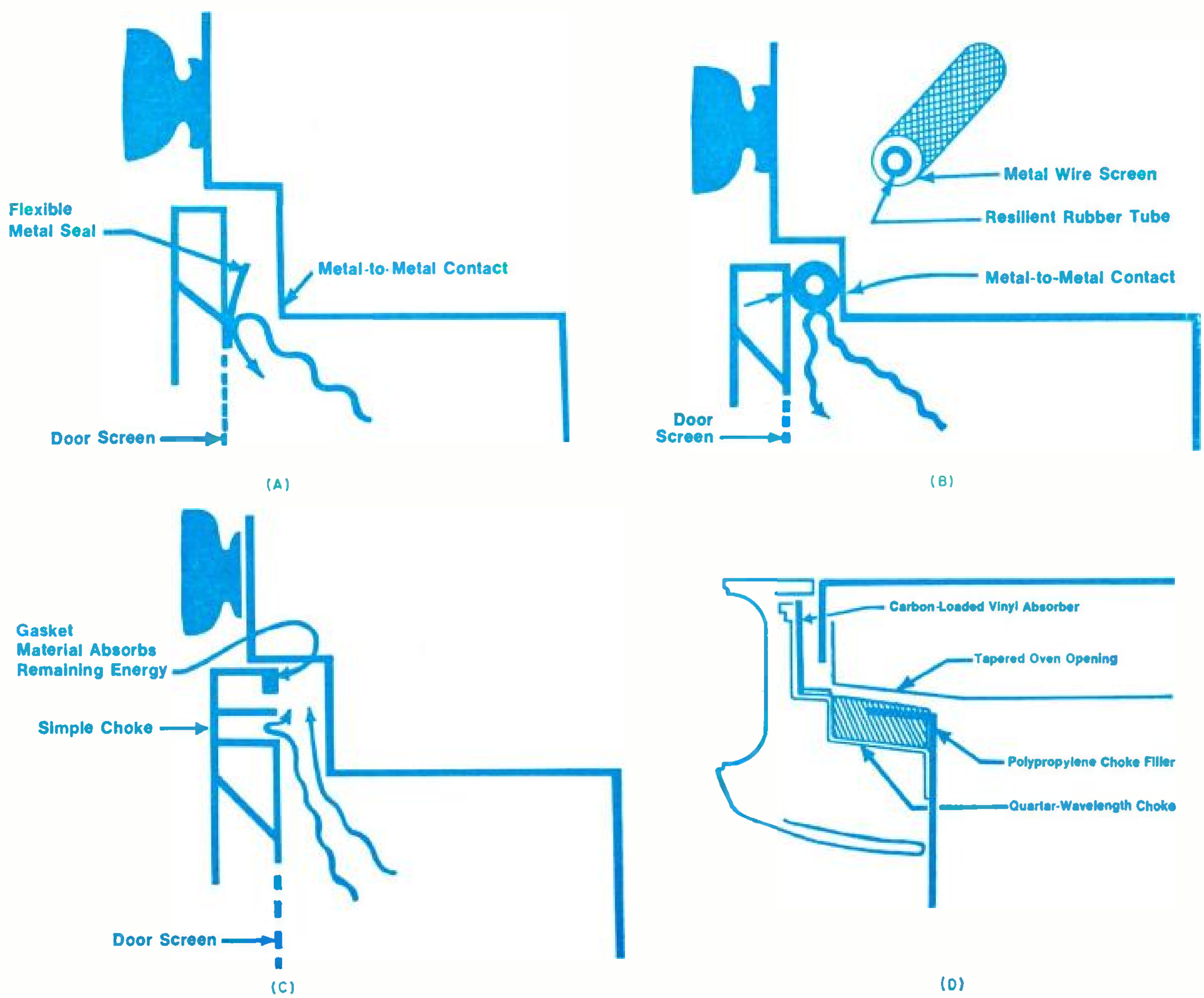
Designing for Safety

Knowing the safety levels for microwave leakage, what design approaches are capable of producing an oven whose initial leakage is comfortably lower than the safety level? The desired design should be essentially free from deterioration over the life of the product. In discussing design approaches we will consider (1) door-closure systems, (2) viewing screens, and (3) door-interlock switches.

It is most important that the microwave oven "contain" the magnetron power. Yet a means for inserting the food for heating *via* a door is necessary. Besides the fundamental frequency, the magnetron may have harmonic-output power which also must be contained within the oven. Spurious-frequency radiation just outside the assigned band and harmonic energy can cause interference with communications.

The simplest of door seals is the contact door. A flat door surface making metal-to-metal contact may be used. The larger the contact surface the better the seal. A variation of the contact door would be a convex metal spring strip between door and oven (Fig. 3A). This gives linear contact that maintains an intimate metal-to- (*Continued on page 72*)

Fig. 3. Various door seals designed to contain the microwave energy and prevent leakage. (A) Simple metal-to-metal contact using metal spring strip. (B) Compressible tube covered with metal screen or braid. (C) Simple quarter-wave choke seal puts short circuit on opening and prevents leakage. (D) A choke-absorber door seal acts to attenuate harmonics as well.



Direct vs Reverberant Sound for Stereo Speakers

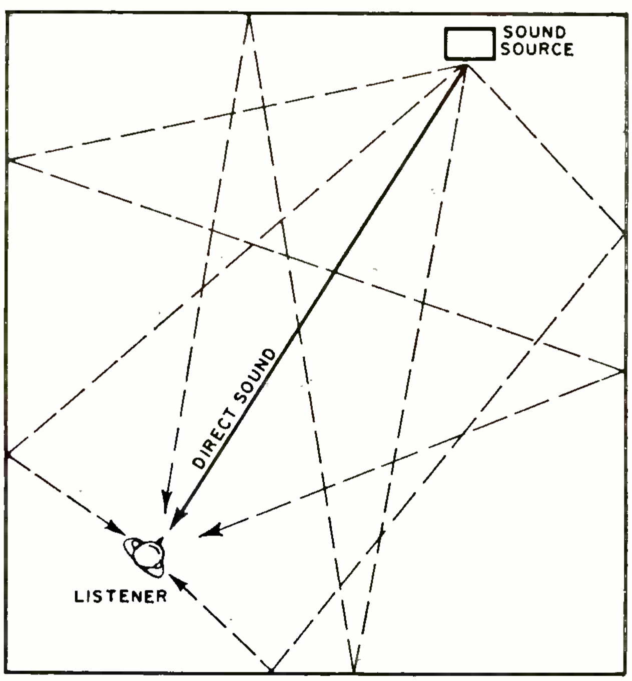
By GEORGE L. AUGSPURGER /Technical Director, James B. Lansing Sound, Inc.

Controversy continues over the best type of speaker for home stereo. A hi-fi speaker system operating as a diffuse sound source, rather than a directional one, is preferred by author.

CURRENT interest in "omnidirectional" or "reflective" loudspeaker systems has produced weighty theoretical discussions, most of which concentrate on the relative importance of direct sound and reverberant sound. One group of experts argues that the major distinction between a home listening room and a concert hall is the greater ratio of reverberant-to-direct sound in the latter, and that the way to make a home music reproducing system more lifelike is to increase the proportion of reverberant sound. The opposing group insists that the reverberant characteristics of the performance environment are present in the recording itself, and that any additional reverberation in the listening room can only contaminate the accuracy of the reproduced sound.

Both groups are fond of mathematical demonstrations and authoritative references. Dr. A. Bose (*The Bose Corp.*), with the aid of higher mathematics and an MIT computer, demonstrates that a direct-to-reverberant ratio of 1:9 not only is desirable for music reproduction, but is one of the attributes of a perfect reproducing system. Don Davis (*Altec Lansing*), by setting forth some critical distance calculations, proves just as convincingly that, if one listens to recorded music in the reverberant field, what one hears bears ". . . no relation to the signal originally recorded." (See "Is Omnidirectionality Desirable in a Loudspeaker?" in August, 1970 issue of ELECTRONICS WORLD.)

Fig. 1. The solid arrow indicates direct sound. Dashed arrows show reverberant sound which reaches listener after reflections.



An hour or two of actual listening in various acoustical environments is enough to demonstrate that neither argument matches up very well with the real world. One reason, perhaps, is a general failure to allow for how the ear differentiates "direct" from "reverberant" sound.

On the surface, the definition is utterly simple. Sound that reaches your ears straight from the source obviously is direct sound. That which arrives after having been reflected from various room surfaces is reverberant sound (Fig. 1). For practical purposes, however, we have to go a step further and determine what proportion of the sound is perceived by the ear as contributing to the "direct" impression, and what proportion contributes to the sensation of reverberation, or hangover.

To begin, one can do no better than quote from the founder of modern architectural acoustics, Wallace C. Sabine, who lists among the criteria for good hearing the requirement that ". . . the successive sounds in rapidly moving articulation, either of speech or music, should be clear and distinct, free from each other and from extraneous noises" ("Collected Papers on Acoustics," *Harvard University Press*, 1922).

Another famous acoustician, Dr. Vern Knudsen, has long emphasized the fact that early reflections are beneficial—they are interpreted by the ear as contributing to the direct signal from the source—and that it is the later arrivals which blur and confuse articulation.

Early and Late Reverberant Sound

What we really need is a way to separate "early" from "late" reverberant sound. There is no hard and clear division between the two categories, but it is generally agreed that sound impulses which arrive within 60 milliseconds or so of the direct sound are lumped together with the direct sound as far as the human ear is concerned.

In a highly reverberant room, such as a gymnasium or indoor swimming pool, one doesn't have to be very far from a source of sound for most of the energy to arrive later than 60 milliseconds. In such a situation, articulation is lost and intelligibility is almost zero.

But many home listening rooms have reverberation periods of less than a second rather than several seconds. It turns out that, in a room having a reverberation time of 1.25 seconds or less, *early sound always predominates over late reverberation, no matter what the directional characteristics* *of the source.* This point is nicely explained by Michael Rettinger in his book "Acoustics—Room Design and Noise Control" (published by *Chemical Publishing Co., Inc.*, New York, 1968).

The importance of early *vs* late sound, rather than direct *vs* reverberant sound, explains why, on the one hand, a small, dead listening room cannot be made to sound like a large auditorium, no matter what is done with reflected energy, and why, on the other hand, the sonic characteristics of a recording are *not* totally lost in a normal listening room, no matter how non-directional the loudspeakers may be.

Which Speaker to Use?

If this is the case, why does a non-directional loudspeaker system sound different from a directional one, and which is better?

With present-day recording techniques, there is no way to include complete directional information in the recording itself; there is nothing that tells the loudspeaker in what directions the signal is to be projected. Stereo helps, of course, but to replicate the sound field perceived when listening to a live performance would require 30 or 40 channels rather than two or four. Moreover, we know from practical experience that while a pair of very directional loudspeakers can produce an excellent, three-dimensional stereo image at a given listening location, the image is lost as soon as the listener moves. If we want to enjoy stereo reproduction from more than one location, *we must choose loudspeakers that are not too directional.*

What about the opposite extreme? Some of the new non-directional speakers systems advertise perfectly balanced stereo anywhere in the room. It seems to me that if one hears exactly the same sound everywhere, then by definition, one is not hearing stereo at all.

Ideally, all listeners within a reasonable area should be able to localize the sound from individual channels without zeroing in on two precise points in space. This effect requires loudspeakers whose characteristics are not those of a spotlight (directional source), or those of a naked light bulb (omnidirectional source), but rather those of a distributed or indirect source (Fig. 2).

One way to produce a spacious, distributed source is to combine several transducers in a large speaker system. The kind of directional field produced by a large system is quite different from that of a bookshelf loudspeaker, even if their response curves are almost identical. A conventional 10-inch woofer and 2-inch tweeter cannot duplicate the complex three-dimensional sound field produced by a grand piano, for example, even if the system has perfect frequency response and no distortion. To reproduce a large sound source, a single large speaker system will do a better job than a single small speaker system, all other factors being equal. (Better than either would be a great number of small sound sources, each driven from an independent recording channel.) The point of this paragraph is not to argue whether or not conventional small speaker systems are "better" or "worse" than conventional big speaker systems, but simply to point out that audible differences may exist solely as a result of their sound-distribution characteristics.

Another way to achieve a diffuse source is to employ loudspeakers aimed toward reflecting surfaces. Some non-directional speaker systems depend on adjacent room walls as reflective elements. Others, such as the *JBL* "Paragon," utilize reflective surfaces as part of the speaker system itself.

Diffuse Sound Sources

Recently, *JBL* has announced several new loudspeaker systems utilizing still a different approach involving the applications of multiple radial slots as sound sources. In the basic approach, Fig. 3, the slots act as diffraction sources, radiating most of the sound energy outward and upward, while maintaining essentially uniform response in all directions.

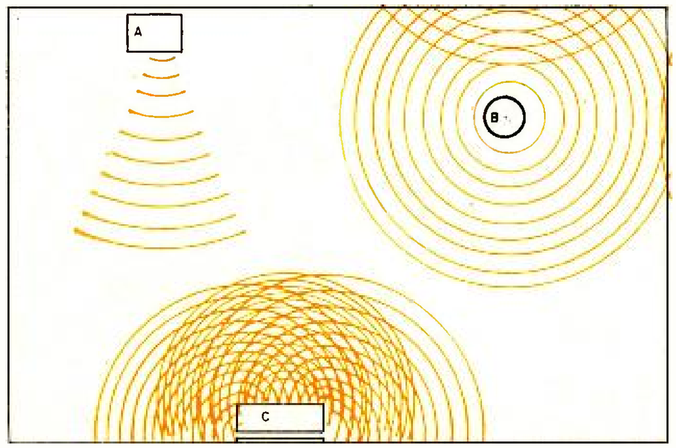


Fig. 2. Simplified representation of (A) directional sound source, (B) omnidirectional source, (C) diffuse source.

Characteristics of different non-directional loudspeaker systems vary greatly, but insofar as they try to achieve a non-localized, diffused sound source, they have certain audible characteristics in common.

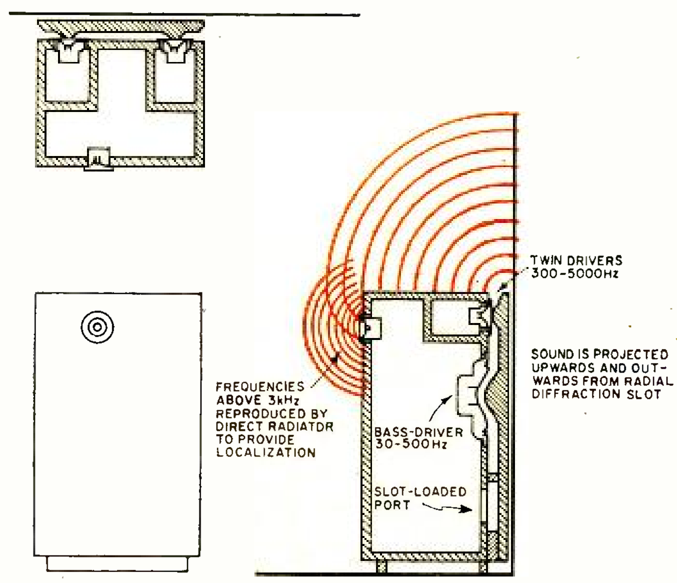
1. While conventional speaker systems tend to create a stereo image within the confines of the listening room, diffuse-source loudspeakers can produce the illusion that sound is coming from an imaginary space behind the speaker systems. The effect is almost as if the room had somehow been increased in size.

2. Properly designed diffuse-source loudspeakers can create a stereo image that remains steady when the listening location is changed. That is, if one is listening to a string quartet and moves closer to the imaginary cello, one still hears the other instruments in perspective. This is not the same thing as having the stereo image follow you around the room, as with the recruiting posters—"Uncle Sam wants you!". Nor is it the effect of losing one channel altogether, as happens when very directional speakers are employed.

3. Because only a small proportion of the sound energy is projected forward, diffuse-source loudspeakers can fill a room with sound without blasting any particular listener. This attribute is especially appreciated by women.

The preceding characteristics will be considered beneficial in most home listening situations. But, as one might expect in an imperfect world, diffuse-source speakers have drawbacks as well. Their sound is influenced more by the room's distinctive acoustical qualities (*Continued on page* 81)

Fig. 3. In new JBL "Aquarius II" loudspeaker system, only very high frequencies are front-radiated. Most of sound emerges from radial diffraction slot around rear edge of enclosure.



The Amplified ZENER

By C.J. ULRICK

Small, low-power zener plus inexpensive transistor, when properly connected, can simulate most large, expensive high-power zeners.

FOR the average experimenter, the zener diode is still the best choice to provide voltage regulation. Zener diodes are simple, compact, easy to install, and the smaller sizes are inexpensive. The shunt connection required by these diodes is not very efficient, but this does not usually disturb the experimenter. But there are times when a lot of power must be regulated, and one of the large 10- or 50-watt rated diodes is needed. It is here that the experimenter balks; he can afford the 400-mW and 1-watt diodes, but the cost of a 10- or 50-watt device may be prohibitive. Luckily, one of the smaller diodes and an inexpensive power transistor can be connected to simulate just about any larger zener diode.

How It's Done

The basic principle is shown in the simple shunt regulator of Fig. 1. Here the components in the dotted box are used in place of the large zener. The circuit works like this; current drawn from the unregulated input voltage will cause a drop across the series resistor and provide the lower, regulated output level which is determined by the voltage rating of the zener and the base-emitter forward drop of the transistor. There is a low-current path from ground through the transistor base-emitter junction and the zener; this current will control the much larger current in the collector circuit.

If the output voltage tends to increase, the zener will cause an increase in the base current which will, in turn, increase the collector current, thus pulling down the output voltage by increasing the drop across the 6-ohm series resistor. Since the change due to the transistor current was in the opposite direction from the original deviation of the output voltage, the deviation is canceled and the output is regulated. As usual with shunt regulators, the transistor carries the highest current when there is no load and the least current when the load current is maximum. It turns out that the current drawn from the unregulated supply is constant, and this allows the supply to be simpler and thus cheaper than it would be if it were used with a series regulator in which the current demand varies with load current.

The 75-ohm resistor from base- (*Continued on page* 63)

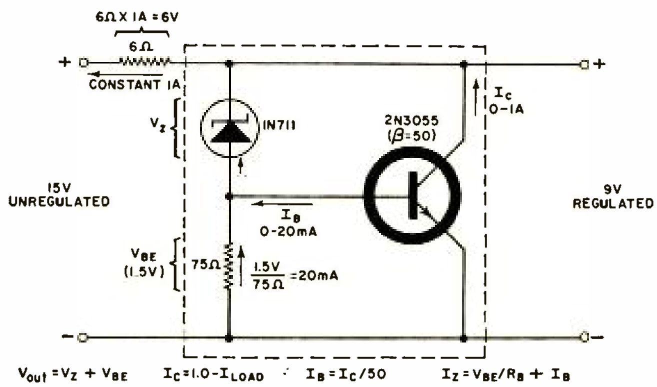
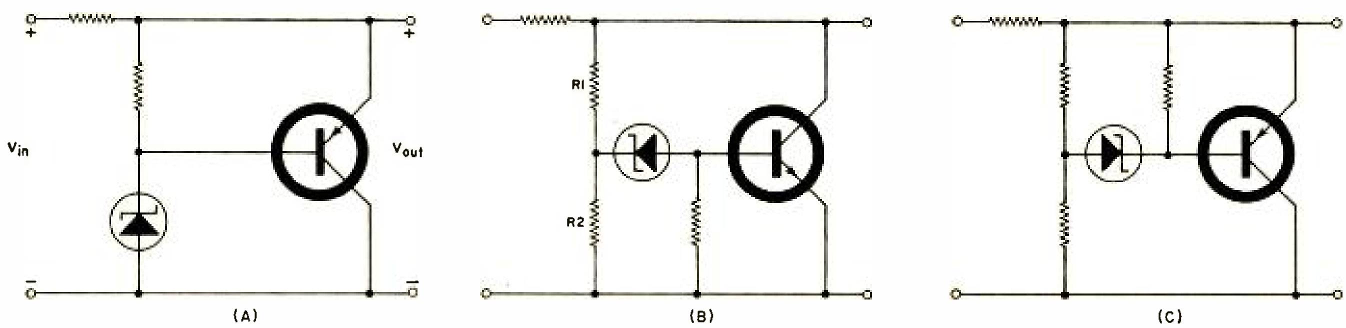


Fig. 1. Schematic of simple shunt regulator circuit. Components in box are used to simulate large (10- to 50-W) zener.



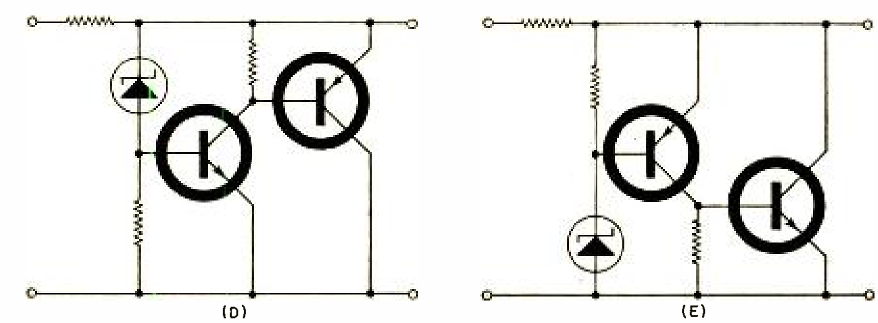


Fig. 2. Circuit schematics of various shunt regulator types. (A) Grounded-collector "p-n-p" for positive output, (B, C) "n-p-n" and "p-n-p" configurations, respectively, for higher output voltages than available selection of zeners, and (D, E) Darlington "n-p-n" and "p-n-p" cascade types, respectively, for increasing amplification factor.

The Scheiber 4-CHANNEL STEREO SYSTEM

By MILTON S. SNITZER / Technical Editor

Some technical details on fully compatible 4-channel system that has been causing much excitement in the hi-fi industry.

WE recently attended an impressive demonstration of 4-channel stereo conducted by *Advent Corp.* The company has signed an agreement with Peter Scheiber, President of *Audiodata, Inc.*, to complete commercial development, grant licenses, and begin production and marketing of the Scheiber System of compatible 4-channel sound. Even though only two channels were being used on a stereo phono disc and a stereo cassette tape, we were able to hear sounds separately from the four loudspeakers positioned at the corners of the listening room.

Part of the demonstration was an A-B test between a selection recorded on four separate tracks on a 4-channel reel-to-reel tape recorder, which was then fed to the four speakers, as against the same source with the Scheiber encoder and decoder inserted. The encoder combined the four original channels into two, such as would be found on a stereo disc or stereo broadcast. Then, the two channels were decoded and separated into the four original channels. When we switched back and forth, with the Scheiber circuits in and out of the chain, we found a remarkable similarity to the straight-through 4-channel program. We definitely heard four channels in both cases and, although these were not absolutely identical with what we heard without the Scheiber circuits, we came away convinced that the circuits do well what they are supposed to do. The A-B test was not really a fair way of checking the new system since the original tape was mastered without using the new circuits. Had these been used by the recording engineer in the first place, a closer facsimile would have resulted.

The important thing about the Scheiber System is that it is completely compatible. Any record, 2-track tape in any format, or stereo-FM broadcast, which has been encoded can be played by all existing stereo equipment today and normal 2-channel stereo will result. If the owner of a stereo system wants to buy the decoder, he can do so, and by connecting it to the extra stereo amplifier and two speakers required for all 4-channel systems, can retrieve the 4-channel information from the compatible source.

Advent expects to make both the encoding equipment, which it will market jointly with *Audiodata* to professional users, and a decoder which will be marketed at first through audio specialist stores.

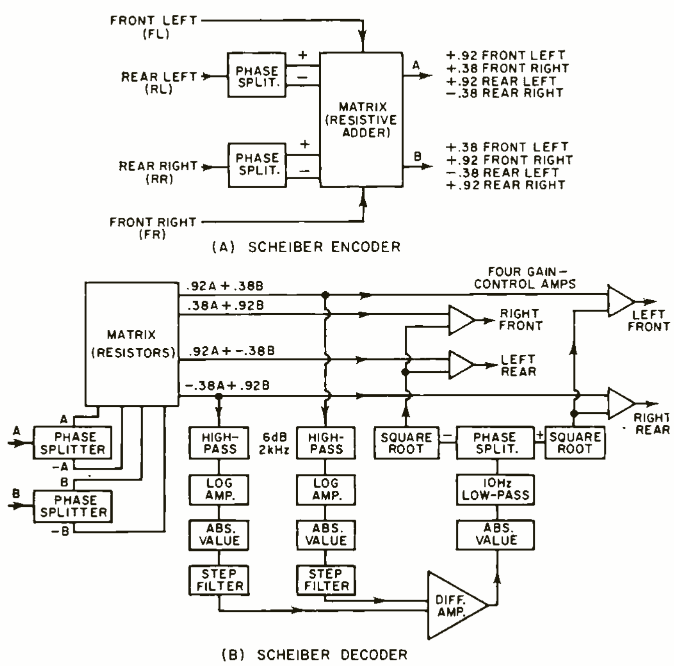
System Block Diagram

Although complete technical details on how the system works are still not available, the two block diagrams shown here have been released along with some technical information. Because of the intense interest in this technique, we would like to pass this on to our readers. The encoder (Fig. 1A) takes the four original signals, phase-splits the two rear channels, and combines them all in a resistor matrix. Matrices of this type are commonly used in color-TV sets to derive the three colors required from two different chroma signals. The two output signals from the matrix, A and B, have the composition shown to the right of Fig. 1A.

The decoder (Fig. 1B) is set to operate in such a way that when the ratio of front left (FL) to rear right (RR) is 2.41 to 1 (which occurs when A = B or B = 0) or when the ratio FL to RR is 1 to 2.41 (which occurs when A = −B or A = 0), the gains of all four channels after matrixing are down 3 dB referred to the maximum.

If a signal occurs solely in the FL channel, the dematrixed outputs will have unity signal in FL, equal reduced signals in front right (FR) and rear left (RL), and no signal in RR. The large ratio between FL and RR is sensed by the differential amplifier and applied to the gain-control amplifiers to turn off FR and RL and increase the gain of FL and RR pair to the 0-dB level. A signal appearing (*Continued on page* 69)

Fig. 1. Block diagrams of (A) Scheiber encoder and (B) decoder. The decoder is inserted into the playback system between the output of a 2-channel preamp and four power amps and speakers.



IC Capacitance Meter

By H.A. WITTLINGER
RCA Solid State Division

Design and applications of a tester with range of up to 10 μF that can also test new high-C, low-voltage disc capacitors.

Meter being used to check unknown capacitor across its terminals

MANY electronics enthusiasts accumulate a large number of capacitors whose values cannot be determined. The integrated-circuit capacitance meter to be described permits rapid and accurate identification of these capacitors. The meter restricts the applied voltage to a maximum of three volts so that some of the newer high-capacitance, low-voltage disc ceramics can be measured within their operating voltage limits.

Circuit Operation

Fig. 1A shows the basic circuit configuration used in the capacitance meter. The square-wave generator is stable in both frequency and amplitude. The unknown capacitor, C_X, is placed in series with the generator, a switching diode network $D1$-$D2$, and a current meter.

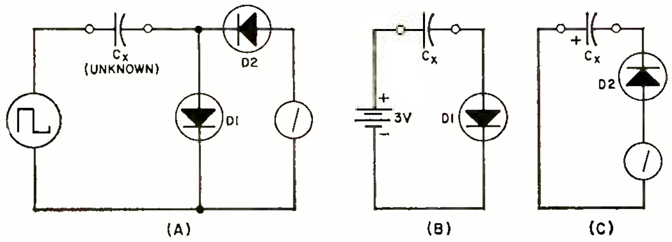


Fig. 1. (A) Basic circuit of capacitance meter. (B) Charging and (C) discharging of the unknown capacitor is shown.

Table 1. Meter-amplifier current and oscillator frequency.

METER RANGE	METER-AMPLIFIER FULL-SCALE CURRENT	OSCILLATOR FREQUENCY*
10 pF	10 μA	460 kHz
100 pF	10 μA	46 kHz
1000 pF	10 μA	4.6 kHz
0.01 μF	100 μA	4.6 kHz
0.1 μF	100 μA	460 Hz
1 μF	100 μA	46 Hz
10 μF	500 μA	23 Hz

*Based on 2.2-volt signal (due to diode drops).

Operation begins when the oscillator output is at +3 volts. In this case, the generator may be replaced by a 3-volt battery, as shown in Fig. 1B. If the voltage drops across the diodes are neglected, the capacitor charges to +3 volts. When the oscillator output drops to zero, the generator may be replaced by a short circuit, as shown in Fig. 1C. This condition results in a current flow through the meter. If the entire operation occurs only once, the meter is momentarily deflected upward and then returns to zero. But, when the operation occurs repeatedly, a steady reading is observed on the meter.

If the capacitor is allowed to charge and then discharge fully every cycle and there is negligible leakage, the average current, I, is directly proportional to the capacitance C, the frequency f, and the amplitude of the generator V: that is, $I = CVf$.

