Electronics World

MARCH, 1971
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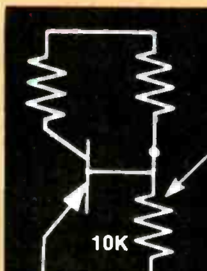
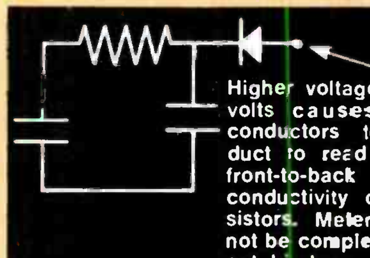


Low voltage of .08 volts prevents transistors from conducting and misreading circuit. Resistor will now read 10K as it should. Also prevents any damage to transistor.

Here is why you should have both Hi and Lo battery voltages for correct in-circuit resistance measurements in solid state circuits:



Higher voltage of 1.5 volts causes semiconductors to conduct to read proper front-to-back ratio or conductivity of transistors. Meter would not be complete without hi-ohms reading.

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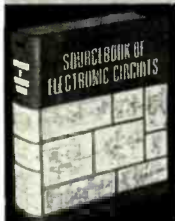

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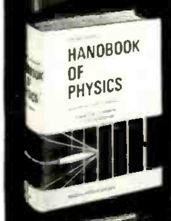

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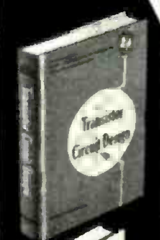

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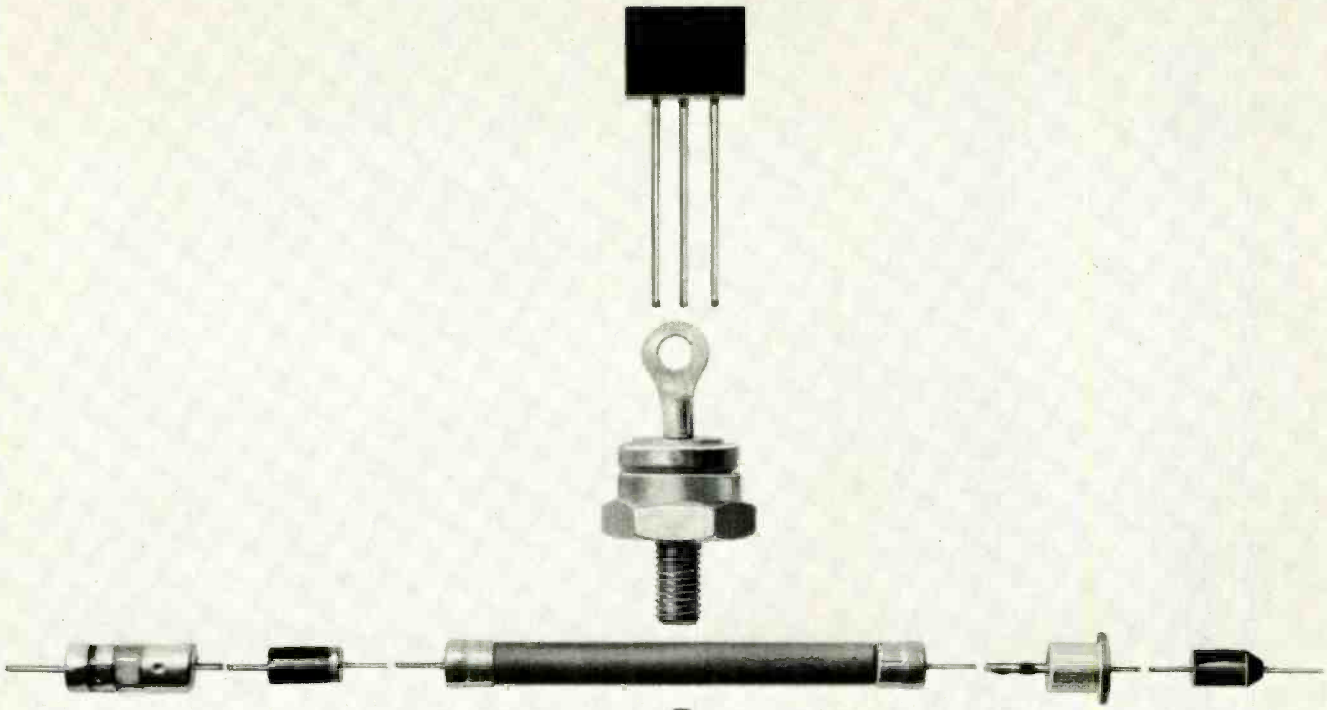

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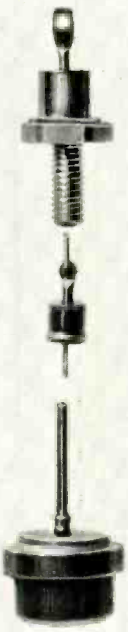

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Electronics World

MARCH 1971 VOL. 85, NO. 3

Contents

Electronics World

THIS MONTH'S COVER shows the three new Dolby-ized cassette decks that we tested and are reporting on in this issue. At the top left is the Harman-Kardon CAD-5; at the top right is the Fisher RC-80; and at the bottom right is the Advent 200. Complete details on performance and prices will be found in our report on these three products. Photograph by Dirone-Denner.