Another approach involves the basic relation $Q = CV$, where Q is the charge on capacitor C resulting from a voltage V. If the capacitor is charged or discharged over a given time t, both sides of the equation may be divided by t and $Q/t = CV/t$. Because the current is the rate of change of charge ($I = Q/t$), it may be substituted into the left side of the equation, as follows: $I = CV/t$. Because frequency f is equal to $1/t$, substitution in the right side of the equation yields $I = CVf$.

The equation for the meter operation must be dimensionally consistent; with the current given in amperes, capacitance in farads, voltage in volts, and frequency in hertz. From the basic equation for the meter, it can be seen that the range may be extended to a capacitance ratio of one million to one (10 picofarads to 10 microfarads full-scale) by changes in both frequency and current-meter sensitivity. Table 1 shows the approximate frequency and meter sensitivity for each range.

IC Generator

It is important to use a stable oscillator because a 1-percent change in either frequency or amplitude results in a 1-percent change in the current.

A multivibrator-type of oscillator is a reasonable choice for the generator because it has the square-wave output desired to insure that the capacitor is fully charged and discharged every cycle. However, the conventional multivibrator circuit shown in Fig. 2 has several disadvantages for this application. First, the firing threshold of the circuit and thus the charge on the multivibrator timing capacitor vary directly with the temperature-sensitive base-to-emitter voltage V_{BE} of the transistors; therefore, operating frequency is temperature-dependent. Second, two sets of timing capacitors and resistors must be switched in the circuit to accommodate different frequencies. An additional disadvantage is a potential starting problem; instead of oscillating, both transistor circuits may remain saturated.

A more suitable circuit for the generator is an astable multivibrator using an operational amplifier, as shown in Fig. 3A. An operational-amplifier configuration is used to provide high gain and consistent switching threshold. In addition, the square-wave output swings from the supply voltage V_{cc} to ground and requires only a single *RC* time constant to determine frequency. The frequency is also independent of supply voltages, as will be discussed later.

The circuit of Fig. 3A operates as follows. When the output of the amplifier is in the high state (V_{cc}), resistors R_c and R_b are in parallel and both connect to V_{cc}. When in the ground-output level, R_a and R_b appear in parallel connected to ground; thus, the non-inverting input (NI) is switched between the two states, as defined by the equations in Fig. 3B, while the inverting input (I) switches exponentially between the two conditions.

When the non-inverting input is high, *C* charges toward V_{cc}. When the capacitor voltage reaches $V_{cc}R_a/(R_a + R_b/R_c)$, the amplifier output switches low and the capacitor discharges toward ground until the inverting input reaches $V_{cc}R_a/(R_c + R_a/R_b)$. At this point, the entire cycle repeats itself.

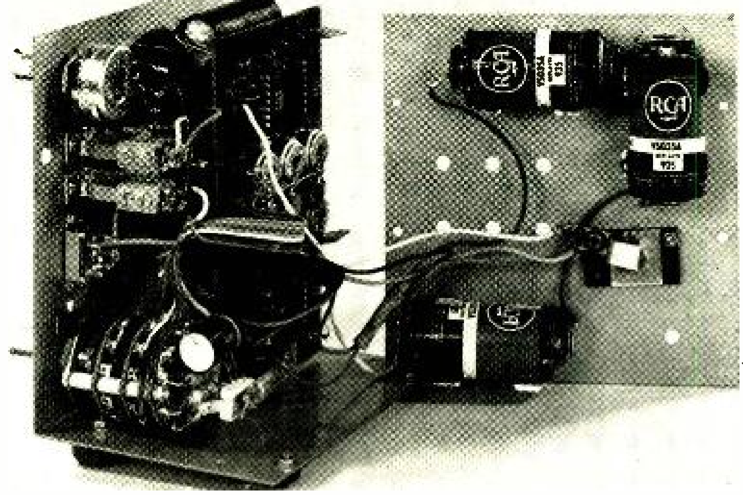
Because existing monolithic operational amplifiers do not meet requirements for this meter, a custom operational amplifier was designed using two *RCA*-CA3046 integrated-circuit transistor arrays. Fig. 4 shows the circuit, in which transistors *Q1A* and *Q2A* comprise a differential amplifier and *Q3A* couples the collector output and level-shifts the signal to the base of *Q5A*. The resistor network *R3* and *R4* provides further level-shifting, while capacitor *C1* aids in speeding up the signal transfer to the base of *Q5A*. Transistor *Q5B* of the second array drives the feedback signal back to the oscillator input.

Up to this point, the oscillator is complete. The remaining transistors in the second IC array further decouple the oscillator from the load and provide a lower output impedance to speed up the capacitor charge and discharge cycles. Transistor *Q4B* serves as an inverter to drive the emitter-follower *Q3B*. The low emitter-follower output impedance helps in the initial positive swing, while *R9* continues to pull up the output beyond saturation of *Q3B*. Two transistors, *Q1B* and *Q2B*, connected in parallel, provide lower impedance in the negative direction. Unlike conventional transistors, IC transistors on the same chip have excellent V_{BE} matching and may be connected in parallel without the current-hogging problems associated with discrete devices. This matching characteristic also provides excellent frequency stability of the circuit with temperature.

One of the advantages of this oscillator is its independence of input-voltage changes. Typically, the oscillator frequency varies less than 0.13 percent for each percentage change in supply voltage. Because the supply voltage is set by the meter during calibration, the influence of oscillator-frequency changes as a result of supply voltages on the capacitance reading is minimal.

Meter Amplifier

The meter amplifier uses two CA3046 transistor arrays in a circuit especially designed to operate a rugged 1-mA meter. An advantage of this meter amplifier is its low idling power of about 2 milliwatts. The open-loop voltage gain of the amplifier is greater than 10,000 which removes all gain errors from the circuit.



Inside view of meter shown here just prior to final assembly.

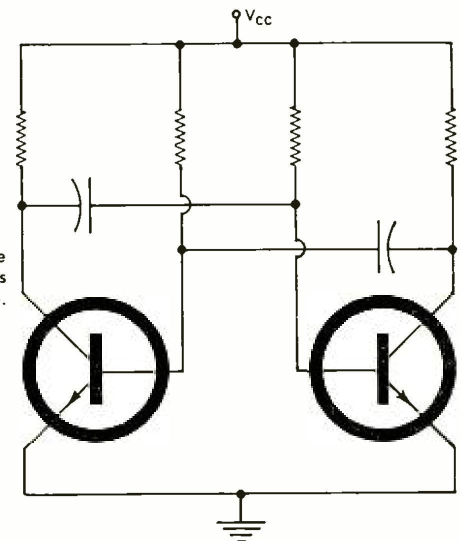


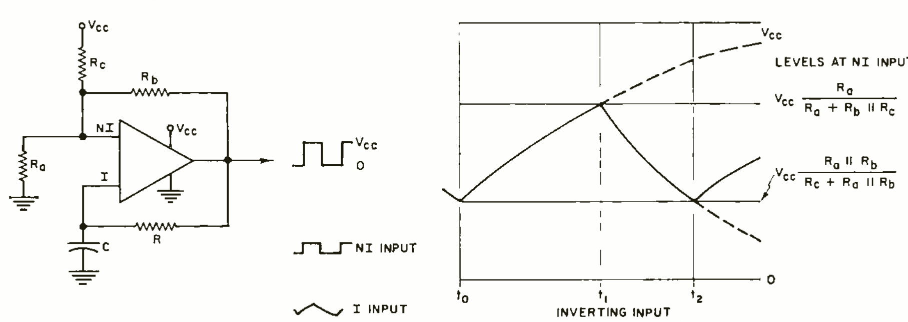
Fig. 2. Simple astable multivibrator circuit has drawbacks for this use.

Fig. 5 shows the meter-amplifier schematic, in which the two IC transistor arrays form a differential-input amplifier, a two-stage d.c. amplifier, and an emitter-follower output. Transistors *Q1C* and *Q2C* form the differential amplifier, for which *Q5C* is a constant-current source. Transistors *Q3C* and *Q4C* comprise input emitter-followers to reduce the amplifier input current to less than 10 nanoamperes. Because this value is only 0.1 percent of the minimum full-scale 10-microampere signal current, negligible error is introduced by the amplifier input current.

Transistor *Q4D* is used both to level-shift the collector signal of *Q2C* and to reduce loading of the 100k-ohm collector resistor, *R3*. *Q1D* and *Q2D* are common-base d.c. amplifier stages, and transistor *Q3D* is an emitter-follower output stage that drives the meter. The *RC* networks *R5,C1* and *R7,C2* compensate for phase shifts within the amplifier by providing two controlled phase shifts that allow closure of the feedback loop to provide unity gain without any oscillation.

When no meter-deflecting signal is present, the total cur-

Fig. 3. (A) Basic IC oscillator. (B) Signal levels at inputs to the oscillator.



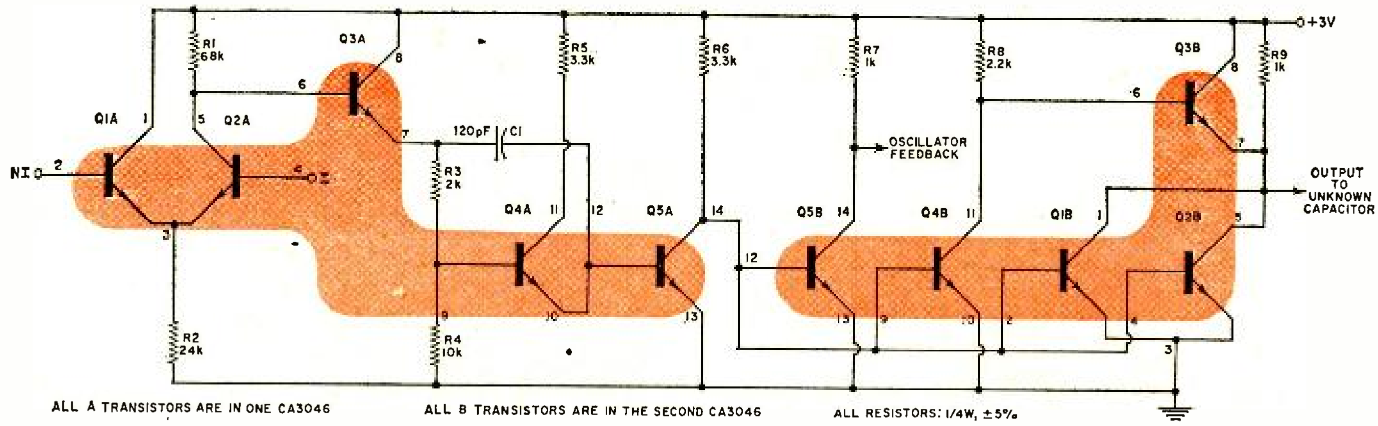


Fig. 4. Schematic diagram of the IC generator section, which employs two IC transistor arrays.

rent from both the 3-volt and 4.5-volt terminals is approximately 530 microamperes, with about 60 microamperes being supplied by the constant-current transistor *Q5D* to keep *Q3D* in class-A operation. At full-scale meter deflection, the current to the output stage *Q3D* increases by the meter current and rises to 1.06 milliamperes. The output stage also supplies the current to the feedback path, which adds to the 1.06 milliamperes.

Resistor *R9* limits the maximum current that may be supplied to the output stage to approximately 2 mA. Resistors *R1* and *R2* set the base reference voltage to the constant-current transistors *Q5C* and *Q5D*. The respective emitter resistors *R4* and *R10* set the operating current for each transistor.

Fig. 6 is the schematic of the capacitance meter with the circuits for the IC generator and meter amplifier represented by two triangles, *IC1* and *IC2*, respectively. A 910-ohm resistor (*R22*) placed in series with the meter sets the full-scale meter deflection at approximately 1 volt. This resistor also minimizes the effects of the meter resistance temperature coefficient which, for an uncompensated meter of 100 ohms, is approximately 0.4 ohm per °C.

Construction

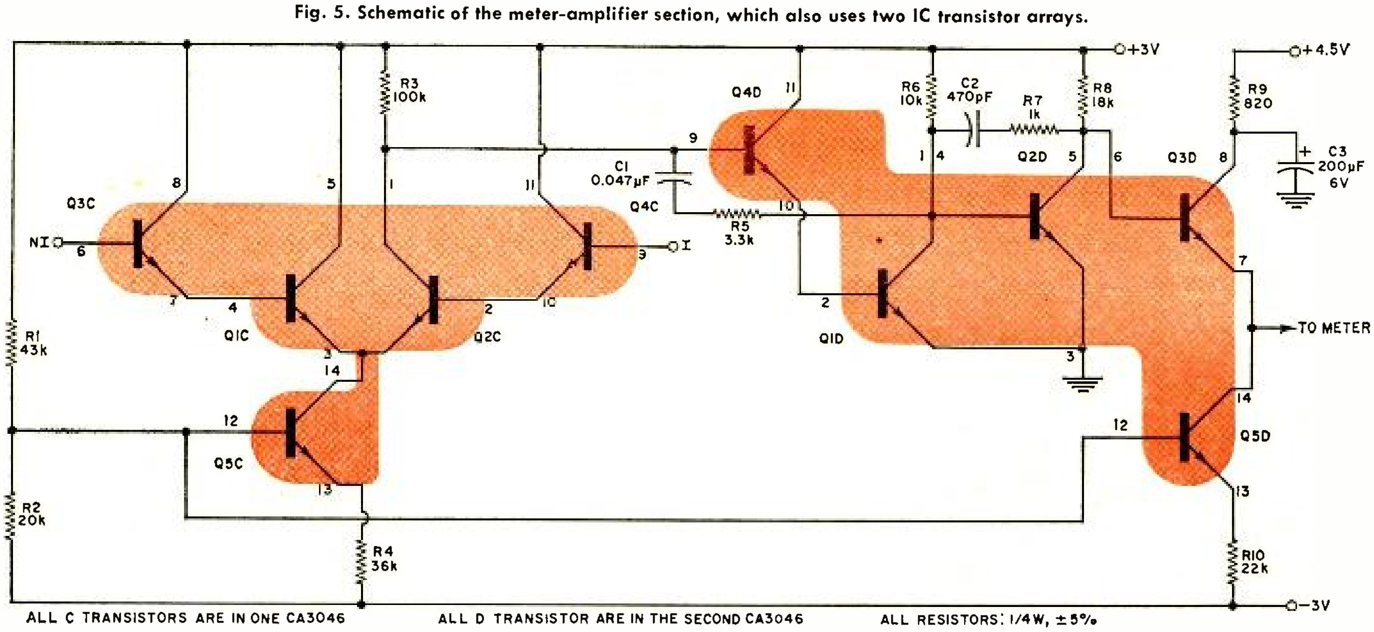
The entire generator and meter amplifier is built on a single PC board. This instrument uses a sloping-side type of cabinet. Before the front panel was drilled, the back cover was cut off. This arrangement helps during assembly and battery replacement later on because only two screws have to be removed to open the back cover and replace the batteries installed on the cover.

A small triangular-shaped hole is cut above the range switch to serve as both a pointer and an "On-Off" indicator. A piece of bright orange paper is mounted on a piece of thin plastic that fits around the "On-Off" switch so that it shows when the switch is in the "On" position and provides a positive "On" indication.

The most critical aspect of construction is to assure that there is minimum internal coupling between the two test terminals. A grounded piece of aluminum is located on the rear side of the front panel to minimize coupling between the two terminals. A ground terminal on the front panel may be used to extend the generator test terminal by use of low-capacitance coaxial cable (such as RG58A/U, or equivalent). For the input terminal to the meter amplifier, only an insulated lead is recommended because stray capacitance on this line appears as a shunt for the unknown capacitance and reduces sensitivity, especially on the lowest range. For example, stray capacitance of 2 picofarads on the meter input results in a reading of only about 1 pF for a 2-pF capacitor placed across the "unknown" terminals. For the meter described, stray capacitance has been about 2 pF; therefore, for the lower capacitance ranges, when the leads are extended beyond the front panel, the meter-amplifier input lead should be kept short, even if the generator lead has to be made slightly longer. On the higher ranges this problem becomes less significant.

Placing the "unknown" terminals lower on the front panel than shown in the photo makes it easier to place the unknown capacitor across them. Separation between the terminals on this unit is about ¾ inch to accommodate standard double-banana-type connectors. If it is more convenient, the gener-

Fig. 5. Schematic of the meter-amplifier section, which also uses two IC transistor arrays.



ator terminal may be moved toward the center of the panel for more separation.

Two large rubber feet are used on the front bottom of the instrument and two smaller ones on the back to raise the front panel and make it easier to use.

Operation

Two momentary-contact push-button switches are located on the front panel to calibrate the meter and check the condition of the negative supply. As pointed out earlier, the accuracy of the meter is directly dependent on the amplitude of the generator output. Therefore, when the "Cal" button is depressed, a potentiometer is used to set the generator supply voltage with the aid of the meter. The "Test" button only monitors the negative battery condition to see that it is above a 2.8-volt threshold.

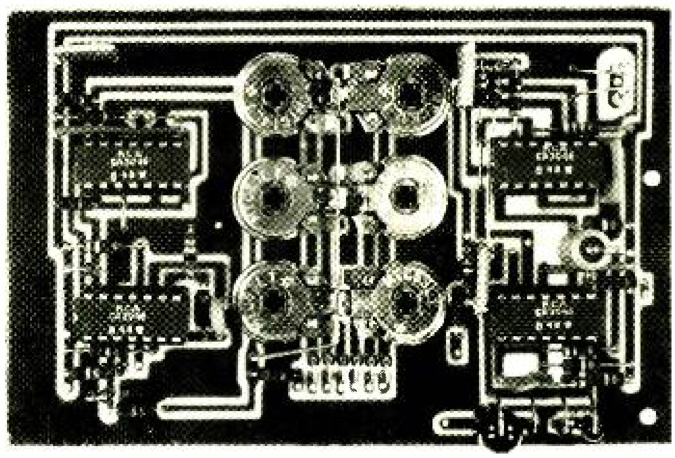
When there is no capacitance across the test terminals, the meter should read 0 ± one small division. On the lowest capacitance range, any stray capacitance between the unknown terminals is indicated if the precautions outlined previously are not followed.

High-capacitance, low-voltage disc capacitors, suitable for many bypassing applications (such as emitter bypassing or coupling capacitors in low-voltage equipment) are available. These devices are made up of a special ceramic dielectric material that exhibits high leakage resistance. Such capacitors are manufactured under the tradenames Ultra-Kap (*Centralab*), Magnacaps (*Mallory*), and Hypercons (*Sprague*). The insulation resistance of these units varies considerably, and for some manufacturers may be as low as 2000 ohms for 2.2-μF, 3-volt units. Although no units have been measured with this low an insulation resistance, such a unit will read low on the meter.

These low-voltage capacitors may be used in this instrument for supply bypassing, but they should have a voltage rating of at least 10 volts to assure lower leakage resistance. For critical locations such as the frequency-determining capacitors (C2, C3, and C4) and in the meter-amplifier feedback loop (C7, C9, C10, and C11), low-leakage units are recommended.

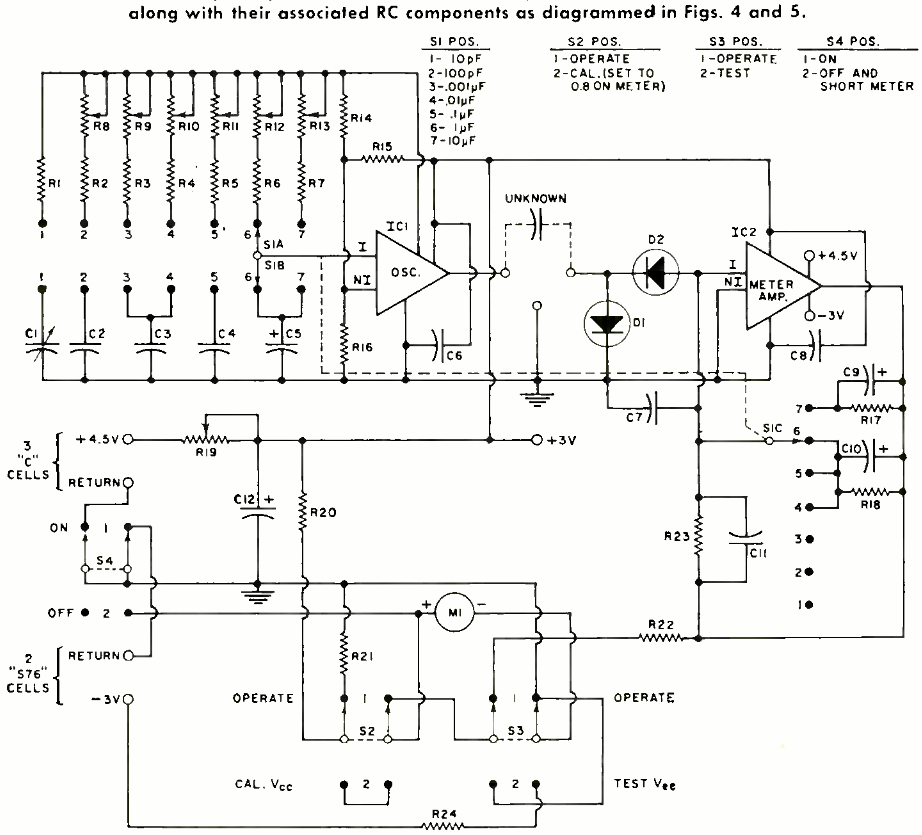
Three low-leakage, low-cost tantalum capacitors are used in the locations mentioned above. The 150-μF capacitor, C9, may be replaced by a low-leakage electrolytic to obtain about a 2:1 cost saving. However, leakage resistance in an electrolytic may reduce the meter sensitivity and, if the leakage varies with applied voltage, the scale will become nonlinear.

"Leaky" unknown capacitors may produce readings on the meter below their actual values. There are two sources of error: the *RC* discharge time constant composed of the unknown capacitance and the leakage resistance, and the loading of the oscillator, which reduces the charging voltage. On the lower capacitance ranges of 10 pF to 0.001 μF (full-scale), a leakage resistance of about 3 megohms results in a reduction of 2 percent of the full-scale reading. The next three ranges, from 0.01 to 1 μF, are also affected primarily by the time-constant error; however, because the meter sensitivity is 100 μA instead of 10 μA (as on the previous range), leakage resistance of about 300k-ohms results in a 2 percent of full-scale reduction in the reading. The last range (500 μA full-scale) can tolerance shunt resistance on the order of 50k-ohms for a 2-percent reduction. These limi- (*Continued on page 84*)



Component side of PC board with frequency pots and four IC's.

Fig. 6. Complete diagram of capacitance meter. Each IC symbol shown is actually composed of two separate integrated-circuit transistor arrays, along with their associated RC components as diagrammed in Figs. 4 and 5.

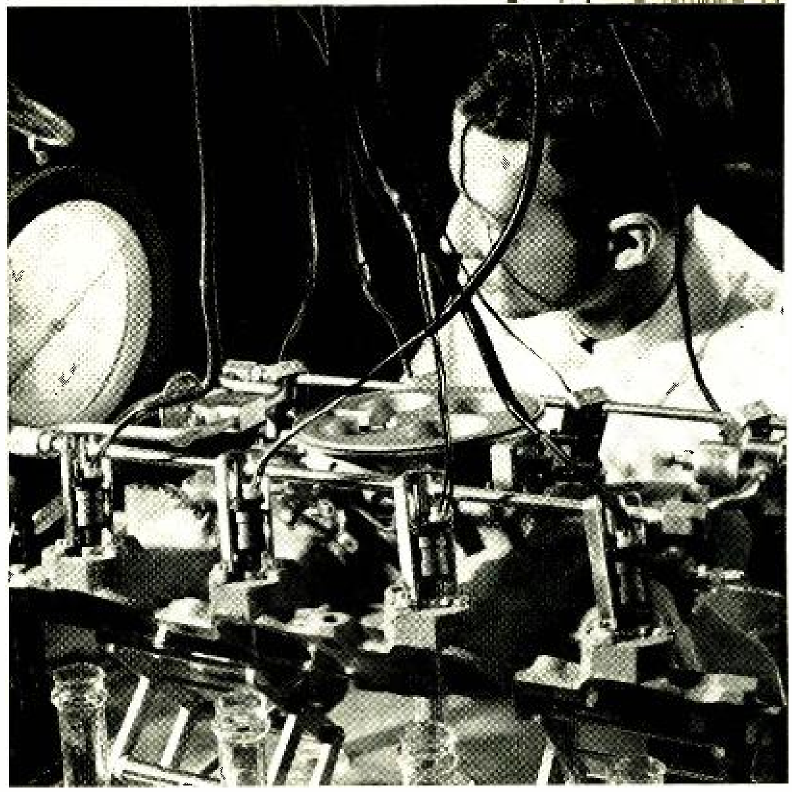


R1, R2, R3, R4, R5, R6—5100 ohm, ¼ W res. ±5%
R7, R15, R16—10,000 ohm, ¼ W res. ±5%
R8, R9, R10, R11, R12—5000 ohm trimmer (Mallory MTC4-55L4)
R13—10,000 ohm trimmer (Mallory MTC4-14L4)
R14—15,000 ohm, ¼ W res. ±5%
R17—2000 ohm, ¼ W res. ±5%
R18—11,000 ohm, ¼ W res. ±5%
R19—500 ohm linear-taper pot (Mallory U-2)
R20—3600 ohm, ¼ W res. ±5%
R21—100 ohm, ¼ W res. ±10%
R22—910 ohm, ¼ W res. ±5%
R23—100,000 ohm, ¼ W res. ±5%
R24—5600 ohm, ¼ W res. ±5%
C1—7-100 pF trimmer capacitor (Elmenco 423)
C2—0.0027 μF polystyrene capacitor
C3—0.027 μF, 80 V capacitor
C4—0.27 μF, 80 V capacitor
C5—2.7 μF, 15 V tantalum capacitor
C6, C8—0.1 μF, 10 V disc ceramic capacitor
C7, C11—0.1 μF, 20 V disc ceramic capacitor
C9—150 μF, 6 V tantalum capacitor
C10—6.8 μF, 6 V tantalum capacitor
C12—1000 μF, 6 V elec. capacitor
D1, D2—1N914 diode
M1—0-1 mA meter
S1—3-pole, 11-pos. (7 pos. used) non-shorting rotary sw. (Centralab PA-1009)
S2—D.p.d.t. momenetary push-button sw. ("Cal")
S3—D.p.d.t. momentary push-button sw. ("Test")
S4—D.p.d.t. slide sw. ("On-Off")
IC1, IC2—Four RCA CA3046 integrated circuits
Three 1.5-volt "C" cells
Two 1.5-volt silver-oxide cells (Eveready S76 or Mallory MS76)

Electronic Fuel Injection Reduces Air Pollution

By FRED W. HOLDER

By doing away with carburetor and injecting fuel directly and automatically, auto exhaust emissions are reduced without need for any power-consuming smog-control devices.



A Bendix engineer is shown testing an intake manifold equipped with the EFI system to make sure Electronic Control unit is metering proper air-fuel mixture into each of the cylinders.

IN 1952, *Bendix* engineers at Elmira, New York built an electronically controlled fuel-injection system using vacuum tubes. This system gave substantially improved engine performance over systems using carburetors to meter fuel. The advent of the transistor aided in their research so that by the late 1950's the company had built about 100 electronic fuel-injection systems. Unfortunately, this system was ahead of its time. The solid-state electronic components needed for the system were much too costly; the system was shelved.

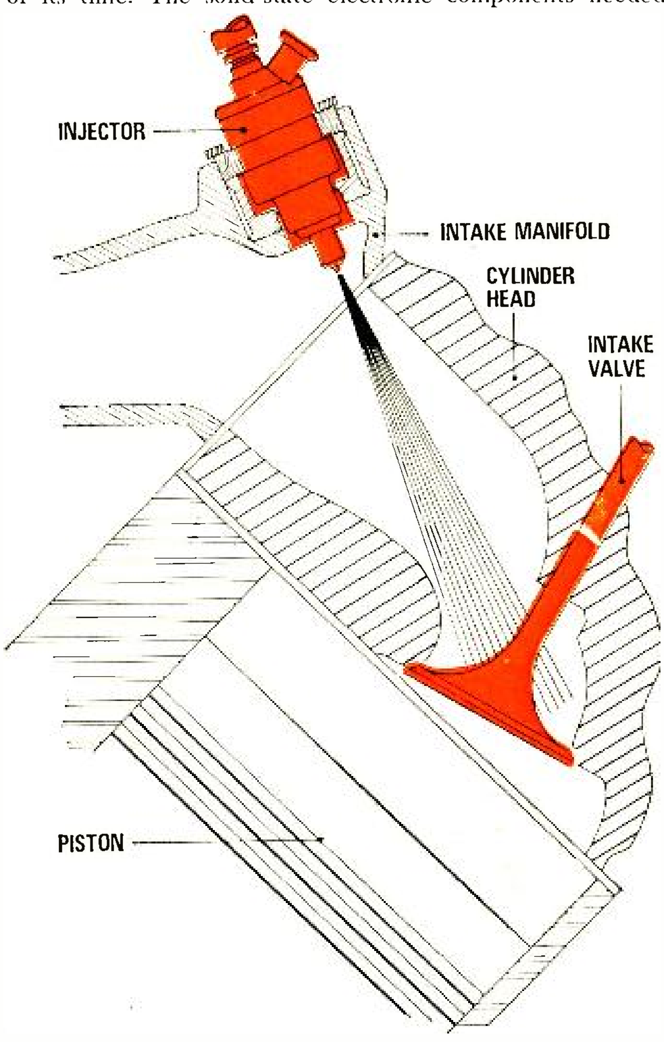


Fig. 1. Cross-sectional view showing how injectors on the Bendix EFI are arranged to spray fuel directly at intake valve.

The *Bendix* concepts emerged again when *Robert Bosch* of Germany introduced an advanced production model of the *Bendix* electronic fuel-injection (EFI) system on the 1968 *Volkswagen* 1600 Series. (The *VW* system was described in the November, 1968 issue of ELECTRONICS WORLD.) The *Bosch* fuel-injection system, produced under *Bendix* license, permitted the *VW* to meet exhaust-emission standards without the need for power-consuming smog-control devices. The increasing air-pollution problem and the more stringent Governmental regulations on exhaust emission require more precise fuel metering for gasoline engines. With lower priced electronic components now available, the *Bendix* system has been revived to help meet these emission standards. The *Bendix Automotive and Automation Company* has an EFI system under development similar to the *Bosch* system, but specifically designed for U.S. automobiles.

In this article, we will review briefly how the *Bendix* EFI system works. We will also cover exhaust emission standards for the future and show how fuel injection is expected to aid in meeting these requirements. Finally, we will discuss the benefits to the auto owner. First, however, let's see how the EFI works.

EFI Operation

In the *Bendix* EFI, fuel is pumped from the gasoline tank through a filter to a common line which supplies all of the injectors. A regulator maintains a constant pressure to the injectors, which are located so that they spray fuel directly at the intake valve, as shown in Fig. 1. By controlling the time the injectors are open, the amount of fuel delivered to each cylinder can be precisely metered. Electromagnetically actuated injectors provide the means for electronic control.

An electronic control unit determines the basic engine needs from various sensors and generates a "timing pulse" signal for each injector. The sensors include a manifold pressure sensor, a full-load enrichment switch, a coolant thermistor, and an engine-speed (r/min) sensing unit. Using information from these sensors, the control unit determines the correct "pulse width" or "open time" for the injectors. A throttle transient-enrichment switch on the fuel-injection system senses how much extra fuel is needed for acceleration and varies the amount of time the injectors are open.

Grouped injection in which fuel is injected to a group of cylinders at the same time is used with this EFI system. For example, the injection grouping for a typical eight-cylinder American car with a firing order of 1-8-4-3-6-5-7-2 would be: Group One containing cylinders 1-8-7-2 and Group Two containing cylinders 4-3-6-5. See Fig. 2. Tests conducted by the company have shown that this method yields virtually all of the advantages of a fully timed fuel-injection system, but permits the use of a much simpler and less costly control system.

A small additional injector is mounted in the throttle body to discharge the additional fuel needed to ensure rapid cold starts. A mechanical temperature-sensitive bypass valve is used to supply the extra air required for smooth idling while the engine is cold. The electronic fuel pump is turned off by the control unit if the engine stalls or if the ignition switch is left on when the engine is not running.

The trigger unit and the electronic control unit form a single, compact package. The electronic control unit package measures only 3½ inches on each side; a significant reduction in size from the foot-long unit used on the VW. The trigger unit can be driven by the mechanical fuel pump eccentric or other indicator of engine phase and speed.

The pressure sensor, consisting of a variable-inductance transformer operated by an evacuated pressure-sensitive capsule, measures absolute pressure in the intake manifold and provides the primary information concerning engine load. The full-load enrichment switch, on the other hand, senses vacuum and provides enrichment for full-power operation whenever manifold vacuum drops below a preset level; thus permitting enrichment for full-power operation at any altitude.

An engine equipped with carburetors might operate better if it had all of these sensing devices helping to meter the fuel. Unfortunately, a carburetor has only the air flowing through it, an approximate temperature measurement, and the driver's demands to determine the amount of fuel needed at any given time. As a result, another method of fuel metering is needed. *Time's* auto writer, Dan Fisher, predicted in an article (January 11, 1970) in the *Los Angeles Times*, "Fuel injection will probably be adopted in most domestic passenger cars as a primary weapon against air pollution within four years."

Fuel Injection's Answer to Pollution

To better understand why fuel injection is considered the answer to immediate pollution problems from exhaust emission, let's take a look at the California emission requirements for 1972 and 1974 and then see how fuel injection may help meet them.

Fig. 3 shows a comparison of the California pollution-control requirements for the three major combustion by-products: hydrocarbon, carbon monoxide, and oxides of nitrogen. In Fig. 3, the 1972 and 1974 standards are compared with the pre-emission control levels. It is anticipated that these requirements, spelled out for California, will be adopted as Federal law in the near future. In an attempt to meet these emission-control objectives, automotive engineers are looking at fuel-metering systems, evaporative fuel systems, the combustion chamber design, cam design, air-intake manifold, ignition system, exhaust manifold, and crankcase-emission controls.

One of the key steps in reaching the emission goals will be the development of a device that can accurately control the air-fuel ratio of an automobile engine. In Fig. 4, the hatched curves illustrate the effect of air-fuel ratio on exhaust emission under road operating conditions. The air-fuel ratios are listed along the horizontal scale of the graph. The vertical scale represents the relative concentrations of the three primary contaminates: hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen (NO). Automobiles using pre-emission carburetors are operating in the 14.5 to 1 air-fuel ratio range (middle arrow on top axis).

From the curves of Fig. 4, we can see that the three contaminates can be significantly reduced by running the engine very lean at approximately 19 to 1 air-fuel ratio. The curves also show that if a reactor is used, (*Continued on page* 68)

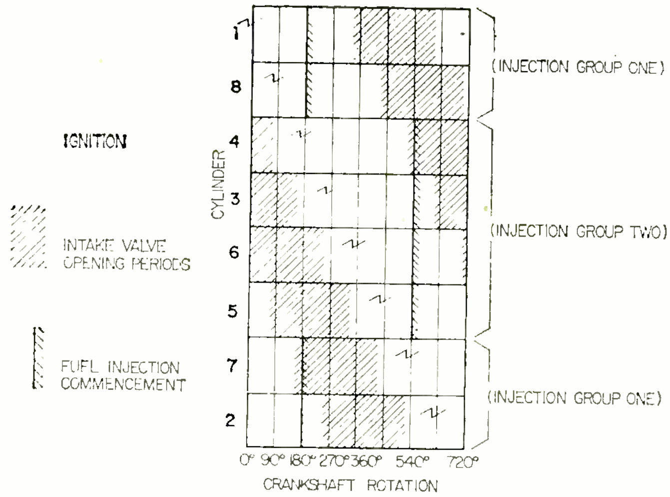


Fig. 2. Injection timing chart for a typical eight-cylinder American car having a firing order of 1-8-4-3-6-5-7-2. The fuel is injected to each group of cylinders at the same time.

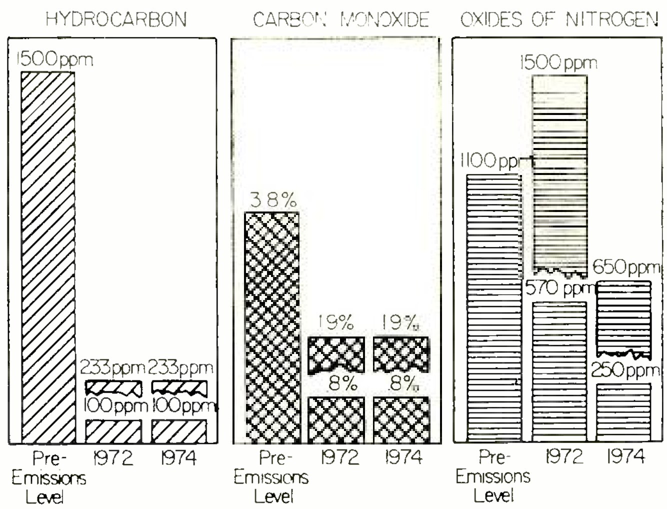


Fig. 3. Graphs showing California's pollution control requirements that must be met by automobile manufacturers in 1970's.

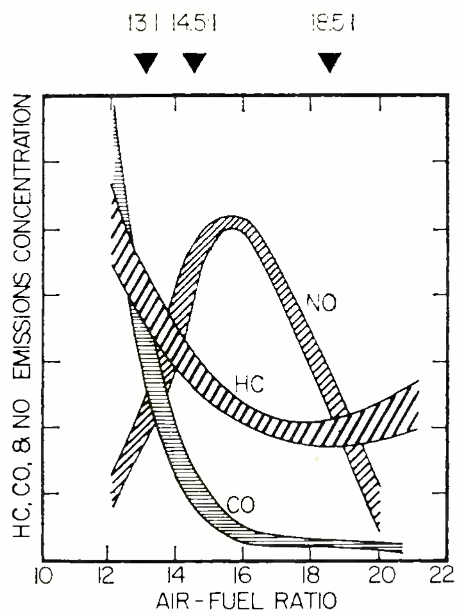
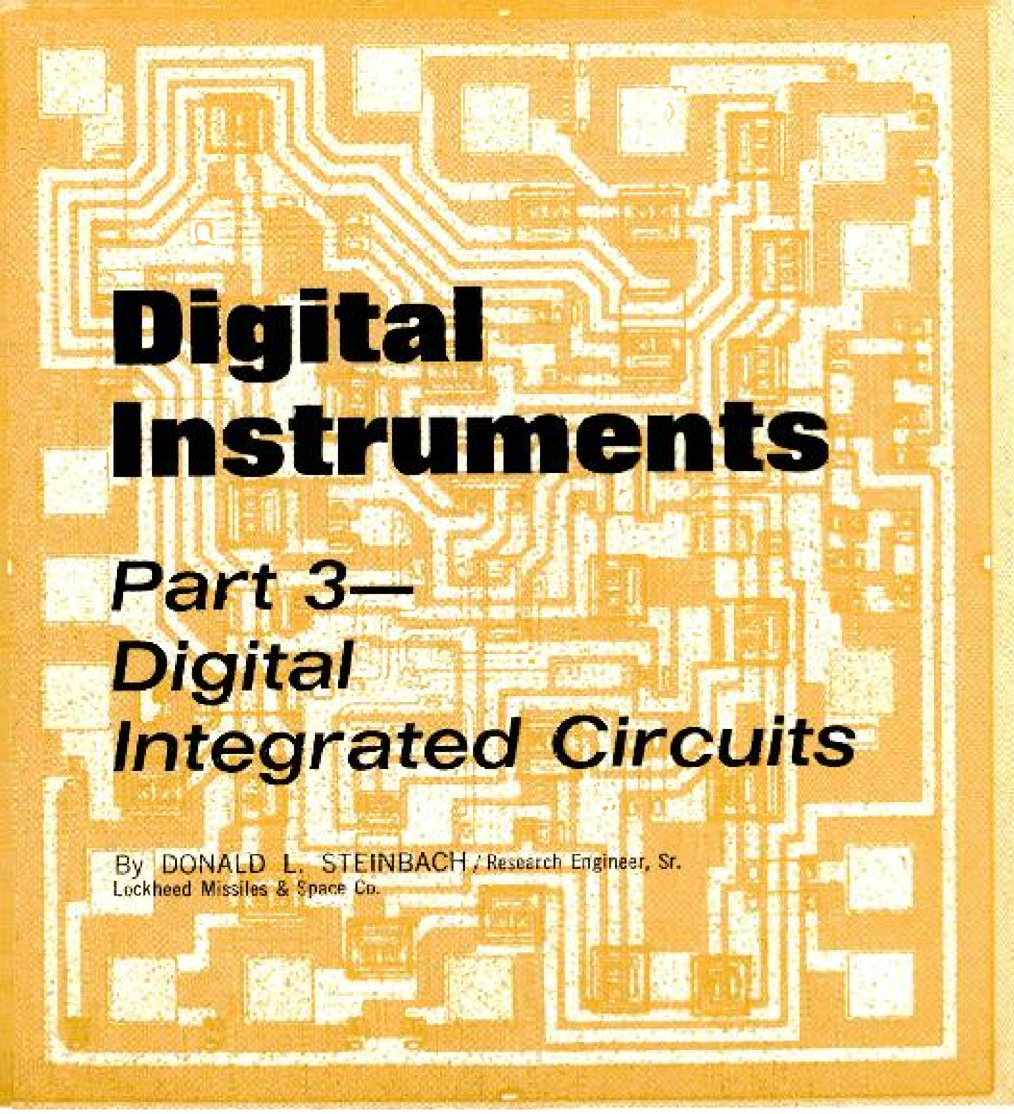


Fig. 4. Three curves showing effects of air-fuel ratios on various exhaust emissioncontaminants.



Digital Instruments

Part 3—Digital Integrated Circuits

By DONALD L. STEINBACH / Research Engineer, Sr.
Lockheed Missiles & Space Co.

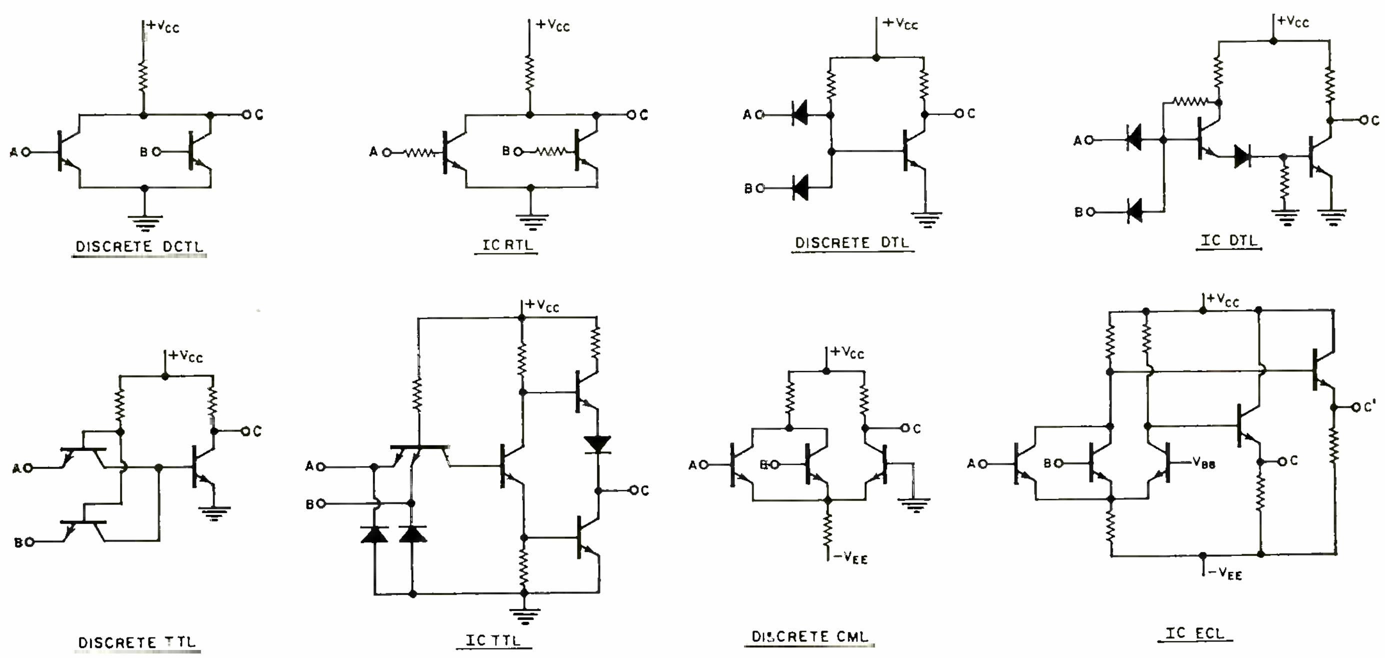
Four digital IC families available to digital instrument designers and some salient features. Here's how one manufacturer classifies these IC logic families according to performance, packaging, and operating range.

Motorola's MRTL MC9760P BCD-to-decimal decoder-driver IC capable of driving a cold-cathode gas-filled indicator tube directly.

INTEGRATED circuits are divided into two major classifications: digital and linear. Linear IC's include amplifiers, multipliers, and other devices whose output is some *algebraic* function of the input; the input and output signals may be of any amplitude within the operating region of the device. Digital IC's include flip-flops, gates, and other devices whose output is some *logical* function of the input; the input and output signals are always considered to be at one of two distinct levels or states, commonly called "high" and "low" or "1" and "0."

An individual IC usually represents one small stage in a complex system. That IC stage, like the total system, must meet certain specified functional, performance, cost, packaging, and environmental requirements. IC's have relieved the designer of considerable routing circuit design, and freed him to concentrate on optimizing system performance and

Fig. 1. Schematic diagrams showing the differences between equivalent typical discrete component gate and typical IC gate circuits. Note the multiple-emitter transistors in the IC TTL gate and that CML is also called ECL (emitter-coupled logic).



contemplate more complex systems; the designer, in return, must work within the framework of a vendor catalogue from which he attempts to select packaged circuits that satisfy his requirements.

Although linear IC product lines are finally beginning to expand significantly, a tremendous variety of digital IC's have already appeared, consistent with the system designer's requirements and the manufacturer's capability. Since most of the IC's used in the devices covered in this series of articles are digital, the balance of this article will be devoted primarily to that topic.

The ideal digital IC would have infinite speed, no propagation delay, complete immunity to noise in the presence of a signal, dissipate no power, and drive arbitrarily large loads. In absence of a "utopian" digital IC, the user is confronted by a wide variety of products, each of which optimizes one or more parameters at the expense of the others. Product tradenames are sometimes confusing, but fortunately all digital IC's are readily classified and any product line may be reduced to a few lowest common denominators.

All digital IC's are derived from one of two basic logic forms—called "saturating" and "nonsaturating" to describe the operating regions of the active elements. These are further divided into four universally accepted logic families. DCTL (direct-coupled transistor logic), DTL (diode-transistor logic), and TTL (transistor-transistor logic) are saturated logic forms; CML (current-mode logic) is the nonsaturating logic form. These four terms describe the general circuit configurations as shown in Fig. 1. Note that TTL is a modification of DTL, and that DTL is the only configuration that uses diodes instead of transistors to perform logical operations. The terms DTL and TTL (or T^2L or TCL) are widely used in vendor literature, but CML is usually called ECL (emitter-coupled logic) since that terminology more accurately describes the usual circuit configuration.

DCTL rarely appears in its "pure" form, because of the difficulty of achieving equal current sharing when DCTL inputs (transistor bases) are connected in parallel, and the low noise immunity associated with DCTL. DCTL in its modified form has resistors in series with the transistor bases and is called RTL (resistor-transistor logic). IC manufacturers offer variations of the four logic families (DCTL or RTL, DTL, TTL, and CML or ECL), and some add their own totally undescriptive Madison Avenue mnemonics for reasons best understood by their advertising people.

In general, ECL is capable of very high operating speeds —followed by TTL, DTL, then RTL. (DTL flip-flops are generally faster than RTL flip-flops, but the propagation delay of an RTL gate is usually less than that of a DTL gate.) High speed and low power dissipation are mutually exclusive; ECL power dissipation is several times that of RTL. Neither ECL nor RTL will tolerate as much external electrical noise as DTL or TTL. Unfortunately, not all of the various IC families will interface directly, but inter-family translators are available.

As one might expect, RTL IC's are quite inexpensive, while some ECL IC's are up in the thirty-dollar class. Most IC's are available for operation over various temperature ranges, with different package configurations available in each temperature range. Naturally, devices operating over wide temperature excursions are the most expensive.

A Typical Product Line

There isn't room in this article to discuss each digital IC produced by every manufacturer. It is informative, however, to look briefly at how one manufacturer divides the four logic families, and to examine the impact of performance, packaging, and operating temperature range on price.

Motorola's line includes a large selection of digital IC's in all four logic families. RTL, DTL, TTL, and ECL appear in the *Motorola* literature under their trademarks as MRTL, MDTL, MTTL, and MECL, respectively. A fifth *Motorola* family, MHTL, is a variation of MDTL. Each family is further subdivided as follows:

A. MRTL
- *1.* Medium-power MRTL IC's, MC900/MC800 Series
- *2.* Low-power mW MRTL IC's, MC908/MC808 Series
- *3.* Plastic MRTL IC's (low-power and medium-power) MC700P/MC800P Series
- *4.* Commercial MRTL IC's (low-and medium-power) MC-700 Series

B. MDTL
- *1.* MDTL IC's MC930/MC830 Series

C. MTTL and MHTL
- *1.* (*a*) MTTL IC complex functions, MC5400F/MC-7400F Series
  (*b*) MTTL IC's, MC5400F/MC7400F Series

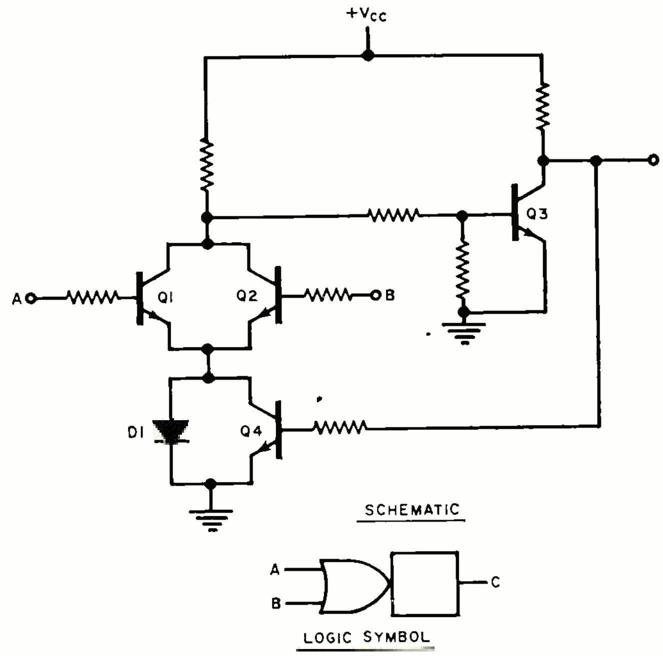


Fig. 2. This schematic diagram of an IC Schmitt trigger shows how an IC device sometimes uses a different circuit design approach than discrete component counterpart. Most obvious difference is dual signal/gating inputs and the diode and transistor in the emitter circuit of Q1 and Q2. Note the logic symbol.

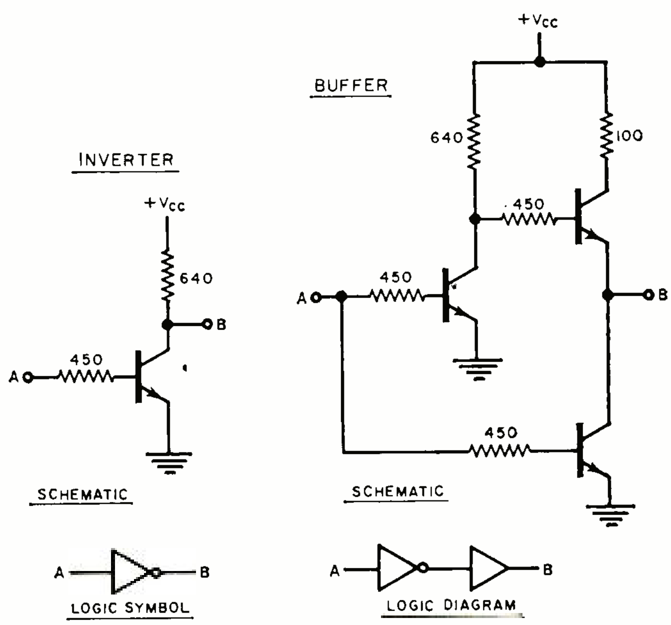


Fig. 3. Schematic diagram and logic symbol of the (left) inverter and (right) buffer. The buffer and inverter perform same logic function, but the low output impedance of buffer makes it suitable for driving large and/or capacitive loads.

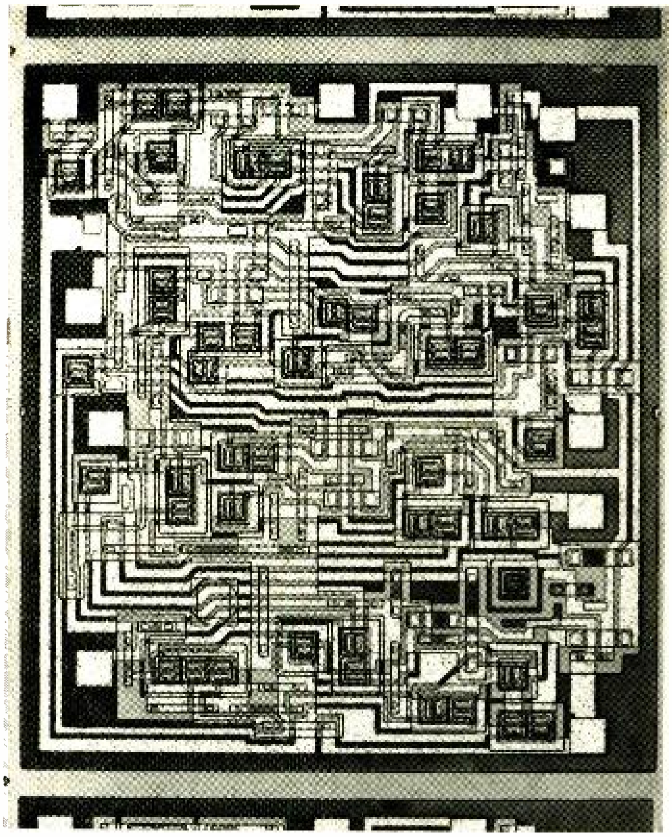


Fig. 4. Photomicrograph of Motorola's MRTL MC780P decade up-counter digital IC that operates at frequencies to 4 MHz.

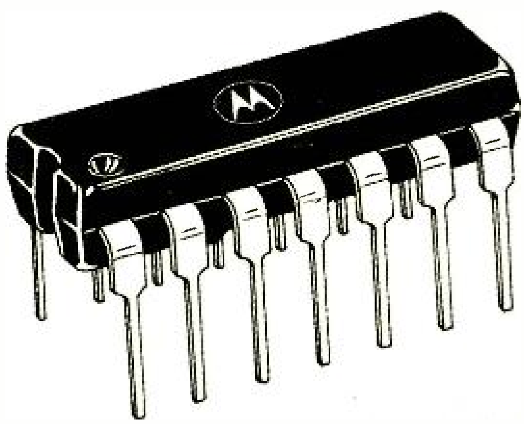


Fig. 5. This 14-pin plastic dual in-line package (DIP) is used for popular MC700/MC9700 series of resistor-transistor logic.

(c) MTTL IC's, MC7400P, MC5400L/MC7400L Series
2. MTTL I IC's, MC500/MC400 Series
3. MTTL II IC's, MC2100/MC2000 Series
4. MTTL III IC's, MC3100/MC3000 Series
5. MTTL IC complex functions, MC4000 Series
6. MHTL IC's, MC660 Series

D. MECL
1. MECL I IC's, MC300/MC350 Series
2. MECL II IC's, MC1000/MC1200 Series
3. MECL III IC's, MC1600 Series.

Each subdivision or series represents a difference in performance or intended market: Commercial MRTL IC's are not available in small quantities, MHTL (*Motorola* High-Threshold Logic) is designed for applications where high electrical noise immunity is of prime importance, MECL III represents the state-of-the-art with FF toggle frequencies greater than 300 MHz, etc.

Single-unit prices range from $1.00 for a MRTL dual 3-input gate and $1.30 for a MRTL JK flip-flop, to $37.50 for a MECL III dual Type-D flip-flop. Variations in packaging and temperature range account for significant price differences among otherwise identical devices: a MECL II gate (chosen at random) costs $4.10 for a −55° C to +125° C device in a 14-pin ceramic flat package, $2.45 for the same temperature range in a 14-pin dual in-line ceramic package, and $1.50 for a 0° C to +75° C device in a 14-pin dual in-line plastic package. Thus, performance, packaging, and environmental requirements can have a significant impact on cost, and overspecification is as wasteful as overdesign.

Designing with RTL

RTL, the first of the logic families to become available in IC form, features economy, simplicity, and flexibility. A discussion of the "care and feeding" of RTL IC's points out the significant items that must be considered when designing with any IC family.

RTL IC's are available in both medium-power and low-power forms. The low-power versions have higher resistances in the base and collector circuits and dissipate (and consume) less power than the medium-power devices. As one would expect, they deliver less output power, require less driving power, and generally have longer propagation delays and lower operating speeds. The characteristics of a medium-power MRTL and a low-power mW MRTL inverter (a transistor and two resistors) are compared below:

Type	Base Res.	Coll. Res.	Prop. Delay	Max. Pwr. Diss.	Norm. Input Load	Norm. Output Drive
MRTL	450Ω	640Ω	12 ns	21.7 mW	3	16
mW MRTL	1500Ω	3600Ω	27 ns	1.2 mW	1	4

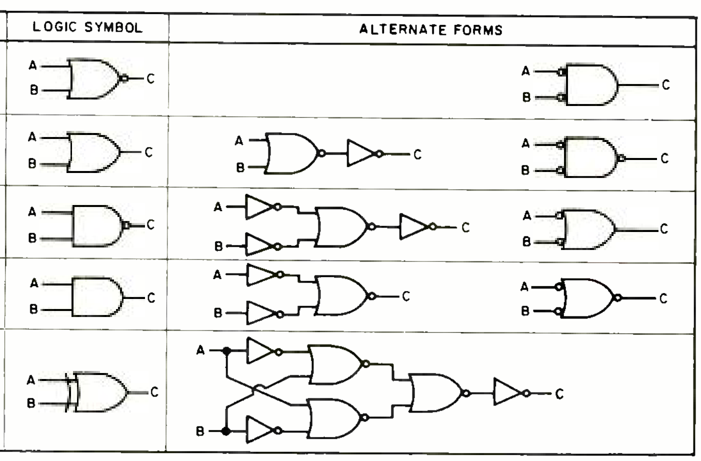
Every digital IC has an input load factor (fan in) assigned to each signal input pin, and an output drive factor (fan out) assigned to each output pin. These normalized numbers are a measure of the input current requirement and output current capability of the device; the output drive factor of a device must be equal to (or greater than) the sum of the input load factors of the input pins of other devices connected to that output. The RTL unit input load factor is typically 140 μA d.c. for a low-power device and 600 μA d.c. for a medium-power device.

The output voltage swing and logic levels of RTL are highly dependent upon temperature and loading. The logical "1" output level can approach V_{cc} when the device is unloaded, and will decrease to a minimum of +1.0 V d.c. at high temperature and maximum load-

(*Continued on page* 80)

Fig. 6. Some common gate logic symbols, their functions, and alternate logic forms.

GATE	DEFINITION
NOR	OUTPUT IS HIGH IF AND ONLY IF ALL INPUTS ARE LOW
OR	OUTPUT IS LOW IF AND ONLY IF ALL INPUTS ARE LOW
NAND	OUTPUT IS LOW IF AND ONLY IF ALL INPUTS ARE HIGH
AND	OUTPUT IS HIGH IF AND ONLY IF ALL INPUTS ARE HIGH
EXCL. OR	OUTPUT IS LOW IF AND ONLY IF BOTH INPUTS ARE THE SAME



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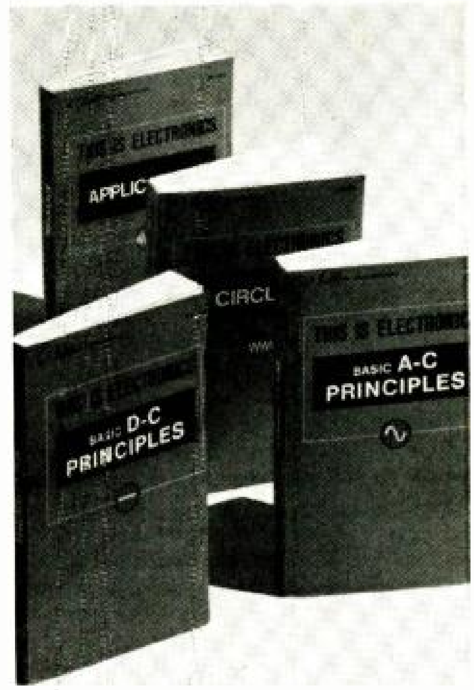

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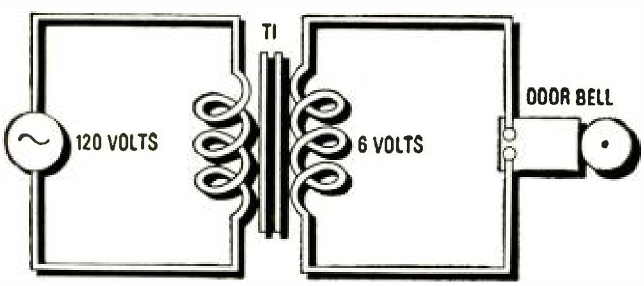

In this door bell circuit, which kind of transformer is T_1—step-up or step-down?

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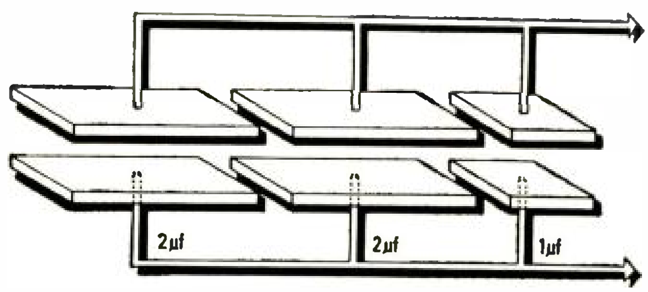

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Cleaning the AIR WE BREATHE

As conscripts in the war against pollution, we must learn the vocabulary as well as the manual of arms.

By **John Frye**

IT was the beginning of what Jeeves described as "the season of mists and mellow fruitfulness," and a dense September fog curled against the windows of Mac's Service Shop. It was not a work-inspiring day, and the three occupants were still congregated in the front room of the shop.

"Maybe I imagine it," Matilda, the office girl, said, "but it seems a little hard to breathe. Guess I've been reading too many smog stories."

"We're lucky we live in a small town," Barney told her. "In a large city with heavy traffic and lots of smokestack exhaust, a temperature-inversion situation like this could easily change such a fog into a killer smog."

"We probably have plenty of the raw ingredients of smog available even here," Mac injected. "According to a National Academy of Sciences survey made in 1966, the U.S. spews 124,000,000 tons of pollutants into its layer of atmosphere every year, a layer that is, relatively speaking, no thicker than the layer of varnish on a desk-size globe. About 12,400,000 tons of this is in the form of smog-producing particulate matter."

"What's particulate matter?" Matilda wanted to know.

"A particle is an object with definite physical boundaries having a diameter between .001 and 100 microns. Note the definition includes suspensions in air of liquid as well as solid particles."

"So how big is a micron?" Matilda pursued.

Picking up a postage stamp from her desk, Mac answered: "A micron is one-millionth of a meter. It would take 25,400 microns side by side to equal the one-inch length of this stamp. About 800 microns are needed to span the eye of an average needle."

"Little rascals, aren't they?" Barney commented. "What kind of pollutants make up those 124 million tons?"

Before answering, Mac took several sheets of paper stapled together from his pocket and consulted them. "*Honeywell*, one of the largest manufacturers of residential and light commercial air cleaning equipment, has prepared this excellent treatise called 'Theory and Fundamentals.' It classifies pollutants according to how they are formed: (1) dusts, fumes, and smokes, which are solid particulate matter; (2) mists and fogs, which are liquid particulate matter; and (3) non-particulate vapors and gases.

"The National Academy of Science says 52% of air pollution is carbon monoxide, 18% sulfur oxides, 12% hydrocarbons, 10% particles, 6% oxides of nitrogens, and 2% other gases and vapors. As to the sources of this pollution, the Academy says 60% is contributed by transportation; 19% by manufacturing, 13% by electricity generation, 6% by space heating, and 2% by waste disposal."

"Getting rid of air pollution presents no problem, then," Barney quipped. "All we have to do is for everyone to stay home and stop sending for stuff, quit making things, junk all our electrically operated equipment, wear lots of clothes to stay warm, and bury the trash."

"A little drastic," Mac agreed with a chuckle, "but that should do it. Seriously, getting rid of pollution at the source will require a lot more knowledge than we now have, plus a great deal of effort, money and time. People with respiratory difficulties may not have that time. Others without any lung trouble *yet* do not like the idea of inhaling with each breath 40,000 to 70,000 of the 100-500 billion particles to be found in every cubic foot of large-city air! A stop-gap solution is to remove most of the particles from the air where these people live and work."

"Since particles constitute only 10% of air pollution, why work so hard to get rid of just them?" Matilda quizzed.

"A good question that has logical answers," Mac replied. "In the first place, according to *Time* magazine, particles are especially injurious to humans because they function as 'carriers' to transport harmful gases, such as sulfur dioxide whose molecules adsorb onto the particles, far deeper into the lungs than the gases could make it on their own—deep enough that the gas cannot be easily exhaled, as it can be from the upper respiratory tract. Other particulates serve as catalysts in the atmosphere to speed the conversion of sulfur dioxide into sulphur acid. Particulate pollutants produced by incomplete combustion in automobile or diesel engines include polycylic, aromatic hydrocarbons, some of which tend to produce cancer.

"Secondly, while we know how to do a good job of trapping the particles, we aren't nearly so knowledgeable about how to get rid of some of the other pollutants. For example, sulfur dioxide is a serious pollutant item in the exhaust of coal-burning electric generation plants. We hear loud demands that this SO_2 emission be controlled. But a National Academy of Engineering panel of the National Research Council recently reported: 'Contrary to widely held opinions, commercially proven technology available for control of sulfur oxides from combustion processes does not exist.' "

"OK, pollution control is the art of the possible right now; so how do I get rid of the dust in my house?" Matilda asked.

"Dusts," Mac lectured, "are solid particles projected into the air by natural processes of wind, volcanic eruption, and earthquakes; or by mechanical processes, such as crushing, grinding, demolition, drilling, shoveling, screening, and sweeping. The dust may be mineral, such as sand; vegetable, such as flour and pollen; or animal, such as hair or feathers. An urban home accumulates an average of two pounds of this dust every week. You may doubt this because only 10% of the dust particles are large enough—at least 10 microns in diameter—to be seen under the most favorable conditions. The ones you see floating in a beam of sunlight are usually 50 microns or larger. Most invisible particles are 3 microns in diameter or smaller. Only when these are present in vast numbers are they rendered visible by their light-scattering quality. That's why we see the wisp of smoke curling up from a cigarette for a few feet, although the smoke is made up of invisible individual particles.

"Visible particles tend to settle on top of horizontal surfaces and worry the heck out of the housewife. She wipes them off with her dustcloth and is happy. But the invisible particles, especially the ones less than 1 micron in diameter, settle on vertical as well as horizontal surfaces and do most of the long-term expensive soiling of curtains, windows, woodwork, furnishings, and clothing. Her dustcloth removes few particles smaller than 3 microns.

"The trick is to remove the particles before they settle. This is easier to do with the invisible ones—1 micron particles take 8½ hours to settle in a room with an 8-foot ceiling—than with the 50-micron variety that settle in 12 seconds. You don't want to throw away your dustcloth when you install an air cleaner because quite a bit of the visible dust is still going to settle on the furniture before the cleaner has a crack at it. However the invisible dust that causes most of the expensive damage will be largely removed.

Air Cleaners

"There are two major types of air cleaners: mechanical and electronic. Mechanical filters, such as those in the ductwork of your forced-air furnace or air-conditioner, will remove most of the 5-micron-or-larger particles passing through it. The air is broken up into many small streams forced to thread their abruptly changing courses through the filter maze. Particles do not make the sharp turns and impinge on the screens, fibers, or plates of the filter medium, where they stay until washed off. To aid in holding them, the medium is often coated with a sticky substance, such as mineral oil or glycol. The dry type, as opposed to this viscous-impingement-type, literally strains the air through cotton batting, wool, or felt and traps the particles in its tiny meshes. Both types increase the resistance to air flow rapidly as particles are collected and must then be replaced or cleaned. The only way to design mechanical filters to remove smaller particles is to reduce the diameter of the air passages, which rapidly increases their resistance to air flow and makes such filters impractical for domestic use.

"The two-stage electronic air cleaner (EAC) is the most practical for collecting airborne particles of a wide range of size without introducing excessive resistance to air flow. The first or ionizing stage consists of a series of fine wires carrying a positive charge of 3000 to 6000 volts. Free electrons are strongly attracted to these wires and in their hurry knock other negative electrons loose from passing air molecules, leaving the latter with a net positive charge. These positive ions accumulate in tremendous numbers in the ionizing stage, and any dust particle entering that area is like a plane flying through a thunderstorm: it's bound to get 'wetted' by the ions through which it is flying, with more of the smaller particles clinging to larger particles.

"The ions hitchhike along with the dust particle into the second or collecting stage, which consists of flat metal plates spaced about a quarter-inch apart. Positive high voltage is applied to each alternate plate, with the intervening plates being grounded. When a dust particle with its cargo of positive ions enters a space between two plates, the positive plate repels and the grounded plate attracts the positively charged particle. Under the influence of these forces, the particle changes course and impacts on a grounded plate, where it loses its charge and remains until it is washed off. In a similar manner any particle carrying a negative charge is collected by the positive plates. Larger particles, because of momentum, require more force to divert them; but this force is provided by the larger charge they carry. Since the EAC does not depend upon tiny, tortuous air passages for its dust-trapping action, it does not restrict air flow as much initially or after accumulating a given amount of dust. It is especially efficient in removing the 90% of the dust which is made up of particles 10 microns down to .01 micron in diameter."

"How can you really tell how good an air cleaner is or will perform?" Barney asked.

How Good are They?

"Most well-designed air cleaners are rated for efficiency by the NBS Dust Spot Method. The cleaner is placed in a duct and dusty air is fed through it. Individually metered amounts of air from in front and behind the filter are blown through very fine white filter papers, and the two amounts of sampled air are adjusted so both filter papers become stained at approximately the same rate. After a certain time the sampling filter papers are removed and compared for optical density with a photocell. Compensation is made for any final difference in optical density, and the two measured volumes of sampled air are compared. The upstream volume is written as a fraction of the downstream volume and subtracted from one. The answer multiplied by 100 yields the efficiency of the filter in percent. Electronic and other high-efficiency filters are tested with outdoor ambient dust. Lower efficiency filters are fed dust from a specific source in combination with standardized lint. Impingement-type mechanical filters are rated between 5 and 7 percent efficiency by the dust spot method, while a high quality EAC will be rated up to 95% by the same method. The efficiency of the electronic air cleaner decreases as the air velocity increases."

"Well," Barney said, "I've enjoyed this little seminar on air cleaning. An understanding of basic principles of air cleaning is going to be necessary for understanding and evaluating what we read, what we see and hear on TV, and what our representatives do and say in the next decade. Your little talk on the problems of particle removing is a good beginning." ▲

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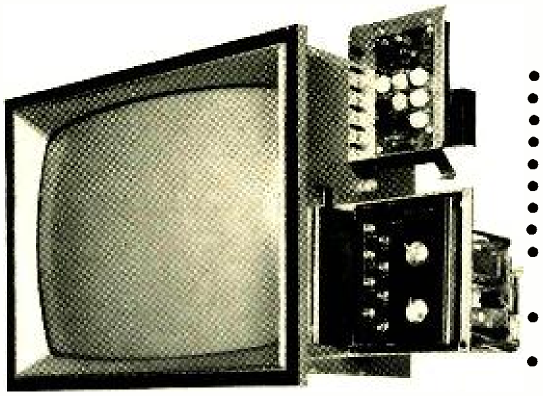

Compare these features:

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- Pushbutton channel advance.
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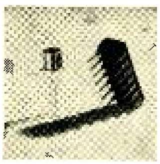

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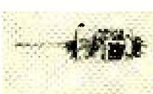

Exclusive design solid-state VHF tuner uses an MOS Field Effect Transistor for greater sensitivity, lower noise, and lower cross-modulation . . . gives you sharply superior color reception, especially under marginal conditions. Gold/Niborium contacts give better electrical connections and longer wear. Memory fine tuning, standard. Solid-state UHF tuner uses hot-carrier diode design for increased sensitivity.

3-stage solid-state IF has higher gain for better overall picture quality. Emitter-follower output prevents spurious signal radiation, and the entire factory-aligned assembly is completely shielded to prevent external interference.

Automatic Fine Tuning — standard on both sets. Just push a button and the assembled and aligned AFT module tunes in perfect picture and sound automatically . . . eliminates manual fine-tuning. Automatic between-channel defeat switch prevents tuner from locking in on stray signals between channels. AFT can be disabled for manual tuning.

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Built-in automatic degaussing keeps colors pure. Manual degaussing coil can be left plugged into the chassis and turned on from the front panel . . . especially useful for degaussing after the set is moved some distance.

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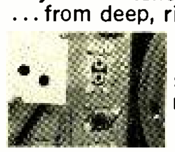
"Instant-On". A push of the power switch on the front panel brings your new solid-state set to life in seconds. Picture tube filaments are kept heated for instant operation, and extended tube life. "Instant-On" circuit can be defeated for normal on-off operation.

Premium quality color picture tubes. Both the 227 sq. in. GR-270 and 295 sq. in. GR-370 use the new brighter bonded-face, etched glass picture tubes for crisper, sharper, more natural color. And the new RCA HiLite Matrix tube is a low cost option for the GR-370. See below.

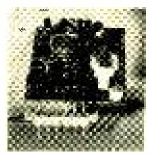
Adjustable tone control lets you choose the sound you prefer . . . from deep, rich bass to clean, pronounced highs.



Hi-fi output permits playing the audio from the set through your stereo or hi-fi for truly lifelike reproducton. Another Heath exclusive.

Designed to be owner serviced. The new Heath solid-state color TV's are the only sets on the market that can be serviced by the owner. You actually can diagnose, trouble-shoot and maintain your own set.

Built-in dot generator and tilt-out convergence panel let you do the periodic dynamic convergence adjustments required of all color TV's for peak performance. Virtually eliminate technician service calls.



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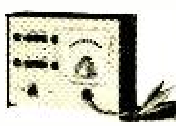

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Kit GR-370, all parts including chassis, 295" picture tube, face mask, UHF & VHF tuners, AFT & 6x9" speaker, 127 lbs. **$559.95***

Kit GR-370MX, complete GR-370 with RCA matrix picture tube, 127 lbs. **$569.75***

GR-270 AND GR-370 SPECIFICATIONS — PICTURE TUBE SIZE: GR-370 Approximate Viewing Area: 295 Sq. In. GR-270 Approximate Viewing Area: 227 Sq. In. **DEFLECTION:** Magnetic, 90 degrees. **FOCUS:** Electrostatic. **CONVERGENCE:** Magnetic. **ANTENNA INPUT IMPEDANCE:** VHF 300 ohm balanced or 75 ohm unbalanced. UHF: 300 ohm balanced. **TUNING RANGE:** VHF TV channels 2 through 13. UHF TV channels 14 through 83. **PICTURE IF CARRIER:** 45.75 MHz. **SOUND IF CARRIER:** 41.25 MHz. **COLOR IF SUBCARRIER:** 42.17 MHz. **SOUND IF FREQUENCY:** 4.5 MHz. **VIDEO IF BANDWIDTH:** 3.58 MHz. **HI-FI OUTPUT:** Output impedance — 1 k ohm. Frequency response — ±1 dB 30 Hz to 10 kHz. Harmonic distortion — less than 1% at 1 kHz. Output voltage — 0.3 V rms nominal. **AUDIO OUTPUT:** Output impedance — 4 ohm or 8 ohm. Output power — 2 watts. **POWER REQUIREMENTS:** 110 to 130 volts AC, 60 Hz, 240 watts. **NET WEIGHT:** GR-370, 114 lbs.; GR-270, 101 lbs.

Modular Color Television!

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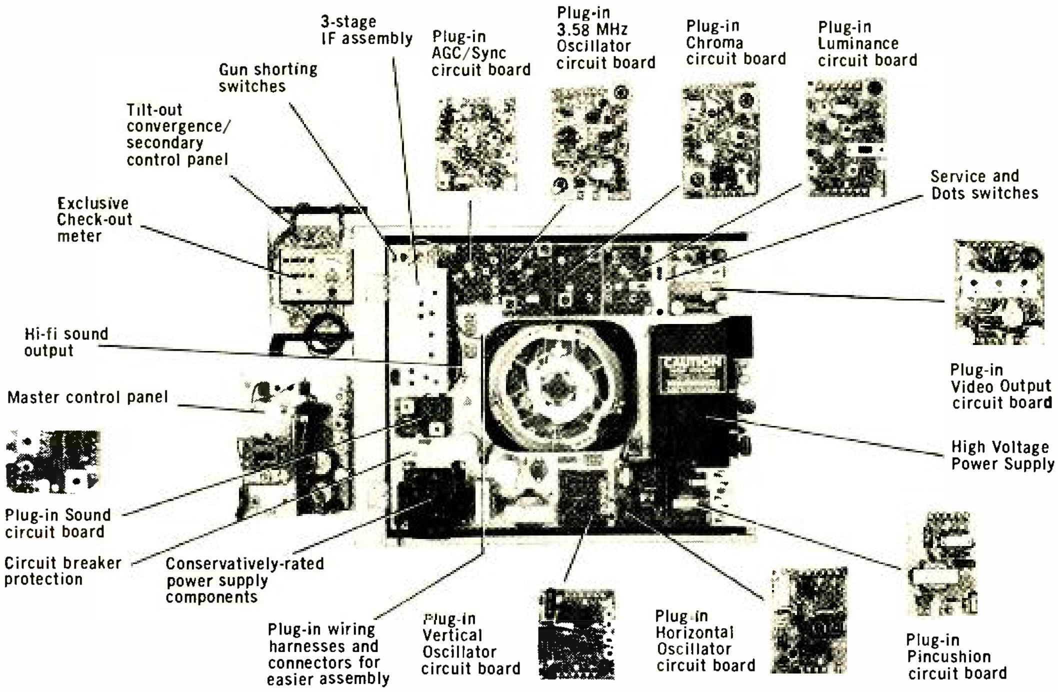

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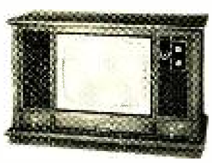
Add extra convenience and versatility to your new GR-270 or GR-370 Solid-State Color TV with this new ultrasonic remote control kit. Lets you turn the set on and off, adjust volume, change VHF channels and adjust color and tint from the comfort of your chair. Assembles and installs complete in just a few hours and the built-in meter on the receiver makes final adjustment a matter of minutes.
Kit GRA-70-6, 6 lbs. **$64.95***

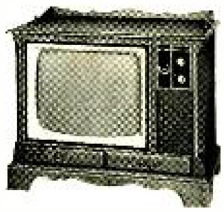
Choose One Of These Handsome, Factory Assembled Cabinets

3 models in 295 sq. in.

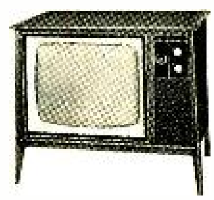
Luxurious Mediterranean Cabinet . . . factory assembled of fine furniture grade hardwoods and finished in a flawless Mediterranean pecan. Statuary bronze trim handle. 30-1/32″ H x 47″ W x 17¾″ D. **Assembled GRA-304-23**, 85 lbs. **$129.95***



Deluxe Early American Cabinet . . . factory assembled of a special combination of hardwoods & veneers and finished in classic Salem Maple. 29-21/32″ H x 37¼″ W x 19¾″ D. **Assembled GRA-303-23**, 67 lbs. **$114.95***

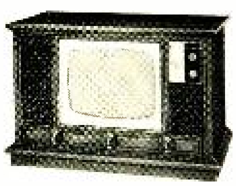


Contemporary Walnut Cabinet . . . factory assembled of fine veneers & solids with an oil-rubbed walnut finish. 29-17/32″ H x 35-13/16″ W x 19⅞″ D. **Assembled GRA-301-23**, 56 lbs. **$74.95***

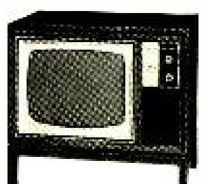


3 models in 227 sq. in.

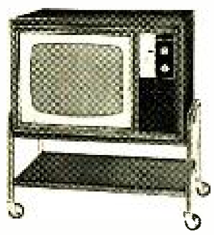
Exciting Mediterranean Cabinet . . . assembled using fine furniture techniques and finished in stylish Mediterranean pecan. Accented with statuary bronze handle. 27-31/32″ H x 41⅞″ W x 19-9/16″ D. **Assembled GRA-202-20**, 70 lbs. **$114.95***

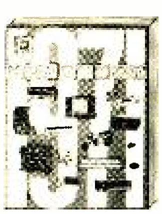


Contemporary Walnut Cabinet and Base Combination. Handsome walnut finished cabinet sits on a matching walnut base. Cabinet dimensions 20-31/32″ H x 31-7/16″ W x 18⅝″ D. Base dimensions 7¾″ H x 27¾″ W x 18⅝″ D. **Assembled GRA-203-20 Cabinet**, 45 lbs. **$49.95*** **GRS-203-6** above cab. w/ matching base, 58 lbs. **$59.95***



Handy Roll-Around Cart and Cabinet Combination. Features the GRA-203-20 walnut cabinet plus a walnut-trimmed wheeled cart with storage shelf. **Assembled GRA-203-20 Cabinet**, 45 lbs. .... **$49.95*** **GRA-204-20 Roll-Around Cart**, 18 lbs. . . . **$19.95*** **GRS-203-5, Cart & Cabinet Combo**, 58 lbs. **$59.95***





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CIRCLE NO. 132 ON READER SERVICE CARD

C.E.T. Test, Section #8

Measurements

By DICK GLASS*

What is your electronics servicing I.Q.?
You must get 75% on entire exam to pass.

This is the eighth in a series of 12 test sections to be published monthly. While these test exam sections are not part of the actual NEA C.E.T. examinations presently being administered, they are similar in nature. Should you find you are able to correctly answer 75% or better, you might be a candidate to become a registered CET. You can take the exam in your area but you must show 4 years of experience to qualify.

(Answers will appear next month.)
Answers to last month's quiz appear on page 96

1. What indication might show an open transistor in a common-emitter circuit?
(a) very low resistance reading between collector and emitter
(b) very high beta reading on a transistor tester
(c) collector voltage equaling the supply voltage
(d) base and emitter voltage readings being only slightly different

2. To locate an intermittent transistor, do not:
(a) apply heat
(b) apply cold spray
(c) short collector to base
(d) short base to emitter

3. Which troubleshooting sequence normally is most effective when making TV tuner repairs?
(a) waveform analysis, resistance checks, then voltage readings
(b) signal insertion, voltage readings, then adjustment
(c) adjustment, waveform analysis, then voltage checks
(d) voltage checks, resistance readings, then signal insertion

4. A service v.o.m. will read approximately what percent of a peak-to-peak sine-wave voltage measured on a scope?
(a) 70.7
(b) the same
(c) 141.4
(d) 35.35

5. One method of operating a transistorized receiver that is drawing excessive current, in order to make voltage comparisons yet protect against further parts damage, is:
(a) operate for short periods only, while making checks
(b) use up to, but no larger than 50 percent larger fuse
(c) lower operating voltages in solid-state equipment makes such precautions unnecessary
(d) insert current-limiting resistor in voltage supply circuit

6. A pocket transistor radio is found to have wide fluctuations of battery current during on-station reception, but steady current use off-station. This indicates:
(a) normal operation
(b) weak battery
(c) intermittent output transistor
(d) poor power-supply filtering

7. Other than direct interchange, the best test of a transformer or yoke is:
(a) resistance check of windings
(b) ringing test
(c) insulation test
(d) intercapacitance test

8. Which secondary winding of a TV power transformer would normally measure highest resistance?
(a) highest voltage winding
(b) lowest voltage winding
(c) 6-volt filament winding
(d) 12-volt filament winding

9. The 60-Hz filament voltage usually cannot be used as a signal-tracing test voltage in the:
(a) video amplifier circuits
(b) audio amplifier circuits
(c) vertical sync circuits
(d) color sync circuits

10. With ordinary service scopes, a demodulator probe should be used:
(a) for all frequencies below the scope vertical-amplifier response
(b) for video amplifier circuits
(c) for video i.f. circuit testing
(d) for color demodulator circuit testing

*Executive V.P., NEA, 1309 W. Market St., Indianapolis, Ind. 46222, assisted by Lew Edwards, chairman of Test Make-up Subcomm.

The Amplified Zener

(*Continued from page 42*)

to-ground is used to set the zener bias current at a level where its regulation is optimum; the design example will explain this. Assume that you need 9 volts at 1 A and have a 15-volt, 1-A unregulated supply from which to develop it. In order to get 100% load capacity (the load current will be allowed to vary from 0 to 1 ampere), a 10-watt zener would be required to handle the "worst case" where the power in the diode would be 9 watts, because it would be carrying 1 A at 9 volts. To use the transistor regulator, you must choose the correct smaller zener diode and base resistor. If the transistor is a 2N3055, the following characteristics are valid: max. collector current = 7 amps, max. power dissipation = 117 watts, typical current gain (β) = 50, and base-emitter voltage = 1.5 volts.

Since the output voltage is the sum of the base-emitter voltage and the zener drop, a 7.5-volt zener is required, and a 1N711 will do. If the transistor is to carry 1 amp, the base current will be 20 mA since the current gain is 50 .The zener will work best at 25 mA, so it would provide a stable voltage drop with 20 mA through it. However, when the transistor collector current is close to zero, a base-emitter bias resistor will maintain the zener current which would otherwise drop to almost nothing since practically no base current is required when collector current is low. In order to maintain the zener current near 20 mA, a 75-ohm resistor is required across the 1.5-volt base-emitter junction. The resulting circuit will regulate at 9 volts for load currents from 0 to 1 amp, with maximum powers of 400 milliwatts in the zener and 9 watts in the transistor.

If the unregulated input were to increase, there would be a resultant increase in the regulator power; nonetheless, due to the constant current drawn by the regulator, there is no reason for the unregulated voltage to change. By definition, an unregulated supply puts out a different voltage at every value of load current; therefore, at a fixed value of load, the voltage is also fixed.

In order to simplify transistor mounting when a heat sink is used, it is convenient to have the collector and heat sink at the same potential, so no insulators are needed. For further simplicity, it is nice to have this potential be the circuit ground level. The simple shunt regulator circuit of Fig. 1 will provide a negative output if the collector is grounded while the one shown in Fig. 2A, using a *p-n-p* transistor, will produce a positive output.

If a higher output voltage is required than obtainable with the zeners that you have available, use the circuits of Figs. 2B and 2C. Here, the regulated output is divided down by $R1$ and $R2$ and the zener is fed from the reduced voltage point. This gives a "leverage" equal to the divider ratio. This circuit works to hold the output voltage at such a level that the divider voltage is held constant at a value of $V_{BE} + V_Z$, which means that the output voltage winds up higher than the zener voltage.

An equation that describes this circuit is: $V_{out} = R1 + R2 \times (V_{BE} + V_Z)$, and it can be made to provide either output voltage with a grounded collector, as described for the simpler circuits. In order to insure good regulation, the current drawn by the $R1$-$R2$ divider should be at least five times the zener current. Also, whenever a power transistor is used at these power levels, a good heat sink or a large chassis should be used to hold the case temperature down.

To increase the amplification factor, a cascade or Darlington circuit will work, as shown in Figs. 2D and 2E. Providing that the output transistor is cooled adequately, these circuits will handle more power than the largest available zeners; but it is a rare experimenter who could devise a circuit requiring as much regulated power as they are capable of delivering. ▲

"CIE training helped pay for my new house," says Eugene Frost of Columbus, Ohio

Gene Frost was "stuck" in low-pay TV repair work. Then two co-workers suggested he take a CIE home study course in electronics. Today he's living in a new house, owns two cars and a color TV set, and holds an important technical job at North American Aviation. If you'd like to get ahead the way he did, read his inspiring story here.

IF YOU LIKE ELECTRONICS—and are trapped in a dull, low-paying job—the story of Eugene Frost's success can open your eyes to a good way to get ahead.

Back in 1957, Gene Frost was stalled in a low-pay TV repair job. Before that, he'd driven a cab, repaired washers, rebuilt electric motors, and been a furnace salesman. He'd turned to TV service work in hopes of a better future—but soon found he was stymied there too.

"I'd had lots of TV training," Frost recalls today, "including numerous factory schools and a semester of advanced TV at a college in Dayton. But even so, I was stuck at $1.50 an hour."

Gene Frost's wife recalls those days all too well. "We were living in a rented double," she says, "at $25 a month. And there were no modern conveniences."

"We were driving a six-year-old car," adds Mr. Frost, "but we had no choice. No matter what I did, there seemed to be no way to get ahead."

Learns of CIE

Then one day at the shop, Frost got to talking with two fellow workers who were taking CIE courses . . . preparing for better jobs by studying electronics at home in their spare time. "They were so well satisfied," Mr. Frost relates, "that I decided to try the course myself."

He was not disappointed. "The lessons," he declares, "were wonderful—well presented and easy to understand. And I liked the relationship with my instructor. He made notes on the work I sent in, giving me a clear explanation of the areas where I had problems. It was even better than taking a course in person because I had plenty of time to read over his comments."

Studies at Night

"While taking the course from CIE," Mr. Frost continues, "I kept right on with my regular job and studied at night. After graduating, I went on with my TV repair work while looking for an opening where I could put my new training to use."

His opportunity wasn't long in coming. With his CIE training, he qualified for his 2nd Class FCC License, and soon afterward passed the entrance examination at North American Aviation. "You can imagine how I felt," says Mr. Frost. "My new job paid $228 a month more!"

Currently, Mr. Frost reports, he's an inspector of major electronic systems, checking the work of as many as 18 men. "I don't lift anything heavier than a pencil," he says. "It's pleasant work and work that I feel is important."

Changes Standard of Living

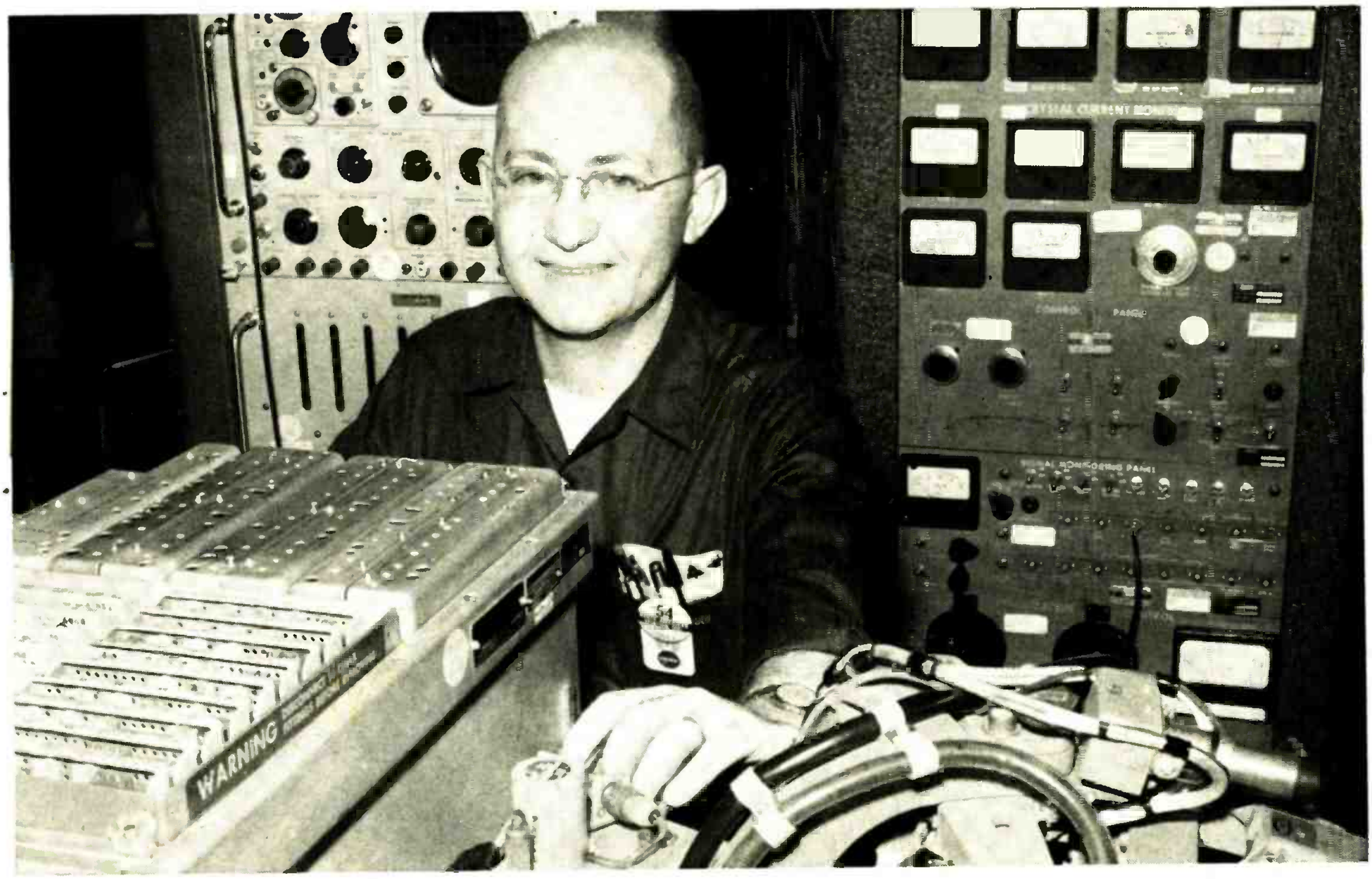
Gene Frost's wife shares his enthusiasm. "CIE training has changed our standard of living completely," she says.

"Our new house is just one example," chimes in Mr. Frost. "We also have a color TV and two good cars instead of one old one. Now we can get out and enjoy life. Last summer we took a 5,000 mile trip through the West in our new air-conditioned Pontiac."

"No doubt about it," Gene Frost concludes. "My CIE electronics course has really paid off. Every minute and every dollar I spent on it was worth it."

Why Training is Important

Gene Frost has discovered what many others never learn until it is too late: that to get ahead in electronics today, you need to know more than soldering connections, testing circuits, and



replacing components. You need to really know the fundamentals.

Without such knowledge, you're limited to "thinking with your hands" ...learning by taking things apart and putting them back together. You can never hope to be anything more than a serviceman. And in this kind of work, your pay will stay low because you're competing with every home handyman and part-time basement tinkerer.

But for men with training in the fundamentals of electronics, there are no such limitations. They think with their heads, not their hands. They're qualified for assignments that are far beyond the capacity of the "screwdriver and pliers" repairman.

The future for trained technicians is bright indeed. Thousands of men are desperately needed in virtually every field of electronics, from 2-way mobile radio to computer testing and troubleshooting. And with demands like this, salaries have skyrocketed. Many technicians earn $8,000, $10,000, $12,000 or more a year.

How can you get the training you need to cash in on this booming demand? Gene Frost found the answer in CIE. And so can you.

Send for Free Book

Thousands who are advancing their electronics careers started by reading our famous book, "How To Succeed In Electronics." It tells of the many electronics careers open to men with the proper training. And it tells which courses of study best prepare you for the work you want.

If you'd like to get ahead the way Gene Frost did, let us send you this 44-page book free. With it we'll include our other helpful book, "How To Get A Commercial FCC License." Just fill out and mail the attached card.

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CIRCLE NO. 144 ON READER SERVICE CARD

Electronic Fuel Injection

(*Continued from page* 49)

the contaminates can be reduced by running the engine rich at approximately 13 to 1 air-fuel ratio. Both methods are being investigated by automotive manufacturers. For the purposes of this article, we are discounting the rich approach because it is not particularly beneficial to the consumer who could expect an increase in gas consumption as high as 50 percent more than that attained on pre-emission vehicles. In addition, there would be substantial reactor service required because of its operating temperature of approximately 2000° F.

It seems reasonable, therefore, to assume that a higher air-fuel ratio would be more desirable. In the area beyond 18 to 1, all three of the contaminate groups are minimized. The emission control of an automobile equipped with a *Bendix* electronic fuel injection is compared to that of an automobile using a 1969-type carburetor and California's emission requirements for 1974 in Fig. 5.

In Dan Fisher's *Los Angeles Times* article he indicated that *General Motors*, which manufactures approximately half of the U.S.-built cars, has already asked suppliers for price quotations on various parts for a fuel-injection system. He also indicated that *Ford* and *Chrysler* are working closely with outside suppliers, principally *Bendix Automotive and Automation Company*.

The *Volkswagen* has proved that electronic fuel injection is feasible. In the case of the *VW*, the fuel injection was developed to help meet exhaust emission requirements, but there were some side benefits obtained by the auto owner in the form of improved performance. What can the American motorist expect to gain from fuel-injection-equipped American cars?

Benefits Gained

According to *Bendix*, its electronic fuel-injection system offers accurate fuel metering at low engine speeds and light loads, high volume breathing at high engine speeds and heavy loads, and even distribution of fuel from cylinder to cylinder throughout the engine operating range as a result of its design characteristics. These attributes can be translated into the following benefits for vehicle manufacturers: improved horsepower per cubic inch, better economy, improved drive-ability and smoothness, and improved cold starts and drive away. Consequently, all of these benefits are available from a system that also reduces harmful exhaust emissions, such as hydrocarbons, carbon monoxide, and oxides of nitrogen, substantially.

Other attractions that the company claims for its electronic fuel-injection system are: the elimination of dieseling after shutdown, a simple starting procedure that is the same for all temperatures and conditions, and a throttle body that can be less than 1½ inches high so that designers can lower the engine profile and hoodline to conform to customers' styling preferences.

Maintainability

The *Bendix* electronic fuel-injection system has no adjustments other than the idle air flow. This reduces maintenance requirements and helps ensure that low levels of harmful emissions will be more easily maintained throughout the life of the vehicle. If a component should become faulty, it is replaced rather than repaired. For an example of how readily electronic fuel injection can be maintained, see "Testing VW's Electronic Fuel-Injection System" that appeared in the January, 1970 issue of this magazine.

In summary, the owner of an electronic fuel-injection-equipped automobile will benefit from significant improvements in power and fuel economy, greatly reduced exhaust emissions, and easier starting under all weather conditions. ▲

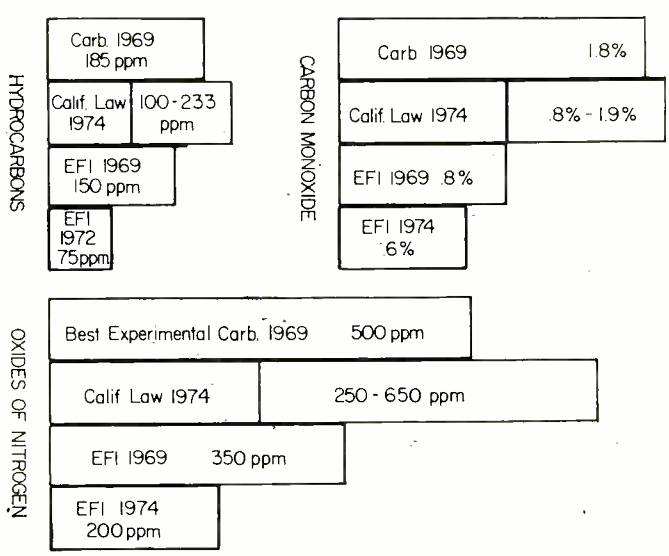

Fig. 5. Graphs comparing exhaust emission control of contaminates of car equipped with EFI system with those using 1969 carburetor and California's 1974 requirements.

Scheiber Stereo System

(*Continued from page 43*)

solely in RR channel causes the same action.

When a signal appears solely in the FR channel, the dematrixed outputs will have unity signal in FR, no signal in RL, and equal reduced signals in FL and RR. The ratio of 1 will cause the differential amplifier to increase the gain of FR and RL channels to 0 dB and turn off the FL and RR pair. A similar analysis holds for a signal solely in RL.

For ratios of FL to RR between the special cases mentioned above, the relative gains of the four channels are adjusted smoothly between the above limits.

Filter circuits are used in the inputs and the outputs of the differential amplifier to prevent undesired low frequencies from taking over the control of the diff amp and from taking over the control of gain in the gain-control amplifiers. Log amplifiers, full-wave rectifiers producing average, absolute values of the signals, and *RC* step filters are used to provide an accurate, rapid means of comparing the amplitudes of the signals which are then used to alter the gains of the control amplifiers almost instantly. Square-root circuits are employed to maintain constant powers into the four gain-control amplifiers when all channels are supposed to be equal.

Summary & Characteristics

In summary, the Scheiber process encodes original information from four separate channels onto two recording or broadcast channels. Through mathematical matrixing of the four original signals, each of the two transmission channels carries a portion of the information originally on each one of the four channels. Dematrixing the 2-channel transmission for playback yields four channels in proper directional relationship to each other, but with the specific power distribution among the channels altered. The proper distribution of power is then achieved by four individual gain-control circuits actuated by a comparator that continuously monitors the amplitude relationship of two diagonal channels and adjusts individual channels to approximate more closely the original power distribution of the four channels.

Frequency response of each of the four channels is not restricted or compromised in any way. Separation between the channels varies somewhat, depending on the kind of signals being handled. However, we were told that, even in the worst case when there are equal signals in all channels, the separation is at least 15 dB. Under these conditions, even that degree of separation is not needed. At all other times, separation is far better. ▲

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Microwave Ovens
(*Continued from page* 39)

metal contact under spring pressure when the door is closed. Another variation would be a compressible metal braid strip or tube between door and oven, again providing intimate metal-to-metal contact. The contact door is the simplest to manufacture. The major disadvantage is that opening the door even slightly destroys the door seal, so that protection from energy leakage depends on how far the door may be opened before the interlocks become effective to shut off the power. A compression, or clamp, door latch can overcome this problem for a new oven. Any deterioration of the intimate contact over the life of the product, however, will again cause an increase in leakage.

More complex door seals are those in which a small gap between door and oven is included as a portion of a microwave transmission circuit which electrically reduces energy leakage. This door seal is called a *choke seal*. In the choke door, a quarter-wave transmission-line circuit is built into the door and located so that it produces an electrical short circuit at the gap between the door and oven. (*This technique is similar to the fixed and rotary choke joints used in microwave radar systems to interconnect sections of waveguide with minimum losses.—Editor*) A voltage cannot be developed across a short circuit and thus energy is effectively prevented from leaking from the oven. In Fig. 3C a cross-section of the choke door is shown. Energy at the gap is 180 degrees out of phase with the energy traversing the choke section and is canceled out. With the choke door a small gap between door and oven does not reduce protection of the seal.

Additionally effective is the inserted choke-absorber door. A carbon-loaded vinyl strip (Fig. 3D) is placed between the choke and the exit from the oven. The effect is to dampen or absorb any energy that passes the choke seal. A properly designed choke leaves only a small amount of energy to be further attenuated by the carbon-loaded vinyl. However, for harmonic energy the vinyl becomes more significant. The choke is not sufficiently effective in suppressing second and third harmonics; therefore, the vinyl gasket provides the necessary attenuation to meet the requirements for low harmonic radiation while adding more suppression to the fundamental-frequency leakage.

Since microwave cooking is new and quick, practicality demands the cooking be observed; thus, the door should have a viewing screen. A typical viewing screen may be provided by a series of holes or perforations in the door. As long as the hole diameters are very small in relation to a quarter wavelength, leakage through the holes is insignificantly low. At 2450 MHz, a door screen with 1/64-inch diameter holes leaks so little energy at the fundamental frequency and all harmonics, that safety considerations are beyond question.

All microwave ovens manufactured today make use of door interlocks or safety switches designed to turn off the power to the magnetron when the oven door is opened. The proposed HEW Standard for microwave ovens will require two independent door interlocks, one of which must be hidden to prevent defeating or "cheating." Some manufacturers have chosen magnetic interlocks, some have selected switches that actuate from the motion of the door and door hinges. Some designs include a lock-latch that mechanically prevents the opening of the door while the magnetron is oscillating. The major criterion for choosing an interlock is reliability, so that safety is insured.

As pointed out in Part 1, the many advantages of the microwave oven, including its work- and time-saving features, should lead to greater acceptance. Housewives may find the microwave oven to be as necessary as the refrigerator-freezer and conventional range. ▲

BOOKS

"SERVICING ELECTRONIC ORGANS" by Max H. Applebaum & Donald A. John. Published by *Tab Books*, Blue Ridge Summit, Pa. 17214. 160 pages plus 36-page foldout schematic section. Price $7.95 simulated leatherette cover.

Since hundreds of homes as well as innumerable commercial establishments now have electronic organs, servicing these instruments can be a profitable adjunct to any service business.

Although a basic knowledge of musical theory is a "must" for those who service electronic organs, most people have been exposed to enough musical training to enable them to qualify as "musical" for organ-servicing purposes.

The text is divided into nine chapters covering organ basics, tone-generating systems, signal distribution, keying and sustain functions, organ voicing, power amplifiers, special effects, rhythm effects, and troubleshooting and tuning. The text material is lavishly illustrated but some of the schematics are difficult to read and the many typographical errors tend to detract seriously from the over-all usefulness of this volume.

* * *

"INTRODUCTION TO COMPUTER ANALYSIS" by Herman Levin. Published by *Prentice-Hall, Inc.*, Englewood Cliffs, N.J. 249 pages. Price $14.65.

Subtitled "ECAP for Electronics Technicians and Engineers," this volume is an introduction to *IBM's* Electronic Circuit Analysis Program which involves analyzing and designing circuits by computer "breadboarding" rather than physically constructing the circuit.

The text is divided into seven chapters covering a review of circuit fundamentals, breadboarding on the computer, breadboarding tools, applying a signal to the circuit, checking the transients, applying computer analysis, and how the computer handles the job. The author describes the procedures step-by-step with plenty of analysis and examples so that the student can follow the entire process from his original equivalent circuit to preparing the coding sheets and punching out the computer card. Each chapter carries a number of exercises for the student to work, with the correct answers provided in the back of the book.

* * *

"TAPE RECORDER SERVICING GUIDE" by Robert G. Middleton. Published by *Howard W. Sams & Co., Inc.*, Indianapolis, Ind. 94 pages. Price $3.95 softbound.

Since the electronic circuitry of tape recorders is basically the same as that found in audio amplifiers, the author feels that audio technicians are missing out on a lucrative source of income if they don't handle tape recorder maintenance and repairs.

To demonstrate how recorder know-how can be acquired, the author deals with his subject in seven chapters covering general principles, preventive maintenance, adjustments and minor repairs, tape transport troubles, recording troubles, reproduction troubles, and recorder test-equipment problems.

The 8½" x 11" format allows the text to be illustrated by large, clear, easy-to-understand block diagrams, schematics, exploded views, photographs, and waveforms which amplify the text and explain some of the more obscure points of tape-recorder circuitry.

Any technician with electronic know-how and a slight mechanical bent should be able to profit handsomely from a perusal of this guide.

* * *

"SOLID-STATE CIRCUIT DESIGN & OPERATION" by Stanton R. Prentiss. Published by *Tab Books*, Blue Ridge Summit, Pa. 17214. 265 pages. Price $9.95.

This is a handbook for technicians and others who find themselves working with semiconductors but without the requisite technical background to understand just what makes such circuits work and why.

Mathematics has been kept to a minimum so those with high-school algebra can work with the equations and formulas. The exposition is clear and concise and the student can learn about semiconductor devices and how they work, semiconductor biasing techniques, a.c. circuits and cascade amplifiers, pulse and switching circuits, logical and digital IC's, operational amplifiers, as well as arithmetic as it applies to electronic circuitry.

The book is lavishly illustrated and hundreds of formulas are worked out so the student can use them not only as practice but as reference as he works on semiconductor circuitry.

* * *

"DICTIONARY OF ELECTRONICS AND NUCLEONICS" by L.E.C. Hughes, R.W.B. Stephens & I.D. Brown. Published by *Barnes & Noble, Inc.*, New York. 443 pages, plus additional charts. Price $14.50.

Two of Dr. Hughes' associates assumed the task of completing this dictionary upon Dr. Hughes' untimely death and have extended his original ideas and have provided additional material to make this a reference work of maximum usefulness.

In standard dictionary format, this handy volume provides definitions relating to electronics and nucleonics, nuclear and atomic physics, electro-acoustics, radio, television, computing, radiation hazards, electronic properties of materials, and much else. In addition to the dictionary text of some 9000 definitions, there is a comprehensive list of abbreviations, acronyms, and symbols. The 108 pages of appendices are used to amplify some of the fundamental theories of the complex fields of atomic and nuclear physics.

For so compact and handy a reference work, the authors have managed to supply a tremendous amount of valuable information which most people in the electronics field will find useful.

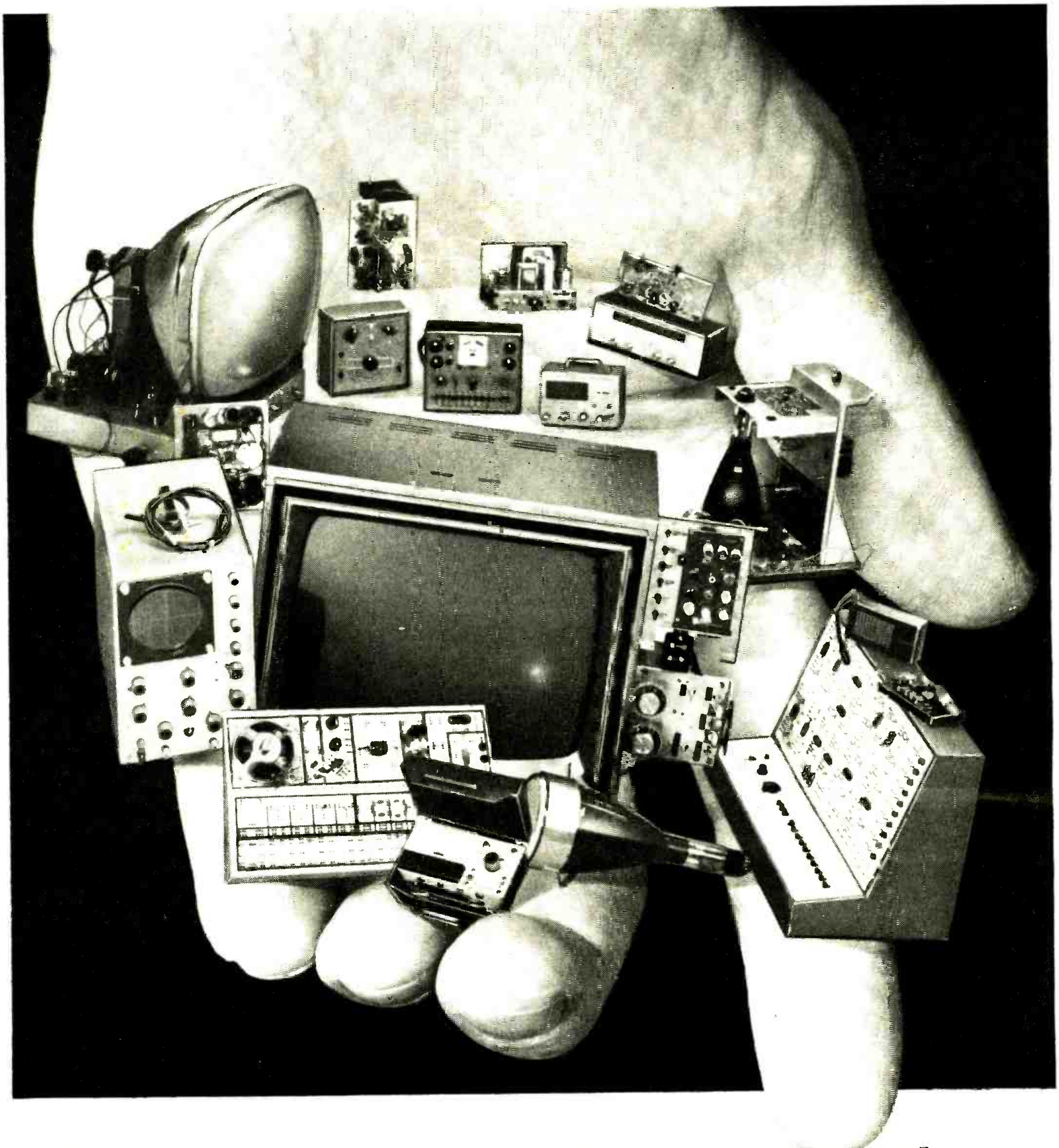
* * *

"THE RADIO AMATEUR'S HANDBOOK" revised by Robert Hertzberg, W2DJJ. Published by *Thomas Y. Crowell Co.*, New York. 361 pages. Price $5.95.

This is the 12th Revised Edition of an information-packed guidebook fathered by A. Frederick Collins and revised by Bob Hertzberg. The familiar W2DJJ should be instantly recognized by most hams and it is the "Old Pro" telling beginning hams everything they need to know—from the fundamentals of electricity to getting that first rig on the air. The book is filled with material on theory, construction, and operation and covers vacuum tubes, construction techniques, transmitter theory, FCC ham licenses, mobile operation, solid-state devices, and operating an amateur station. Elaborately illustrated with over a hundred photographs, diagrams, tables, and references lists, the author has also included a number of useful appendices and a detailed glossary of terms the would-be ham is likely to encounter when studying for his ticket.

From long experience in helping novice hams get their tickets by writing and talking about his hobby, Mr. Hertzberg has developed a useful vocabulary and approach which is both technically sound but informal enough to hold the attention and interest of his readers.

If you have been thinking about getting your ticket, here is a good book to start you on your way to a worthwhile hobby and a lifetime interest. ▲



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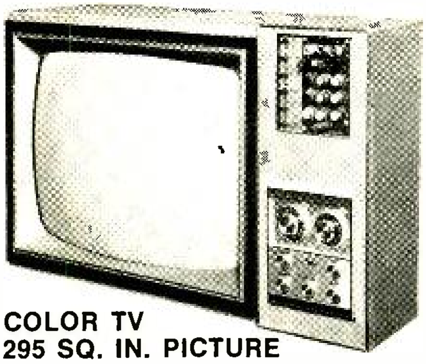

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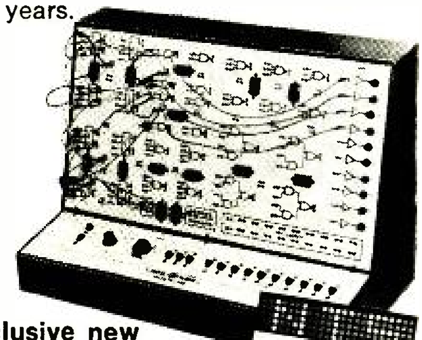

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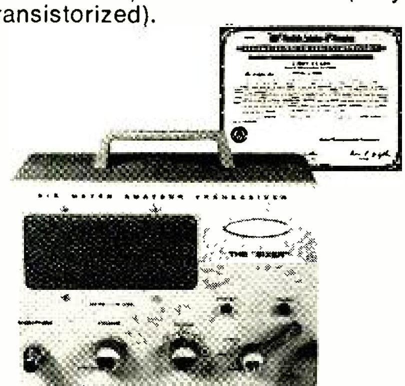

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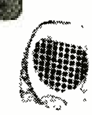

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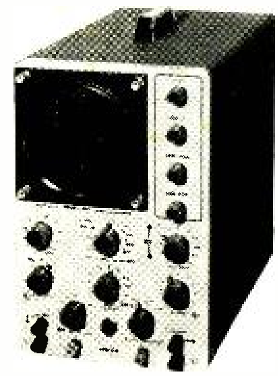

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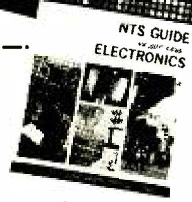

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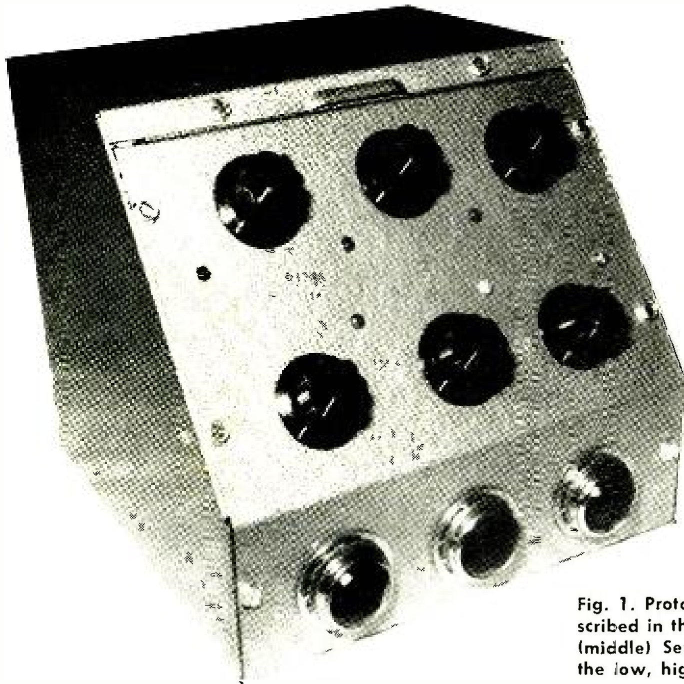


High-Power COLOR ORGAN

By R. A. HERTZLER

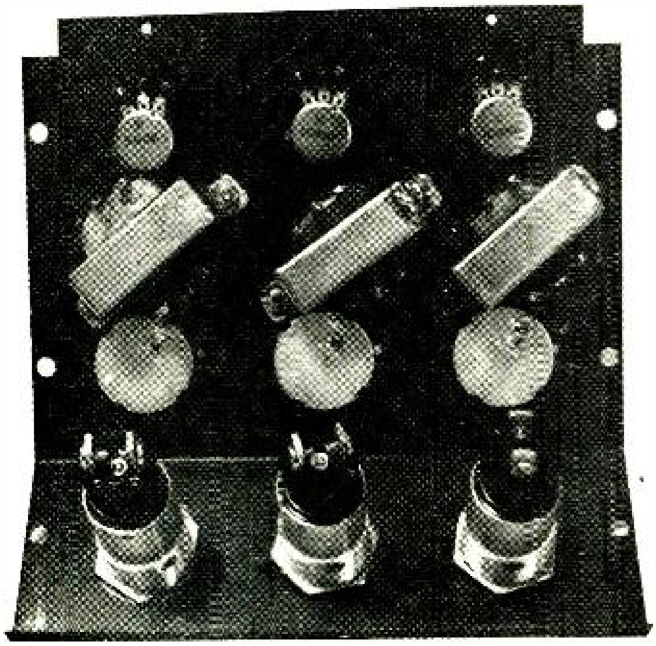
Reasonably priced SCR color organ, rated at 450 watts of lamp load for each of its three channels, has almost unlimited display capacity.

Fig. 1. Prototype version of the high-power color organ described in this article showing (top) the Background controls, (middle) Sensitivity controls, and (bottom) pilot lamps for the low, high, and middle frequency channels, left to right.

IN recent years various psychedelic entertainment devices have appeared, including the staged light shows, strobe lights, and color organs. Although other forms of color organ have been around for many years, today's rapidly advancing solid-state technology continues to reveal newer methods for accomplishing the same effect, that is, light modulated by sound. Today SCR's permit switching of 117-volt a.c. current into high-wattage loads (lamps), making it possible to design a color organ with virtually unlimited display capacity.

Numerous designs using this switching technique are available both commercially and as published construction articles. This article describes a color organ (Figs. 1 and 2) built by the author that: (1) uses readily available components, (2) costs about $40 for a 3-channel model capable of driving 117-volt loads rated up to 450 watts per channel, and (3) is easy to build using either point-to-point wiring or a printed-circuit board you can make yourself or purchase ready to wire. The average enthusiast might find the cost of a similar commercial unit prohibitive. This unit can be tailored by the individual to his specific display requirements; it can be used in the home as well as with a band's equipment in public.

Fig. 2. Rear view of front panel of the color organ. Shown, from top to bottom, are Background controls, audio transformers, Sensitivity controls, and pilot lamps for the high, middle, and low-frequency channels going from left to right.



The following sections describe the circuits shown in the schematic of Fig. 3 and detail some of the possible modifications that can be made by the builder.

Filters

Simple audio filters, using three audio transformers, *T*1, *T*2, and *T*3, divide the input into three frequency channels: low (20 to 400 Hz), middle (200 to 2000 Hz), and high (4000 Hz and up). The hole in the response between the middle and high channels enhances the display's response to solo or lead instruments; the overlap between the low and middle channels creates color blending in the display's response to bass and rhythm instruments. (The high-channel turn-on point can be lowered to approximately 1400 Hz by substituting the optional values shown in the parts list of Fig. 3 for *R*4 and *C*1.) The use of active-filter transistor stages would require a power supply and additional components which would increase cost and complexity. Passive *RC* filters provide sufficient drive for the gate of a sensitive silicon controlled rectifier (*SCR*1). Forward conduction of *SCR*1 supplies current to the gate of *SCR*2 which switches a.c. current to the display.

Background Circuit

The background circuit is provided to permit firing *SCR*2 to a constant conduction angle for each cycle of the a.c. line. This allows the display threshold to be varied, further enhancing the visual effect. Capacitor *C*5 in each channel charges at a rate established by "Background" potentiometer *R*11 and resistor *R*10 and discharges through a programmable unijunction transistor (*PUJT*1) into the gate of *SCR*2 once each cycle. Resistors *R*8 and *R*9 form a voltage divider that provides a reference voltage for *PUJT*1.

Power SCR

With adequate temperature control *SCR*2 will switch an

8-ampere load, although, with cost and construction simplicity considered, the SCR selected operates without a heatsink. The load rating under these conditions is 450 watts for each channel—adequate for most applications. A higher power capacity can be obtained by using any combination of the following: (1) adding a suitable heatsink for the SCR, (2) adding a full-wave bridge rectifier at the line input, and (3) selecting a higher capacity SCR. There is a wide range of available power SCR's that can be triggered by the filter and background circuits.

The color organ can be wired either by the point-to-point technique or by using a printed-circuit board. A pre-drilled circuit board and kit of semiconductors are available (see parts list). The completed unit can be housed in any convenient enclosure although the discussion that follows details construction in a sloping front-panel cabinet.

Construction

Mounting of the three transformers, six potentiometers (or three dual potentiometers, combining the "Sensitivity" and "Background" controls for each channel), and three pilot lights is shown in Fig. 2. The three transformers are mounted diagonally with the secondary taps (3.5 ohms) toward the respective "Sensitivity" controls. The three pilot lights are optional; they connect directly across the output receptacle (*SO1*) of each channel and permit adjustment without necessarily viewing the display. A suitable audio input jack is mounted on the rear panel; shielded cable should be used between the jack and the front panel.

When point-to-point wiring is used, each channel is wired on a 12-lug terminal strip. The tab of *SCR2* mounts directly to one lug of the output receptacle (*SO1*) for the display. The three terminal strips are wired as separate subassemblies before mounting them parallel (low, middle, high—left to right) to the bottom of the cabinet on one-half inch stand-offs. Semiconductors are tack soldered to the respective lugs of each terminal strip as the last step.

When the printed-circuit board method is used, the board is installed in the bottom of the cabinet after all components are mounted. Fig. 4 shows mounting details for *SCR2*. Connect the leads for the transformers (*T1*, *T2*, and *T3*), "Background" potentiometers (*R11* each channel), and a.c. supply to the board before mounting the board on the one-half inch stand-offs.

Power Distribution

Special attention should be paid to the distribution of a.c. power within the cabinet. The power switch and fuseholder mount on the rear panel (Fig. 5). Use separate heavy wires from the fuseholder to each channel, as indicated in Fig. 3. A pair of twisted hook-up wires is used to connect the pilot lights. Use a line cord heavy enough for the display.

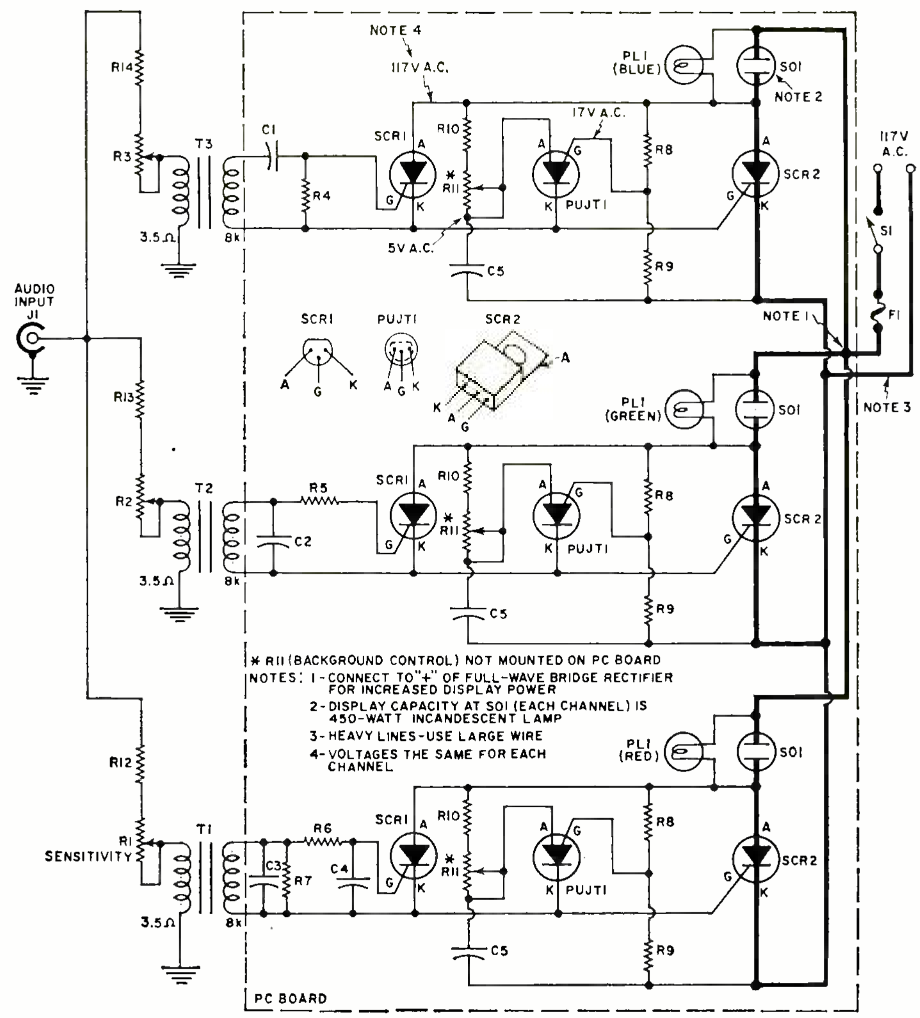
Adjustments

Before applying power to the completed unit, recheck all connections, especially to the semiconductors. Apply power and observe the pilot lights (when used) or three ordinary *lamps* plugged into the receptacles (*SO1*). Rotate the "Background" controls; find the balance point from which each channel can be adjusted, in turn, between full-off and full-on. Set the "Background" controls as desired, and connect the 4- to 8-ohm output of an amplifier to the input jack. Advance the "Sensitivity" controls and check to see that the low-frequency channel responds to the bass; the middle-frequency channel to voice and mid-range; and the high-frequency channel to solo high-frequency passages. The bass and treble controls on the amplifier will affect the color organ and can be set in conjunction with the "Sensitivity" controls as desired.

In case of trouble, recheck all connections and the proper lead identification on the semiconductors. The voltages shown in Fig. 3 are typical with the "Background" controls set halfway and the audio input shorted.

No particular display is recommended because this area is subject to the individual's personal preferences.

Fig. 3. Complete schematic diagram and parts list for the high-power color organ.



R1, R2, R3—100 ohm pot ("Sensitivity")
R4—1000 ohm, ½ W res. (or 6800 ohm, ½ W res. See text.)
R5—220,000 ohm, ½ W res.
R6, R7—56,000 ohm, ½ W res.
R8—100,000 ohm, ½ W res. (3 required)
R9, R10—27,000 ohm, ½ W res. (6 required)
R11—250,000 ohm pot ("Background," 3 required)
R12, R13, R14—27 ohm, ½ W res.
C1—820 pF disc capacitor (or 0.002 μF, 100 V paper)
C2—0.01 μF, 100 V paper capacitor
C3—0.1 μF, 100 V paper capacitor
C4—0.033 μF, 100 V paper capacitor
C5—0.15 μF, 200 V paper capacitor (3 required)
T1, T2, T3—Audio output trans. 8000 ohm: 3.5 ohms (Stancor A3329 or equiv.)
SCR1—0.8 A (r.m.s.), 200 V SCR (GE C103B)
SCR2—8 A (r.m.s.), 200 V silicon controlled rectifier, (General Electric C-122B)
PUJT1—Programmable unijunction transistor (General Electric D13T1)
SO1—Receptacle (Cinch Jones 2R2 or equiv. 3 required)
PL1—Pilot light, 125 V a.c. (Dialco 0431-302, red; 0432-302, green; 0434-302, blue), with 6S6, 12.5 V lamp
S1—S.p.s.t. switch
F1—6 A fuse
J1—Audio input jack
The PC board (Part 408) is available at $6.00 while a kit of all semiconductors can be obtained for $10.00. Both from WWW Electronics, P.O. Box 5363, Charlottesville, Va. 22903.

The color organ provides three sources of power for display, one for each channel at 450 watts. The author has set up the following displays:

1. *Wall display*—A wall display or floor cabinet can be constructed by mounting Christmas tree lights in a simple frame behind hobnail Plexiglas or plastic ceiling panel. Mount each lamp through pegboard to eliminate the shadows that may be caused by the wires, and paint the pegboard either black, white, or silver. Each color gives different display effects.

2. *Bar-top display*—An interesting display can be obtained by placing Christmas tree lights under frosted glass used as a bar top. Seal the glass to prevent entrance of moisture. The glass can rest on a simple frame that forms the top of the bar.

3. *Dichroic spots*—These true-color temperature lamps, available from either *Sylvania* or *General Electric* lamp distributors, provide a high degree of color blending. Mount a red lamp (low channel) between a green (middle channel) and a blue (high channel) for maximum blending. A mobile hanging in the light path will produce shadows of complementary colors to those used. Dichroic spots are available in 100- or 150-watt sizes.

A special word of caution: never use any but resistive loads (lamps) with this color organ. Unfortunately you won't be able to hear your electric drill purr to the strains of the Tijuana Brass. ▲

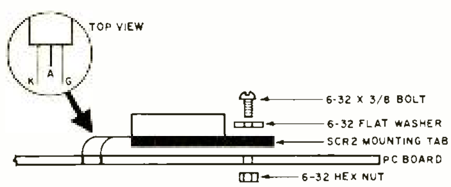
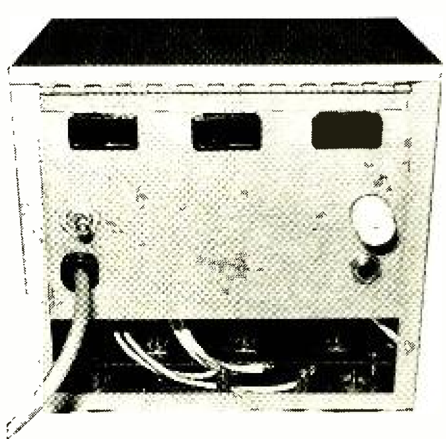


Fig. 4. Details on mounting thyristor, SCR2, to the printed-circuit board.

Fig. 5. Rear panel view of the high-power color organ shown in Fig. 1. (Top, left to right) The high, middle, and low frequency channel display receptacles, (right) fuseholder and audio input jack, and (left) line cord and power-on switch.



Digital Instruments

(*Continued from page 52*)

ing; the logical "0" output level will range from +100 mV d.c. to +400 mV d.c. under all conditions of temperature and loading. Noise margins are a function of logic level, loading, and temperature, and may be as small as 150 mV. All unused input pins should be grounded.

RTL IC's require a power-supply voltage (V_{cc}) of either +3.0 V d.c. ±10% or +3.6 V d.c. ±10%, will withstand power-supply transients of +12 V d.c. (total V_{cc}) for up to one second, and tolerate signal input voltages up to ±4 V d.c. The power-supply voltage must be well filtered and free from transients to avoid false triggering of certain devices, notably flip-flops and counters.

The clock pulse (CP) input to an RTL JK FF is a 1-to-0 transition whose fall-time may range from 10 nanoseconds to 100 nanoseconds. Control signals applied to the S and C inputs of the JK FF must comply with the device set-up and release-time restrictions. Set-up time is the time for which the S and C input levels must be maintained prior to the arrival of a CP; release time is the time for which the S and C input levels must be maintained after the arrival of a CP. Set-up and release times are typically 50 ns and 5 ns (worst case), respectively. JK FF's with unbuffered outputs are sensitive to capacitive loading, and the capacitance from any output to ground should not exceed 50 pF.

RTL Circuits and Applications

The relative ease with which transistors, diodes, and resistors can be fabricated during the IC manufacturing process sometimes results in an IC circuit configuration considerably different than would normally be used with discrete components. The relatively new MC-9709/MC9809 quad Schmitt trigger (Fig. 2) is an interesting example. The most obvious difference between this circuit and the usual discrete-component version is the dual signal/gating inputs, and the diode and transistor in the emitter circuit of Q1 and Q2. When the Schmitt trigger output voltage is at the logical "0" level, Q4 does not conduct and the upper trigger level of about 1.4 V (the sum of the voltage drops across the emitter-base junction of Q1 or Q2, and the junction of diode D1) is established. As the input voltage crosses the upper trigger level, the output voltage of the Schmitt trigger increases, turning Q4 on and increasing the base current of Q1 or Q2, causing the output voltage to rise rapidly to the "1" level. Transistor Q4 is now saturated and the circuit does not change state again until the input signal crosses the lower trigger level of about 0.75 V (the sum of the forward voltage drop across the emitter-base junction of $Q1$ or $Q2$ and $V_{ce\,(sat)}$ of $Q4$). The typical upper frequency limit of the Schmitt trigger is 18 MHz, and the rise and fall times are less than 100 nanoseconds. The total cost of the four Schmitt triggers is about $2.45.

Buffers are designed to have a high output drive capability, and to maintain respectable rise-times when driving capacitive loads. This is accomplished by using a low value of resistance in the collector circuit of the output transistor (Fig. 3). The associated series transistor disconnects the resistor when the buffer output is at the "0" level, and forms an active pull-up circuit when the buffer output rises to the "1" level.

The *and*, *or*, and *nand* gates are relatively recent additions to the RTL IC logic family, and are simple combinations of the familiar RTL *nor* gate and inverter. More information on the function and arrangement of these devices will be found in Fig. 6.

A decade counter IC, a quad latch IC, and a BCD-to-decimal decoder-driver IC may be interconnected to form a single decade counter module. The decade counter IC (MC780P), Fig. 4, operates at frequencies up to at least 4 MHz, and the decoder driver (MC9760P), the lead photomicrograph, is capable of driving a cold-cathode gas-filled indicator tube directly. The quad latch (MC767P) is a storage device and allows the previous count to be displayed while the counter is counting. The total cost of the three IC's is about $12.35—much less than an equivalent counter assembled from individual FF's, gates, and transistors. As yet, no manufacturer has introduced an RTL BCD-to-seven-line decoder, even though the seven-segment readouts are becoming increasingly popular.

The RTL IC's available at the time this article was written include gates (*or, nor, and, nand*, and *exclusive or*), expanders, inverters, buffers, flip-flops (JK and Type D), Schmitt triggers, counters, shift registers, latches, decoders and decoder-drivers, adders, subtractors, and data selectors and data distributors. At least one version of each of these devices is available in the *Motorola* plastic MRTL (MC700P/MC800P) Series (Fig. 5). RTL IC offerings will undoubtedly continue to expand, and the reader is again reminded that prices quoted in this article are those in effect at the time the article was prepared—hopefully the current downward price trend will continue.

The next article in this series will describe a 6-digit, 24-hour digital clock built around RTL IC's. The clock uses 7-segment readouts, and includes time-setting circuitry and a unique time-base generator that accommodates any one of four input signal frequencies.

(*Continued in November Issue*)

Direct vs Reverberant Sound

(*Continued from page 41*)

than is the case with more directional speakers. Because sound is scattered in all directions, somewhat more amplifier power is required for a given loudness level than with comparable conventional speakers. And, of course, certain of the diffuse-source designs are quite awkward in their demands for proper room placement.

Is it an Improvement?

Well, then, do diffuse-source loudspeakers represent a step forward in sound reproduction or not?

The answer depends on how and where the speakers are to be used, and who is listening to them. Having experimented with various kinds of diffuse-source speakers over the past several years, it is my conclusion that when they are good, they are amazingly good. They can produce a spacious, "airy" sound image that is dramatically real and life-like to a substantial proportion of critical listeners.

Note, however, that we are talking about speaker systems used to reproduce commercially recorded program material in normal home surroundings. By "normal home surroundings" we mean listening rooms that are fairly small (say, less than 3000 cubic feet) with fairly dry acoustics (reverberation times of one second or less). In large, reverberant rooms diffuse-source speakers tend to hopelessly blur the desired stereo image. A rough rule is that the more live the room, the more directional the loudspeakers should be.

And we deliberately specified a "substantial proportion" of listeners, not everybody. Individuals differ in their perceptions of reality, and for some people the most realistic reproduction possible requires sitting close to very directional loudspeakers.

One last point: diffuse-source loudspeakers produce an interesting *spatial* effect that has nothing to do with frequency response or tonal balance or distortion. The use of diffuse-source speakers and/or four-channel stereo and/or any other spatial technique does not relax the requirement for sound quality as such—for high fidelity, in other words. A speaker system that produces hash in the treble and 30-percent distortion in the bass will eventually be found out by your ears whether it is reflective, directional, or diffuse.

For my own ears, in my own home, diffuse-source reproduction is the only way to listen to music. Certainly, anyone interested in the art of music reproduction should make it a point to audition several loudspeaker systems of this type. You may be pleasantly surprised at what you hear. ▲

The CURIOSITY Box

By PAUL FRANSON

Like to startle the curious? Here is tempting looking black box that, when touched, emits a continuous, ear-piercing, head-splitting wail.

Fig. 1. Push-button Curiosity Box discussed in article.

THIS article describes an insidious device guaranteed to delight the heart of the jaded practical joker: Imagine a little black box (Fig. 1) with a small contact labeled "Do Not Touch." Could you resist the challenge? Few can. But if curiosity gets the better of you and you do touch, the box immediately emits an ear-piercing, head-splitting wail that cannot be stopped short of smashing the the box with a sledge hammer or awaiting the demise of its internal-battery power supply in a month or so.

Or think of a small box on the desk of a company executive. It, too, says "Do Not Touch." But when the executive steps out to talk to his secretary, how can a visitor or subordinate resist a quick look? Here, again, the non-stop scream, actuated by the unseen switch, proclaims that curiosity has led the visitor to a surreptitious investigation of the boss' private desk. The effect is crushing, leaving the executive with an overwhelming psychological advantage in any negotiations or discussions that follow.

The Curiosity Box is simple and inexpensive to build. Two types are described here, one using a touch button, the other a push-button. The box contains a simple oscillator combined with a semiconductor latching circuit. The oscillator uses only four inexpensive, non-critical parts—a transistor, a resistor, an inexpensive transformer, and a speaker—yet emits an incredibly loud note with an input of only 15 milliwatts at 1.5 volts. The latching circuit uses a small silicon controlled rectifier (SCR) and a few passive components. The circuit with its two-penlight-cell battery can be mounted in almost any small chassis box, as shown in Fig. 1, and used to trap the curious.

The Push-Button Box

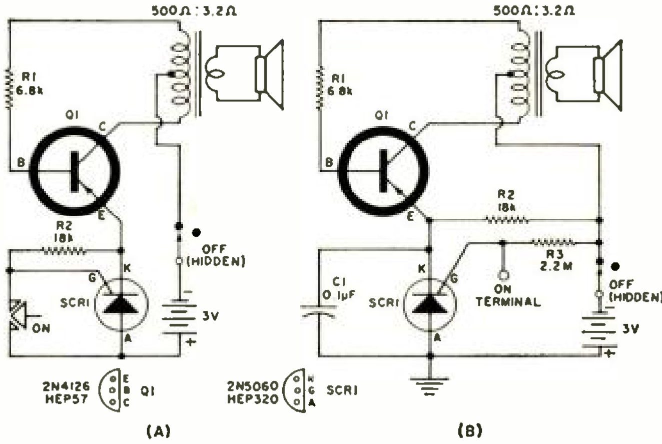
The push-button version of the Curiosity Box, Fig. 2A, will be described first since it is simpler. Transistor *Q*1 and its associated components make up a simple oscillator. While component values are not critical, resistor *R*1 can be changed to vary the tone (and output level) of the oscillator. A value of 6.8k-ohms for *R*1 provides optimum annoyance when used with the component values shown in Fig. 2A. Two penlight batteries were used to overcome the voltage drop across the latching circuit although one penlight battery will provide a sufficient noise level with this circuit.

The latching circuit uses an inexpensive plastic-encapsulated silicon controlled rectifier (SCR) that acts as a latching relay when d.c.-operated. A pulse of positive current applied to its gate (by shorting the gate to the anode with a push-button) turns the SCR on, making it appear almost like a short circuit. (An SCR has a small forward drop.)

Once the SCR is on, and the oscillator is emitting its irritating scream, there are only two ways to stop the noise: interrupt the current flow (by disconnecting the battery with the hidden switch) or wait until the batteries discharge enough so that the oscillator stops working or the current flow drops below the 1 mA required to hold the SCR in conduction.

Resistor *R*2 stabilizes *SCR*1, which is very sensitive, by keeping it from turning on whenever the anode circuit is

Fig. 2. Schematic of very simple and inexpensive (A) push-button, and (B) touch-button Curiosity Boxes built by author.



broken and then reconnected. Characteristically, SCR's can be triggered on by an excessive dV/dt—the rate at which voltage is applied across the anode and cathode terminals. Biasing the gate negative helps prevent this.

Depending on the application of the Curiosity Box the switch used to turn it on can either be in plain view, marked "Do Not Touch," or hidden and actuated if the box is lifted by a visitor who cannot control his curiosity.

The Touch Box

In some applications, the Curiosity Box requires triggering at a touch instead of a push so that even a very light, very quick touch can set off the noise. The circuit for such a touch-control box is shown in Fig. 2B.

As mentioned before, the SCR is very sensitive and can be turned on by the current flowing through the large resistance of a person's skin, by body capacitance, or by a small static charge. Thus, it is only necessary to touch the gate—either with or without contacting the positive battery connection simultaneously—and the SCR will turn on. The gate-touch contact can be an insulated terminal in a metal panel, or some similar arrangement. However, for best results, both the contact and the positive battery terminal should be touched simultaneously.

One Disadvantage

Unfortunately, this simple arrangement has one disadvantage; the SCR, due to the dV/dt, usually turns itself on when power is applied. The simple solution used in Fig. 2A is not applicable here because the 18k-ohm gate-to-cathode resistance reduces sensitivity so that a very low resistance (such as a direct short) would be required for triggering. Instead, two commonly used methods for reducing the dV/dt problem were applied: adding capacitor $C1$ across $SCR1$ from anode to cathode and resistor $R3$ between the gate and negative terminals of the battery. Capacitor $C1$ is charged through the oscillator circuit. Since the capacitor charges relatively slowly, it reduces the rate of voltage rise, while resistor $R3$, by applying a slight negative bias to the gate, increases the resistance to dV/dt and only slightly reduces the sensitivity, making it necessary to simultaneously touch both the anode and gate for reliable triggering. A hidden switch, the same as that described for the push-button box, can be used to turn off the sound.

In addition, for the circuit of Fig. 2B, a resistor ($R2$) or large electrolytic capacitor is needed to keep the oscillator operating properly over a wide voltage range (it may not be needed with all transistors). The resistor is used here because it is smaller and less expensive than an electrolytic. ▲

Inertial Navigation

(Continued from page 30)

received special attention because of their very great effect on system reliability. These circuits are purchased to special documents which specify, in detail, the critical processes to be used in manufacturing the circuits and the inspection criteria which the manufacturer will use to judge the quality of his parts. Resident source inspectors and other quality control personnel are maintained in the vendors' plants.

The integrated circuits are received at *AC Electronics* and immediately subjected to dynamic operating tests at room temperature and the temperature extremes (−55° C, +125° C). The units which survive this testing are then placed in special burn-in racks. These racks provide full fan-out of the integrated circuits. Operation of the circuits is dynamic, and they are run for 168 hours at an ambient air temperature of 125° C. The units are again tested at room temperature and those which survive are assembled into the equipment.

All semiconductor components receive such burn-in. The transistors and diodes receive this burn-in at the vendor's plant. Other components, such as tantalum capacitors, wirewound resistors, and transformers receive special testing as well as temperature cycling and some burn-in.

The components are assembled to printed wiring boards by flow soldering or by reflow soldering in the case of most of the integrated circuits. The electrical connections are carefully inspected and touched up as required. Each completed module is then subjected to five temperature shocks to uncover any defective solder joints. After the entire navigation unit has been assembled, it is subjected to system testing which consumes more than 100 hours' operation before the equipment is finally sold.

The FAA requires that the inertial navigation system have a high reliability, namely, 544 hours mean time between in-flight failures. At the present time, the in-flight reliability of the system is approximately three times that. For the equivalent complexity, every color-television set with the same demonstrated reliability would typically operate without malfunction of any kind for forty years.

The FAA also specifies accuracy of within ±20 miles crosstrack and ±25 miles along track on 95% of flights of 1000 nautical miles or more. From November 1969 through January 1970, the system has met this specification on 99.5% of the flights on which it had been used. The system has also met *Boeing's* specification of no more than 2 nautical mile error per flight hour on 95% of flights up to 10 hours' duration. ▲

IC Capacitance Meter

(*Continued from page 47*)

tations are not unduly restrictive and should cause no problems.

Calibration

After the instrument is checked for proper operation, calibration is performed as follows.

1. The range switch is set to 0.001 μF.

2. The meter is then mechanically "zeroed" (it should be no more than one division on either side of zero).

3. The instrument is then switched on, the "Cal" button is depressed, and the control is set for 0.8 on the meter.

4. Known capacitors of about 0.8 times full-scale for each range are placed across the "unknown" terminals and the appropriate oscillator-frequency-adjustment potentiometer (or variable capacitor on the 10-pF range only) is adjusted until the meter indicates the value of the known capacitor.

It must be emphasized that, for maximum accuracy, the "Cal" supply voltage V_{cc} should be checked after the unknown capacitor is placed across the terminals. This step is especially important on the 10-μF range because the capacitor charging current comes from the oscillator and results in increased current to the oscillator circuit. The increased current causes a greater voltage drop across the 500-ohm calibration pot, and thus results in reduced oscillator voltage. For example, on the 1-μF range, the full-scale current supplied to the oscillator may be expected to rise by about 100 microamperes when a 1-μF capacitor is placed across the "unknown" terminals. This change amounts to 2 percent of full scale when the oscillator current is 5 mA. As mentioned previously, this error does not exist if the "Cal" V_{cc} is checked each time an unknown capacitor is placed across the terminals.

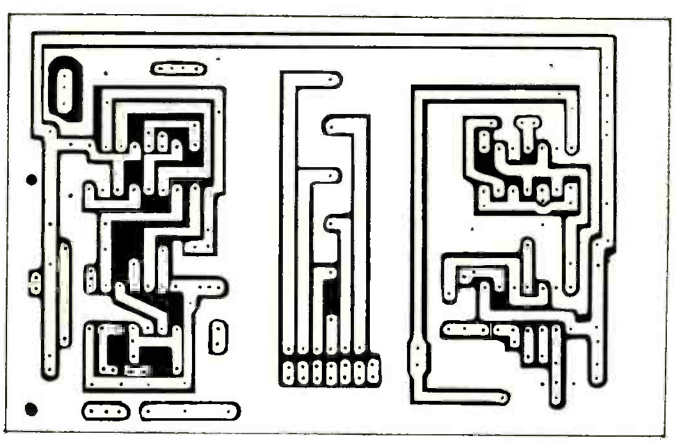
Battery life is about 500 hours, with an end voltage of 1 volt per "C" cell and 1.4 volts for the silver-oxide cells. The silver-oxide battery was selected for the negative 3-volt supply (V_{ee}) because of its excellent voltage stability with life. If the battery voltage drops below 2.8 volts, the constant-current source in the meter amplifier changes and causes the meter to move up-scale from zero. The stable silver-oxide battery prevents such changes. Therefore, it is only necessary to note the initial test reading on the meter with the original silver-oxide batteries and to note the point for 0.93 of this reading. After this point is reached, the negative batteries should be replaced. With the V_{ee} calibrating resistor, R24, shown, the meter with new silver-oxide batteries reads between 0.5 and 0.55 when the V_{ee} "Test" button is depressed.

If desired, the V_{ee} test button and the associated circuit may be omitted. In that case, zero offset must be noted when the meter is switched on in any range except the 10-pF position with no unknown capacitor. The zero-offset sensitivity for the 3-volt supply, in terms of full-scale deflection, is about 0.12 percent for each percentage change in supply voltage, that is, a 0.5-volt decrease in the V_{ee} supply results in one small division deflection up-scale (or 2 percent of full-scale).

The meter can be expected to be within 3 percent of full-scale on all ranges except the 10-pF and 10-μF range. As a result of stray capacitance of about 2 pF, the lower portion of the 10-pF range reads about 1 to 2 pF low for values below 3 pF. The upper end (0.8 and above) of the 10-μF range reads about 5 percent low as a result of high a.c. signal current in the meter amplifier.

The author wishes to thank John Klinger for laying out the PC boards and constructing the capacitance meter. ▲

EDITOR'S NOTE: *Even for those readers who may not be interested in constructing the IC capacitance meter described above, this article should serve to show how IC's can be incorporated into a piece of test equipment of novel design.*



Circuit side of PC board after soldering of components.

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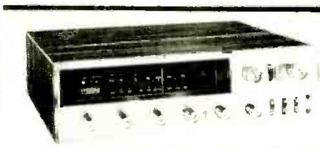

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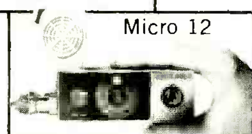

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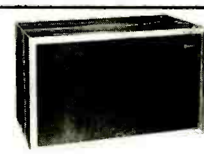
For Home and Car



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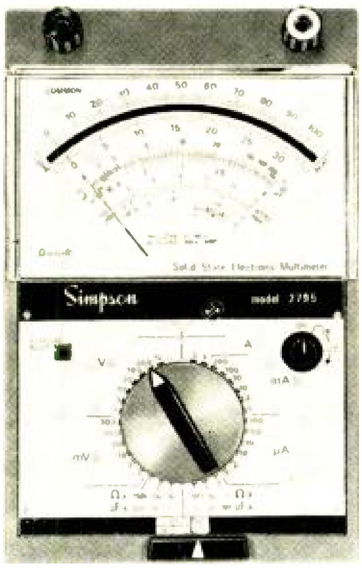
Product Report

Simpson Model 2795 Solid-State V.O.M.

For copy of manufacturer's brochure, circle No. 2 on Reader Service Card.



THIS new *Simpson* Model 2795 solid-state v.o.m. has no less than 68 switch-selectable functions plus 12 output (dB) ranges. It can measure a.c. and d.c. voltages as low as 1 mV full-scale, a.c. and d.c. currents as low as 1 μA full-scale, and it has six low-power resistance ranges that are safe to use for measuring transistor and IC resistance values. The meter is temperature-compensated over a range of 0° to 50°C, and has a rated accuracy of ±1 percent for both a.c. and d.c.

There are two unusual functions included in this instrument's repertoire: the ability to make direct measurements of capacitance and temperature. To measure capacitance, a built-in electronic chopper employing a MOSFET is used. This chopper provides the a.c. that is needed for capacitance measurements. There are 6 capacitance ranges capable of measuring values from 2000 μF to 0.05 μF full-scale. The two temperature ranges can measure a span of ±18°C from ambient and ±180°C from ambient. A separate thermocouple probe is required for these measurements.

The battery-operated meter has 10-megohm input impedance on both a.c. and d.c. ranges above 10 volts. Meter amplifier stability is sufficiently good so that no zero adjustments are required.

This lab-type precision FET v.o.m. is overload-protected on all ranges by use of a reset-type front-panel push-button circuit breaker. The breaker will operate even if the batteries are completely dead. As additional protection, a varistor prevents meter-movement overloads. A taut-band suspension movement is used so that error-causing friction is eliminated and the movement is protected from shock and vibration. An anti-parallax mirror dial is used and there is a single, linear scale for all a.c. and d.c. voltage and current measurements.

The Model 1795 is priced at $230, with test leads and batteries. A number of accessories are also available separately for the meter. These include a clamp-on shunt for high-current d.c. measurement, clamp-on current transformer for high-current a.c. measurements, thermocouple probes, and a high-voltage probe. ▲

RCA Type WO-505A Oscilloscope

For copy of manufacturer's brochure, circle No. 3 on Reader Service Card.

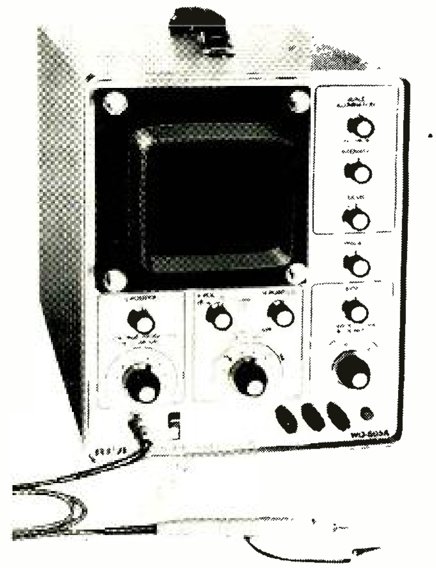
SOLID-state scopes are no novelty in the laboratory-oscilloscope field, but there are not too many of them available for general-purpose or servicing use. The new *RCA* WO-505A is just such an instrument. It is a 5-inch all-solid-state scope that is smaller, lighter, and more versatile than its tube predecessor. The CRT has a flat face, uses return-trace blanking, an illuminated graph scale, and camera-mounting studs.

The scope has a very high gain of 15 mV (p-p) per inch on its highest sensitivity range of the vertical amplifier. Frequency response of this amplifier is flat, within ±1 dB from d.c. to 5 MHz, and is usable up to 8 MHz. The vertical input attenuator and the graph screen are calibrated directly in volts so that the scope can be used as a visual voltmeter. An internal calibrated voltage source is provided. The attenuator is frequency-compensated and has eight steps of attenuation. FET's are used in both vertical and horizontal input circuits in order to produce a high input impedance.

The sweep oscillator in the scope is

not triggered but it is a free-running circuit that is synchronized by the incoming signal to be observed or by the power line. The sweep frequency is adjustable from 10 Hz up to 1 MHz in 6 ranges, permitting lock-in of signals up to 10 MHz. The level of sync signal applied to the sweep oscillator is adjustable so that synchronization is stable throughout the sweep range. Pre-set TV vertical (30 Hz) and horizontal (7875 Hz) sweep positions are provided for the convenience of the TV service technician. A separate phase control varies the phase of the a.c. line when it is used as a sweep signal. This permits the scope to match the phase of a sweep generator used for TV or FM sweep-alignment so that a proper display is produced.

The a.c. power supply is regulated to prevent trace bounce due to line-voltage fluctuations. The unit measures 11⅜-in high, 9-in wide, and 15½-in deep. It weighs 25 lbs and costs $298.50. ▲

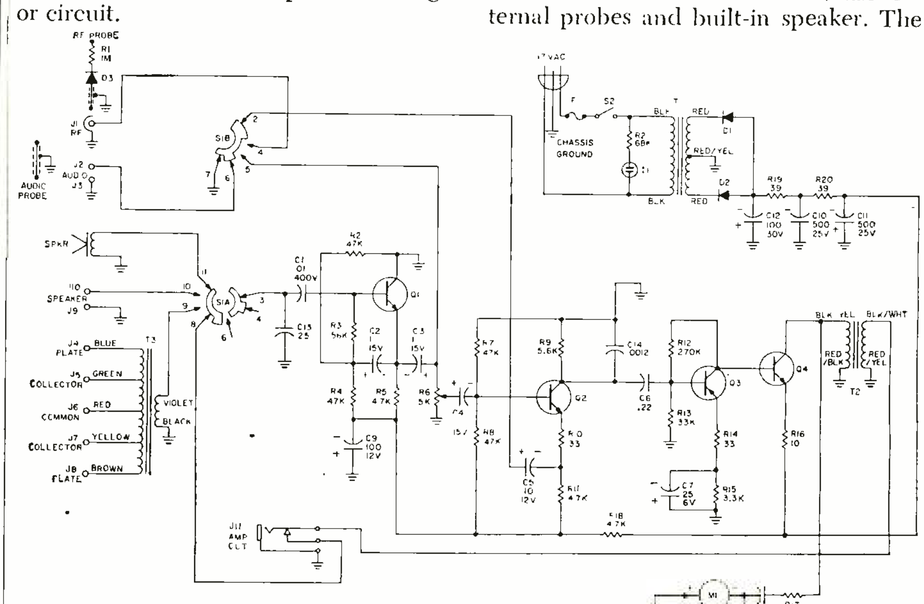


Eico Model 150 Signal Tracer

For copy of manufacturer's brochure, circle No. 4 on Reader Service Card.

SIGNAL-tracers have been used by the service technician for a good many years to trace r.f., i.f., and audio signals through a receiver or amplifier. The instrument simply consists of a high-gain audio amplifier with built-in speaker or earphone jack. A direct or crystal-detector r.f. and i.f. probe plugs into the instrument's amplifier and permits audio or r.f. signals to be traced successively through a receiver or amplifier. The idea is to start near the front-end of a receiver or the low-level preamp stage of an audio amplifier. Then you keep moving the signal tracer down the line of circuits toward the loudspeaker. When your signal disappears from the signal tracer's speaker, then you have found a break in the signal path and you should be able to pinpoint the trouble to a particular stage or circuit.

Some signal tracers incorporate all their circuitry entirely within the probe itself. An earphone must be used with these. Others, more elaborate, use external probes and built-in speaker. The



NOTES
1. ALL RESISTOR VALUES ARE IN OHMS, 1/2 WATT, 10% UNLESS OTHERWISE SPECIFIED
2. ALL CAPACITOR VALUES ARE IN MICROFARADS, UNLESS OTHERWISE SPECIFIED
3. THE FOLLOWING SWITCH LUGS ARE CONNECTED TO EACH OTHER: S1A-4 TO S1B-4, S1A-6 TO S1B-6

Eico Model 150 is one of the latter types, although the company also has an all-in-the-probe version (the PST-2 priced at $19.95 in kit form or $29.95 factory-wired) as well.

The Model 150 (see circuit shown) has two input channels: a high-gain r.f. and a medium-gain audio. A shielded r.f. crystal demodulator probe and a direct audio probe are provided. In addition to the built-in 4-in speaker, a meter is provided to indicate the signal level being measured.

Terminals from the unit's output transformer and loudspeaker are brought out to the front panel. Hence, you can substitute the built-in speaker and transformer, either together or separately, for speakers and transformers that you suspect of being faulty in equipment you are troubleshooting. The signal tracer has an isolated a.c. power supply and 3-wire power cord for safety.

The Model 150 measures 7½-in high, 8½-in wide, and 5-in deep. A convenient carrying handle is provided. Price is $49.95 in kit form or $69.95 factory-wired. ▲

VOLTAGE-VARIABLE CAPACITOR IMPROVES SAWTOOTH LINEARITY

By FRANK H. TOOKER

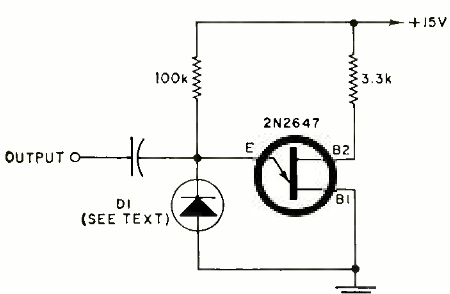
THE accompanying schematic diagram is deceptive if one takes it too literally, for the diode in the emitter circuit of the UJT actually performs as a voltage-variable capacitor.

The author used an ordinary silicon rectifier diode rated at several amperes for the prototype set-up, but Varicaps (diodes made especially to operate as capacitors) are recommended.

In the schematic, the UJT operates as a relaxation oscillator. The capacitor (in this case, D1) charges through the 100k-ohm emitter resistor. When the potential across the capacitor reaches the UJT's peak-point emitter voltage, the UJT suddenly turns on, discharges the capacitor, and then turns off again. The cycle then repeats.

A conventional capacitor charges logarithmically, but the capacitance of a reverse-biased diode decreases as the voltage across it is increased. This causes the charging rate to increase as the voltage level increases. In other words, the charging rate tends to become more linear.

The result is improved linearity of the sawtooth waveform obtained from the circuit in the schematic. ▲



TRANSISTOR BASE-EMITTER JUNCTIONS for VOLTAGE REGULATION

By THOMAS J. CARMODY
PRD Electronics, Inc.

A READY supply of zener diodes is available in most labs if the reverse-voltage characteristics of transistor base-emitter junctions are utilized. Silicon mesa and silicon planar transistors exhibit sharp avalanche break points, as shown in Fig. 1. To demonstrate this capability, a voltage regulator of the shunt type was built, using the reverse-biased base-emitter junction of a 2N697 as the voltage-reference element.

In the operation of a shunt regulator (see Fig. 2), a transistor is placed in parallel with the load and biased so that at the lowest expected input voltage it draws the minimum current. The bias is set by the reverse-biased base-emitter junction of Q2. An increase in output voltage causes this junction to pass more current through the base of Q1. Q1 goes harder into conduction, drawing more current and causing the voltage drop across R1 to increase, thereby reducing the available voltage to the load.

The impedance of the reverse-biased junction is 100 ohms at a current of 1 mA with a nominal zener voltage of 7.3 volts. A change in input voltage of 1.0 volt causes a change in the output voltage of 1.7 mV. This represents voltage regulation of better than 0.2% at room ambient.

The output voltage of the regulator is determined by the avalanche voltage of the base-emitter junction of Q2 and the V_{BE} of Q1. The regulated output voltage, E_o, is relatively fixed at approximately 8 volts. If a higher regulated voltage output is required, silicon diodes may be placed in series with the base-emitter junction of Q2. Each diode will increase the output voltage by 0.7 volt. To double the voltage, two base-emitter junctions would be placed in series. This will degrade regulation but, in most cases, not by a significant amount. The only limitation on the regulator is to stay within the power dissipation ratings of the particular transistor chosen as the shunt.

Component values (neglecting the zener current) were determined as follows: $R1 = (E_{i\,(min)}/I_o) - E_o + (20-8)/20 = 600$ ohms. Use the next lower standard value of 560 ohms. $I_{Z(max)} = (E_{max} - E_o)/R1 - I_o = (30-8)/560 - 20 = 19$ mA. $I1_{max} = I2_{max} + I_o = 19 + 20 = 39$ mA. ▲

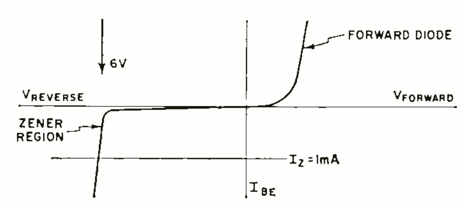


Fig. 1. Base-emitter current as function of V_{BE}. The sharp avalanche break points are characteristic of both silicon mesa and silicon planar transistors.

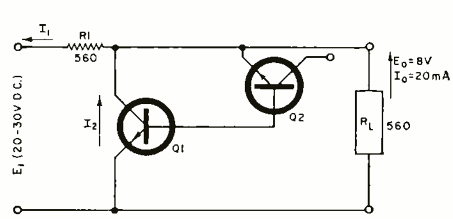


Fig. 2. Operation of a shunt regulator.

ELECTRONIC CROSSWORDS

By JAMES R. KIMSEY

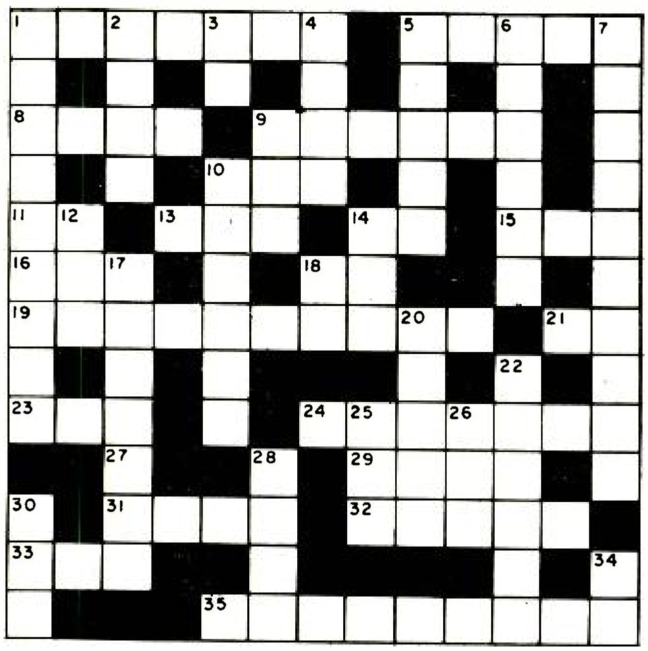
(Answer on page 96)

ACROSS

1. A discrete portion of energy of a definite amount.
5. The maximum useful distance of a radio transmitter.
8. A matching element in a waveguide.
9. A series capacitor inserted into the oscillator-tuning circuit of a superhet.
10. ________ Dailey (actor).
11. City division (abbr.).
13. Tube connection.
14. Used to be.
15. Skill.
16. Head covering.
18. Roman numeral for 150.
19. A chemical reaction in which heat is produced.
21. One one-thousandth of a henry (abbr.).
23. Plaything.
24. A continuous-wave, low-frequency navigation system.
29. In a transistor, the element which corresponds to the control grid of an electron tube.
31. Ended.
32. Rub out.
33. Combine, as numbers.
35. Subjected to equal pressure from every side.

DOWN

1. Condition of a circuit when no input signal is being applied to it.
2. A chemical compound.
3. Kind of capacitor (abbr.).
4. ________ free path. The average distance which sound waves travel between successive reflections in an enclosure.
5. The total number of distinct marks or symbols used in a numbering system.
6. Position of the relay contacts when the coil is not energized.
7. A backing plate around an opening.
9. Move a camera up and down or across a scene.
10. An oscillation introduced for the purpose of overcoming the effects of friction, hysteresis, or clogging.
12. Necessary evil.
14. Shade tree.
17. An end-fire, dielectric, microwave antenna made of a clear thermoplastic material.
18. Kind of picture tube (abbr.).
20. An alloy used primarily as resistance wire.
25. A famous president's nickname.
26. Peer Gynt's mother.
28. Greek god of war.
30. A conductive graphite coating on the inner side walls of some cathode-ray tubes (abbr.).
34. Type of current (abbr.).



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ELECTRONIC REVERB UNIT

A fully electronic reverberation unit which is smaller and more versatile than existing systems, according to its maker, is now available as the

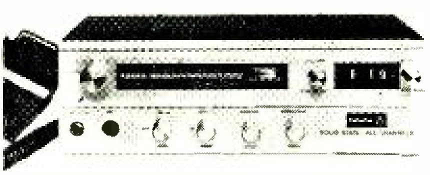
Model RE-100. The unit uses IC's and incorporates computer technology to provide a compact unit. Input and output amplification and equalization are self-contained and no additional equipment is required for connection to a system. Front-panel switches provide selection of various types of reverb and reverb time. Melcor

Circle No. 5 on Reader Service Card

BASE TRANSCEIVER

Two new CB transceivers featuring IC's and full 23-channel operation using slide-rule selection have been introduced as the Models SFT-500 and SFT-400.

The former is equipped with two speakers and



a digital clock that can be programmed to automatically turn on the transceiver and give an audible alarm. The Model SFT-400 with one speaker is supplied without the clock. They are identical except for that. Both offer a built-in p.a. system with volume control and an auxiliary speaker/phone jack. 100% modulation is provided, assuring full talk power. The transceivers come with all 23 crystals. Fanon

Circle No. 6 on Reader Service Card

STEREO RECEIVER

The Model S7100 AM/stereo-FM receiver provides 35 watts per channel dynamic power at 8 ohms and harmonic and intermodulation distortion of 1% of rated output. Frequency response is 30-20,000 Hz ±2 dB, power bandwidth is 25-20,000 Hz @ 1% distortion.

The receiver features stereo and mono speaker output impedances of 4, 8, or 16 ohms, high or low impedance stereo headphone output, and stereo recording output of 200 mV at 2000 ohms.

FM sensitivity (IHF) is 1.9 μV and signal-to-noise ratio is 65 dB. The unit operates from 115-125 V, 50/60 Hz and has 200-watt switched a.c. outlets. A data sheet with full specifications on the Model S7100 is available on request. Sherwood.

Circle No. 7 on Reader Service Card

ALL-CHANNEL TV SPLITTERS

A new type of all-channel signal splitter, one that connects two TV receivers to one ultra-tap, is now on the market as the Model 1572G.

The unit plugs into an outlet and instantly converts from a single outlet to a dual unit. The unit is captured by the same screw that holds a UT cover plate. The hybrid unit prevents interaction between receivers, mates with quickly connected "G" fittings, and is used for all-channel color TV. Splitting loss is 3.5 dB from 54 to 216 MHz, and 3.8 dB from 470 to 890 MHz. Isolation between outputs is a nominal 15 dB. Jerrold

Circle No. 8 on Reader Service Card

INTERFERENCE FILTERS

The Series 6000 power-line interference filters are compact, feature high-performance characteristics, and are available for bulkhead or in-line mounting. The units are two-circuit pi filters, available with current ratings of 1, 3, 5, or 10 amps per pi section. Voltage and temperature ratings are 120 V a.c. or 200 V d.c. @ 125° C and 120 V a.c. or 400 V d.c. @ 85° C. Frequency rating is 0 to 400 Hz. The filters are hermetically sealed and are available with 2, 3, or more sections.

Additional information on the Series 6000 line is available on request. Sanders Associates

Circle No. 9 on Reader Service Card

NEW CASSETTE UNITS

Four new cassette models have just been introduced including the Model 3303 AM/FM 8-track recorder system, the Model 3124 8-track custom car stereo with FM radio, Model 2123 a similar version without the FM radio, and the Model 2609 AM/FM stereo cassette recorder with swing-out stereo speaker.

The car units are both floor-mounting types with theft-resistant features. The units are installed on floor or transmission tunnel of cars and lock into their mounting base after installation. A specifically coded magnetic key lock makes it virtually pick-proof. All electrical connections are made through a quick-disconnect plug so that the unit may be removed for storage and conveniently re-installed.

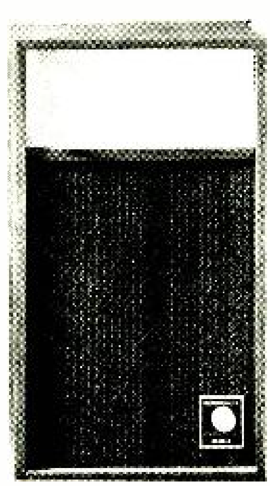
The Model 3303 is a fully transistorized unit which provides reception of AM, FM, and stereo-FM; plays all 8-track endless-loop cartridges; and records 8-track stereo cartridges from the built-in radio, microphones, stereo record player, or other signal sources. Craig

Circle No. 10 on Reader Service Card

SPEAKER/COLOR ORGAN

A combination speaker system/color organ has been introduced as the "Sonoglo 5" and is aimed at the youth market.

Sold in stereo pairs consisting of a master and a slave, the new unit is easily installed with any hi-fi system. The light display has its own separate circuitry and power supply. The slave unit is fed by cable from the master which excites the lights in the slave unit.



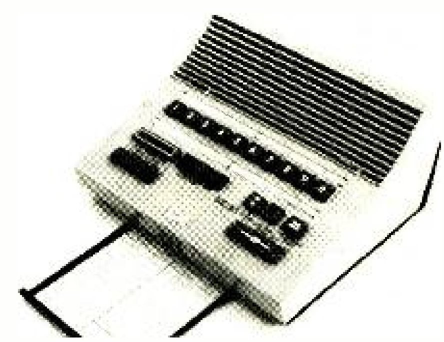
The units are housed in a walnut enclosure which contains a 2-way speaker system with 8" woofer and $3\frac{3}{8}$" tweeter and integral crossover network. The speaker cabinet measures $10\frac{1}{4}$" w. x 18" h. x $7\frac{1}{2}$" d. and the light display itself has an area of 37 square inches. Benjamin

Circle No. 11 on Reader Service Card

INTERCOM SYSTEM

A new intercom system which is flexible enough to link 30 to 450 loudspeaking or private phone stations through one completely automatic exchange has been introduced as the AVF 404.

The primary function of the new system is to provide high quality, hands-free communications



among working positions. The system is adaptable to a wide variety of applications and a number of optional facilities can be incorporated to provide even more flexibility.

The compact desk master station measures $4\frac{1}{8}$" h. x $9\frac{3}{16}$" w. x $8\frac{3}{16}$" deep and weighs 2.6 pounds. Ericsson Centrum

Circle No. 12 on Reader Service Card

AUTO ALARM SYSTEM

Protecting a car from theft or unauthorized entry through doors, windows, trunk, or hood compartments is now possible with a new auto alarm unit recently introduced. The solid-state alarm can be installed in minutes by the owner since no drilling is required and electrical connections clip to the car's electrical system.

The alarm senses changes in the vehicle's electrical system and causes the car's horn to emit a rapid succession of blasts. Upon entry into the car the dome light will set off the alarm. In addition, the car's ignition system will become disabled, preventing motor operation.

Two models are available, the C-7380 and the C-7381. The latter model features additional switches to monitor entry of all areas of the car. James

Circle No. 13 on Reader Service Card

DIGITAL PANEL METER

A new $3\frac{1}{2}$-digit digital panel meter featuring bipolar operation as well as the company's no-zero-adjustment and constant-high-impedance features has been introduced by Digilin Inc.

Designated the Type 332, the meter's bipolar feature allows it to read either positive or negative voltages without regard to lead placement. According to the company, this enhances convenience of operation and eliminates worry about meter damage due to wrong polarity. A neon minus sign indicates negative voltages.

Full scale ranges are 1-1000 volts, 1000 ohms-10 megohms, 100 μA-1A with 100% overrange on all ranges and overvoltage protection of 100 times range. Maximum sensitivity is 1 mV, 100 nA, 1 ohm and accuracy is 0.1% full-scale ± one digit.

For further information write the company at 6533 San Fernando Road, Glendale, California 91201.

ELECTRONIC DEPTH FINDER

The "Fish Scout" is an electronic finder which is compact enough to fit into a tackle box yet will provide a read-out precise within inches. Weighing slightly more than a pound, the unit includes a solid-state precision meter, a mini-transducer, 8 feet of cable, an omnidirectional transducer bracket, carrying case, and manual containing operating instructions and fishing tips.

The instrument operates from standard 9-volt transistor batteries which will last about five days at an average of 6 hours a day usage. Full details on request. Vexilar

Circle No. 14 on Reader Service Card

STATIC METER

An electrostatic field meter designed to be used not only in environment research but in safety, weather, and manufacturing areas is now available as the "Portable Scanner."

The instrument has five ranges plus battery test: 5, 50, 500, 5000, and 50,000 V/cm full-scale, positive or negative. Sensitivity is 0.2 V/cm. Phase detector synchronizing provides linear output both sides of 0. Meter switching is unnecessary to read changes in polarity.

The meter is completely portable, measuring 2½" x 2½" x 8" plus handle. It is powered by rechargeable nickel-cadmium batteries. Electro-fields

Circle No. 15 on Reader Service Card

ALARM SYSTEM

A simple alarm system which can be installed without special tools to check up to 50 critical points has just been introduced as the "Power-horn." It is designed for home, office, and small industry applications. It fires 25 seconds after any monitored door or window is opened unless the owner keys a special switch. The alarm is tamper-proofed by an extruded aluminum cover and operates independently of any power-line connections.

When fired, it makes a loud, unmistakable, and continuous noise. Power is supplied by three "D" cells. Over-all dimensions are 3⅜" x 12" x 1⅞". It comes with 30 feet of wire, a magnetic sensor switch, a set of keys, and operating instructions. Radio Shack

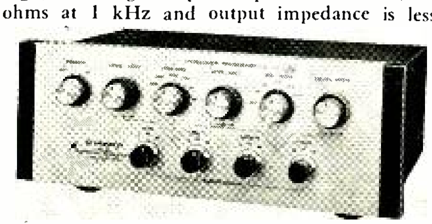
Circle No. 16 on Reader Service Card

ELECTRONIC CROSSOVER

A stereo electronic crossover, the SF-700, has been developed to supply complete hi-fi control through its ability to match amplifiers, speaker systems, and room acoustics.

Since the crossover frequencies are variable, the most suitable ones for any particular installation can be selected. Because cut-off and crossover points can be controlled, radio, record, and tape reproduction is enhanced, according to the manufacturer.

Use of four knobs on the front panel of the SF-700 can control the cut-off characteristics near each crossover frequency. They supply an attenuation of 6 dB/octave, 12 dB/octave, or 18 dB/octave at four positions: low, mid-low, mid-high, and high. Input impedance is 100,000 ohms at 1 kHz and output impedance is less

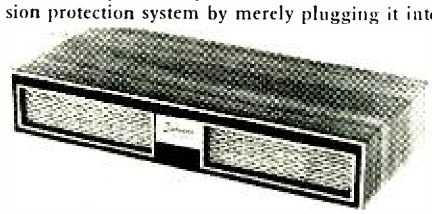


than 200 ohms at 1 kHz. Harmonic distortion is less than 0.3% and insertion loss less than 20 dB. S/N ratio is more than 85 dB. Pioneer

Circle No. 17 on Reader Sevrice Card

FIRE/INTRUSION ALARM

The Model A-4 security center alarm system features complete fire, burglar, and intrusion protection to fit any home or business application. The system may be used as a basic intrusion protection system by merely plugging it into



the 117-volt power line and connecting a lamp or bell as an alarm device. Additional protection accessories are available for fire and smoke detection as required.

Maximum range is 18-26 feet depending on area acoustics and humidity. The cabinet measures 10¼" wide x 4¾" deep x 1⅞" high. Three different ultrasonic frequency channels are available to prevent interaction of multiple units installed in the same area.

A four-color brochure describing the basic unit and available options will be supplied on request. Bourns

Circle No. 18 on Reader Serivce Card

STEREO TURNTABLE

A fully automatic stereo turntable, Model PL-A25, uses a 4-pole outer rotor high-torque hysteresis synchronous motor for constant turntable speed. Two speeds are available—33 and 45 r/min. The platter is a massive, precision-finished 12" aluminum die-cast type driven by a polyurethane belt that is unaffected by temperature, oil, or humidity, according to the company. Wow and flutter is less than 0.1%.

The turntable comes with a stylus-protecting automatic lead-in device, adjustable for use with 7", 10", or 12" records. It also has automatic cut and automatic return and an automatic repeat device which permits the record to be repeated.

A two-motor system with the drive motor of the turntable separated from the timing motor of the automatic devices permits independent operation. However, the PL-A25 can be used either automatically or manually.

It comes in an oil-finished walnut cabinet and measures 17 5/16" wide x 6 11/16" high x 13¾" deep. Pioneer

Circle No. 19 on Reader Service Card

OMNI SPEAKER SYSTEM

The SS-9500 speaker system is a radical departure in design and styling and consists of 6 acoustic-suspension speakers sealed in an air-tight barrel-shaped enclosure. The barrel shape results in an enclosure rigid enough to handle

50 watts of program material. The six full-range speakers are equally spaced around the perimeter of the enclosure, producing omnidirectional sound in the horizontal plane.

The combination of speaker design and enclosure are such that the impedance presented to the driving amplifier never drops below 6 ohms over the frequency range 18-21,000 Hz. Sony Corp.

Circle No. 20 on Reader Service Card

23-CHANNEL CB UNIT

The "Bearcat 23" is a 23-channel CB radio that incorporates a large illuminated combination r.f./S meter, illuminated s.w.r.-forward meter, s.w.r.-reflected meter, 3-position delta-tune switch, automatic noise limiter and true r.f. noise blanker.

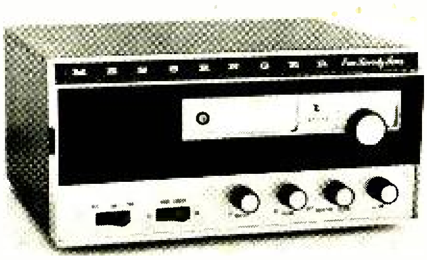
The radio has a combination 12 V d.c. and 115 V a.c. supply for base or mobile applications and modulation and "on the air" lights. A digital clock automatically turns the set on at preselected times or rings an alarm.

Controls are slide switches for volume, squelch, and s.w.r. calibration. The unit has an upward-tilt pedestal for operating convenience. Pearce-Simpson

Circle No. 21 on Reader Service Card

CHANNEL-9 MONITOR

A specially prepared Messenger 124 base station has been demonstrated which incorporates



capability for monitoring channel 9 while conducting regular communications on any one of the other 22 CB channels.

When an emergency or motorist's assistance call is received on channel 9, the set automatically switches from the communications channel to receive channel 9. An indicator light signals that channel 9 is being heard. Adjustment of a separate squelch control assures that only calls of the desired signal strength trigger the automatic switching action. A separate on/off volume control is also provided for the monitoring function. E.F. Johnson

Circle No. 22 on Reader Service Card

AUTOMATIC-CALLING SECURITY

A new protective unit, called the HotLiner, is designed to be installed by simply plugging it into a telephone jack and attaching it to any type of home security system. It will automatically dial pre-programmed telephone numbers to alert police, or neighbors, to intruders.

The unit is tamperproof and features a built-in test circuit to provide visual and audible indication to show that the instrument is operating properly. Teletronics

Circle No. 23 on Reader Service Card

120-WATT AMPLIFIER

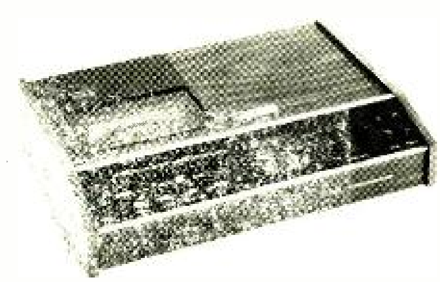
The new Model 32 amplifier has a guaranteed 120 watts of undistorted power at any audible frequency. It incorporates a variable-overlap drive, a relay protective circuit, massive heat sinks, regulated power supply, and other of the company's standard features.

The unit will drive reactive or capacitive loads such as electrostatic speakers. The amplifier measures 15⅜" x 5¾" x 9⅝" and weighs 21 pounds. A walnut cabinet is available as an optional extra. Marantz

Circle No. 24 on Reader Service Card

TAPE CASSETTE DECK

The new CAD5 professional tape cassette recorder incorporates the Dolby B noise reduction processor. The recorder's frequency response extends beyond 12,000 Hz and, according to the



company, distortion is extremely low and tape-speed regulation excellent.

The CAD5 is self-contained and an electronic speed control assures minimum speed variation with subsequent reduction of wow and flutter. Professional-type sliding pots set recording level and a unique recording overmodulation circuit, working in conjunction with the dual recording meters, shows when the recording sound level is too high. Harman-Kardon

Circle No. 25 on Reader Service Card

MINIATURE CAPACITORS

S&EI Manufacturing, 18800 Parthenia Street, Northridge, California 91324 is now in production on a new line of mini-miniature metalized polycarbonate capacitors, the Series 22.

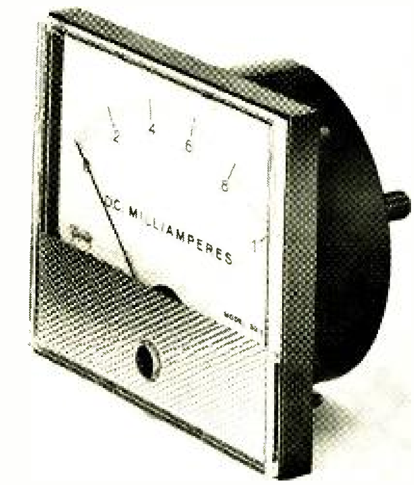
The new line is available in all standard case styles and in 50 and 100 volt d.c. space-saving sizes that range from 0.001 μF through 50 μF with tolerances of $\pm 1\%$.

Specifications typical of the new series include: operating temperatures from $-55°$ to $+105°$C; capacitance change over temperature range $\pm$ 1.5% and only a max. -0.7% from $+25°$ to $+105°$C, insulation resistance min. 100,000 megohms x μF at 25°C, and 0.3% max. dissipation factor. All capacitors are tested by MIL-C-18312.

Complete catalogue information and prices are available by writing the company direct.

SHALLOW-BARREL METERS

A special line of shallow-barrel panel meters for applications having back-of-the-panel space



limitations, Series GS with molded plastic backs, is now being offered by Triplett Corporation, Bluffton, Ohio 45817.

The special shallow barrel is designed for the company's 1½", 2½", 3½", and 4½" G-Series panel meters. The new series carries the 120, 220, 320, and 420 "G" series prefix.

Voltmeter, millivoltmeter, ammeter, milliohmmeter, and microammeter versions with front-panel or bezel mounting are available. For complete details address your letterhead request to the Marketing Department of the company.

PATIO SPEAKER SYSTEM

A new outdoor speaker system for patio or pool use is being marketed as the "Round Sound Machine." Because of the unique treatment of the speaker cone and special assembly techniques, the speaker is completely weatherproof. A heavy gauge steel sphere, measuring just 8 inches in diameter, houses the high-compliant air-suspension driver. The system will deliver 20 watts of dynamic power and has a frequency range of 55-15,000 Hz. Maximus Sound

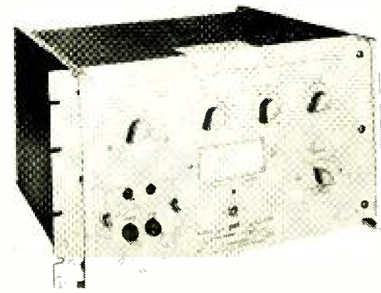
Circle No. 26 on Reader Service Card

LAB D.C. POWER SUPPLY

Power Designs, Inc., 1700 Shames Drive, Westbury, N.Y. 11590 has designed a new precision calibrated high-voltage power source especially for lab and equipment applications in nuclear detectors, photomultiplier tubes, c.w. lasers, electron optics, and similar instrumentation.

The Model 1543A offers 10-10,000 volts d.c. at 0-10 mA output with improved circuit technology and design specifications which have resulted in better performance in a smaller package, according to the company. Panel height is now 10".

The new unit features an IC control amplifier, solid-state voltage references, a temperature-stabilized all-silicon transistorized control amplifier, and a vacuum-tube series regulator. The amplifier includes electronic protection circuits



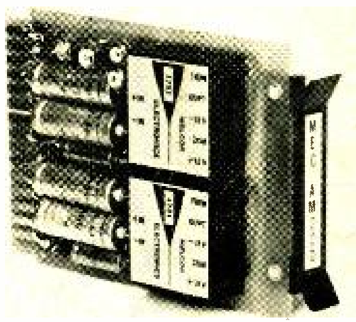
which guard against damage due to overloads, short circuits, voltage transients, or internal arcing of the regulator tube.

The company will supply complete electrical specifications on the Model 1534A upon letterhead request.

DUAL MIKE PREAMP

A dual microphone preamplifier containing two complete mike preamps on a single PC card is available. Known as the Model AM220, the unit's two amplifiers feature balanced transformerless input that is achieved by using the differential input capability of the Model 1731 audio operational amplifier.

The unit is suited for operation from high level capacitance microphones. Gain is factory set at 45 dB, but can be precisely adjusted from 45 dB to 20 dB with the addition of fixed resistors connected across the appropriate terminals



of the external connector. The gain changes take place in the feedback loop of the amplifier to maintain optimum S/N ratio. Melcor

Circle No. 27 on Reader Service Card

FM POCKET MONITOR

Two new, all-solid-state, battery-operated personal pocket portable FM monitor receivers are now available as "Portamon" Models CRX-106 and CRX-107 that tune the entire low- and high-band ranges covering police communications, fire departments, civil defense, public service, business and industrial radio, CB, 10-meter ham, and other services.

Both units incorporate such engineering features as an adjustable squelch control, continuous tuning, stability and drift-free operation, an r.f. stage to increase pulling power, tunable superhet

with three i.f. stages, and class-B push-pull amplification.

Each unit measures 6" h. x 1⅝" w. x 2¾" d. and weighs 1 pound. Hallicrafters

Circle No. 28 on Reader Service Card

PROCESS CONTROLLER

Delta Technical Laboratories, P.O. Box 617, Arcadia, California 91006 has developed the Model 30-160 Chlorometer which is an accurate all solid-state electronic process controller and measuring instrument sensitive to chlorine in aqueous solutions.

The meter measures from 0 to 20 parts per million chlorine with other ranges available for measuring from 1 to 1000 p.p.m. chlorine full-scale. The instrument operates on the established electro-chemical redox principle and specially polarized electrodes produce an electrical potential that is proportional to the chlorine concentration.

Full details are available on letterhead request to the manufacturer.

STEREO TAPE DECK

A 3-head stereo tape deck which features a special record/playback preamp has been introduced as the KW-4066. The preamp uses low-noise silicon transistors throughout for high S/N ratio and low distortion.

The unit incorporates the company's new tape-transport system which features tension-free tape travel and automatic/stop mechanism built into the head housing. Independent left and right recording buttons permit sound-on-sound while a special mode switch achieves a natural mono sound through both speakers for mono tapes. The unit has three tape speeds—7½, 3¾, and 1⅞ in/s plus a tape monitor switch to check recording quality. Kenwood

Circle No. 29 on Reader Service Card

MANUFACTURERS' LITERATURE

MODULAR POWER SUPPLIES

North Electric Company's Electronetics Division, Galion, Ohio 44833 has issued a 12-page catalogue covering its line of standardized modular power units.

The line of shelf power packages is available in six package sizes at seven different voltage levels ranging from 3.6 up to 28 volts d.c. at current ratings from 0.35 to 85 amps.

In addition to providing complete information on the power units, the catalogue covers accessories for use with the supplies.

WIRE, CABLE & TUBING

Birnbach Company, Inc., P.O. Box 592, Freeport, N.Y. 11520 has issued a new industrial catalogue, No. 2570, covering a complete line of wire, cable, tubing, and hardware for the electronics industry.

The publication is indexed by catalogue numbers and by product classification to make it easy to find the exact part required.

CHOOSING A MICROPHONE

A free booklet on the fundamentals of microphones, including the characteristics of each type, is now available on request.

Entitled "Microphones—How to Choose & Use," the text includes information on microphone placement, feedback, and limiting factors. There are full details on microphone impedances, techniques, and applications. Stanford

Circle No. 30 on Reader Service Card

CROSS REFERENCE/PRODUCT GUIDE

A 70-page, full-color 1970-71 Cross Reference and Product Guide which lists replacement products, including transistors, capacitors, heat exchangers, SCR's, and diodes, is now available for distribution.

The full catalogue listing of electronic dealer-service replacement products is combined, for the first time, with a complete cross reference guide—all in one convenient book. Items include products available from the company's distributors in the "5 & 10" packaging.

Products are listed in handy tabular form by product category. Illustrations of various case styles are presented on each page for ready reference. Following this is an alpha-numeric index of all products.

The cross reference is divided into major device categories: transistor, rectifier, capacitor, and heat-exchanger types used in professional service jobs are listed in sequence and cross-referenced to the company's replacement line. International Rectifier

Circle No. 31 on Reader Service Card

SCR CAPACITOR LINE

A technical bulletin covering the firm's new SCR commutating capacitor line is now available. The bulletin provides complete product descriptions, list of applications, dimension drawings, and a list of available standard ratings.

The publication, Bulletin 209.75, also includes an application specification questionnaire with space needed for description. Cornell-Dubilier

Circle No. 32 on Reader Service Card

GRAPHIC LEVEL RECORDER

An 8-page, two-color bulletin describing the Model 2305 graphic level recorder, its uses, features, and accessories is now available for distribution.

The bulletin describes the recorder as a measurement control center capable of operating other instruments in synchronization with the pre-printed chart frequency or time-base scales. The unit measures true r.m.s., peak, or average

Total U.S. sales of consumer electronic products for the first quarter of 1970 shown as units sold. These statistics were compiled and supplied by the Marketing Services Dept. of the Electronic Industries Association.

Product	Factory Sales (U.S. Produced)	Imports (Domestic Label)	Imports (Foreign Label)	Total U.S. Sales
HOME RADIO				
AM	380,819	850,701	1,727,674	
FM-AM or FM	188,670	430,198	4,004,106	7,582,168
AUTO RADIO				
AM	1,886,558	—	447,571	
FM-AM or FM	373,908	—	45,310	2,753,347
TELEVISION				
B&W	822,060	340,027	327,970	
Color	979,596	89,372	91,451	2,652,479
PHONOGRAPH	671,280	107,561	345,309	1,124,150
TAPE RECORD.	123,624	217,574	1,300,391	1,641,589
TAPE PLAYERS				
Auto	N.A.	N.A.	700,512	
Other	N.A.	N.A.	688,944	N.A.

values of a.c. signals in the frequency range from 2 Hz to 200 kHz. It also records d.c. levels.

Numerous photographs and full descriptive data on matching equipment is contained in the bulletin. A block diagram is also included. B&K

Circle No. 33 on Reader Service Card

TOOL USER'S GUIDE

A 40-page, 4-color catalogue which describes a comprehensive line of hand tools is now available. Each of the tools is fully illustrated and described, together with a color-keyed application and user's guide for correct tool selection and use.

Products illustrated include a variety of "unique" tools each specifically designed to solve a particular tool usage problem. A special section is devoted to displays for distributors and retail store operators.

A copy of Catalogue SD-170 is available on request. Vaco

Circle No. 34 on Reader Service Card

DIGITAL INDICATOR DATA

A 4-page brochure which describes in detail the new H550/H551 miniature digital indicator which accepts linear or non-linear signals is now ready for distribution.

The booklet provides complete information, specifications, and dimensional drawings with typical application data presented in tabular form. Howell Instruments

Circle No. 35 on Reader Service Card

ANTENNA CATALOGUES

Two new catalogues, a revised 32-page #710 and the new #107, are now available covering various antenna systems.

The #710 illustrates and describes an entire line of over 100 TV-FM outdoor and indoor antenna models and more than 200 electronic products for home and commercial systems. Catalogue #107 features commercial systems equipment for MATV, CCTV, ITV, ETV, CATV, and NATV installations. Winegard

Circle No. 36 on Reader Service Card

R.F. CATALOGUE

The Bendix Microwave Division has issued a new 161-page fully illustrated catalogue covering all major r.f. connector classifications and subtypes.

The "RF Connector Catalog," designated #1069, includes comprehensive parts number cross-reference tables (MFG/MIL and MIL/MFG), cable data, and cable assembly instructions. The catalogue is complete with part numbers, dimensions, and engineering data for each connector type within a series and includes a full line of adapters between series, terminations, and diagrams of mounting holes and mounting plates.

Designed for use by component engineers and purchasing personnel in the electronics field, copies of the catalogue are available on letterhead request to the company at Franklin, Indiana.

AMERICAN STANDARDS

The American National Standards Institute, Inc., 1430 Broadway, New York, New York 10018 has just published its 1970 catalogue which lists nearly 4000 American National Standards and 1700 international recommendations and includes an 18-page index to the titles of all listings.

Added to the expanded 128-page edition are American National Standards approved by ANSI through January 15, 1970, the international recommendations (standards) received by that date from the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC), the International Commission for Rules for the Approval of Electrical Equipment (CEE), and the Pan American Standards Commission (COPANT).

ENCAPSULATED R.F. CHOKES

Vanguard Electronics, 930 West Hyde Park, Inglewood, California 90302 has just issued a four-page brochure on its improved high-temperature encapsulated r.f. chokes. All included on military QPL, these chokes are designed to meet MIL-C-15305, Grade 1, Class B.

Included in the two-color publication are complete specs on Series 101, 102, and 103 chokes which provide inductances ranging from 0.1 to 4700 μH and standard inductance tolerance of $\pm 5\%$, the Series S, M, and L with inductance tolerances of $\pm 20\%$ for the 0.1 to 1.0 μH inductance range, and $\pm 10\%$ for the 1.0 to 10.0 μH range.

LINEAR IC's

An 88-page, pocket-size catalogue describing the firm's complete line of linear integrated circuits has been issued by Fairchild Semiconductor.

Known as the "Linear Integrated Circuit Condensed Catalog," the $3\frac{1}{2}$" x 6" booklet provides key information and pin diagrams for 31 linear IC products. These include operational amplifiers, dual op amps, a.c. amplifiers, comparators, communications devices, preamplifiers, differential amplifiers, stereo multiplex decoders, chroma demodulators, and other specialized electronic circuit functions.

Write the Distribution Services department of the company, Box 880A, Mountain View, California 94040 on your business letterhead for a copy of the catalogue.

VARIABLE CAPACITORS

Higher "Q's" than previously available are featured in the new variable capacitor Stock Catalogue No. 170 issued by Johanson Manufacturing Corp., 400 Rockaway Valley Road, Boonton, N.J. 07005.

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Answer to Electronic Crosswords appearing on page 91

Q	U	A	N	T	U	M		R	A	N	G	E
U		C		A		E		A		O		S
I	R	I	S		P	A	D	D	E	R		C
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G				I	S	O	S	T	A	T	I	C

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Answers to C.E.T. Test, Section #7

Published in Last Month's Issue

1. **(a)** An open delay line causes a loss of luminance signal but the color circuits continue modulating the tube with varying amounts of color. Some receiver designs are such that an open delay line causes "no brightness" and therefore no color, but for our purposes, answer "a" is correct.
2. **(a)** Proper purity adjustment normally involves exact placement of deflection yoke. Ion traps are not used on color tubes.
3. **(a)** The color-burst signal, riding on the back porch of the horizontal sync pulse, must be received to turn the color killer stage "off." A keying pulse from the horizontal section is also needed, but it is present at the killer during B&W telecast and color telecasts.
4. **(a)** The object of the chromanance circuits is to supply the proper color phase difference signals to the picture tube.
5. **(b)** Problems at station's video tape recorder produces this effect.
6. **(d)** Most a.f.c. circuits use the 45.75-MHz video i.f. carrier as the reference signal.
7. **(a)** V.t.v.m. is usually required.
8. **(d)** This control adjusts the phase of the color signal.
9. **(d)** a, b, or c normally would upset convergence and require touch-up or reconvergence.
10. **(b)** Dual trace. There are no two-gun style picture tubes currently in use. Sony uses a one-gun type, most common is a three-gun triangularly oriented assembly, and GE portables use the side-by-side or in-line 3-gun arrangement.

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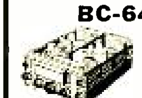

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September 1970

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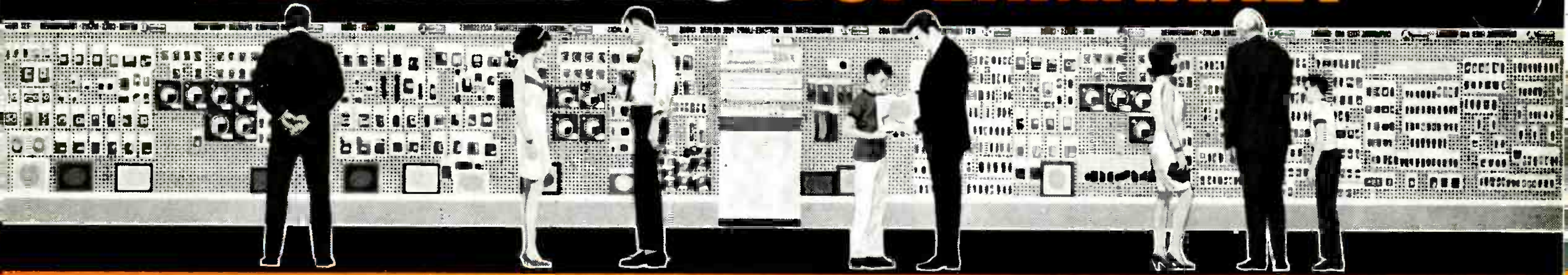

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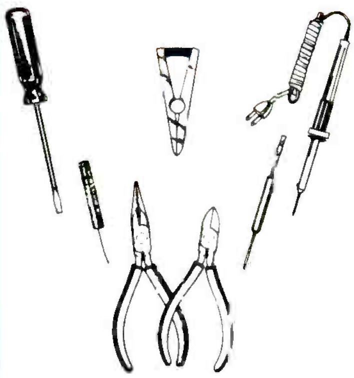

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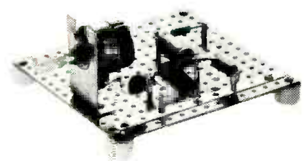

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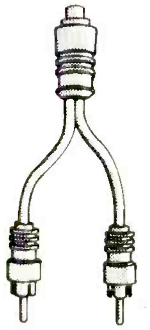

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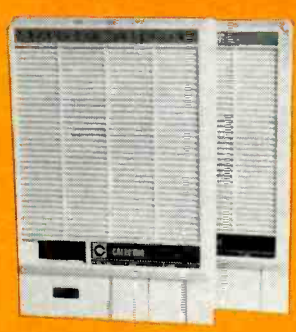

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