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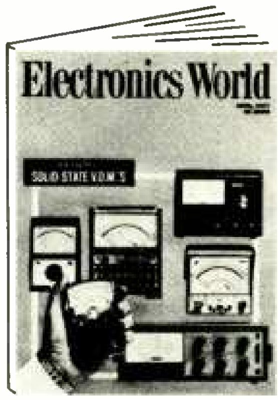
Coming Next Month

Special Feature Article



HIRSCH-HOUCK LAB TESTS SOLID-STATE V.O.M.'s

These test instruments—used by service and maintenance technicians in many fields—are gaining wide popularity because of their convenience and compactness. Hirsch-Houck Labs has tested a number of available units especially suited for radio and TV servicing and reports on performance, specifications, and special features of each of these transistorized units.

Behind the UL Label

Today's emphasis on consumer protection is "old hat" to Underwriters' Laboratories which has been protecting the consumer against hazardous products since 1894. How UL tests various consumer products, including such devices as radios, TV sets, microwave ovens, phonographs, hand tools, etc., is revealed in this timely story.

Multi-set TV/FM Systems for the Home

Eliminate clutter and improve reception by installing a multi-set system in your home. What's available in the way of active and passive couplers, splitters, combiners, baluns, and complete signal-distribution systems is covered by Thomas R. Haskett in this comprehensive and informative survey.

Unusual—But Useful—Digital Circuits

What happens when you need a resistor-transistor logic element and you have none on hand? Here is a collection of digital circuits that have been designed to serve as substitutes in RTL setups operating at speeds up to 100 kHz at the input.

All these and many more interesting and informative articles will be yours in the April issue of ELECTRONICS WORLD . . . . . on sale ***March 18th***

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Radio & Television news

By MURRAY SUNTAG/Associate Editor

Technology Graduates Fare Well

According to survey conducted by the Engineering Manpower Commission of Engineers Joint Council, starting salaries for new engineering technicians and technologists, despite economic downturn, showed an increase. Graduates of two-year program averaged $616 per month while those with bachelor's degrees averaged $806. Average salary compared favorably with the $862 per month received by bachelor-degreed engineers. Salaries, which varied considerably, were found to be directly related to curriculum and type of school, with some institutions reporting offers of above $1000 per month to their graduates.

Bachelor of technology programs are designed to prepare men and women for technical and managerial positions in industry which do not require as rigorous a science and mathematics background as typical engineering jobs. A copy of this 40-page report, "Prospects of Engineering and Technology Graduates—1970," may be obtained from Engineers Joint Council, Department "PT," 345 East 47th Street, New York, N.Y. 10017 at $2.00 per copy, postage prepaid.

Microwaves Protect Grade Crossings

One little-known fact, especially to urbanites, is that of the 225,000 railroad grade crossings in U.S. 180,000 are without automatic protection. As a result, the ratio of death to injury in grade-crossing accidents is second only to aviation accidents and approximately 15 times greater than highway accidents in general. Why isn't something done about it? Well, up to now the only excuse for lack of adequate grade-crossing protection has been the high cost of buried-cable electrical systems now in use.

To remedy this anachronistic condition, the U.S. Department of Transportation at Cambridge, Mass., reflecting government's increasing concern for its citizens, is conducting exploratory research into a highly reliable economical microwave system to protect unguarded railroad grade crossings. This system, which can operate in all types of weather, would transmit a continuous microwave signal from up-track to grade crossing. When train triggers a sensor, the microwave signal is turned off and the grade-crossing warnings—flashing lights or gates—are activated. System will also be capable of indicating to motorist the length of train and suggest, through a signal, that he consider an alternate route, be flexible enough to allow for varying speeds of trains, and give motorist a consistent 25 or 30 second warning regardless of train's speed. In addition, although this represents only one system for a much-too-long-ignored condition, it also opens up an area where aerospace and defense engineering know-how could effectively be put to use. (See February's "Radio & Television News" item, "Taking Up the Slack.")

CBS's EVR Team Grows

Hitachi, Ltd. of Tokyo, Japan, in a license agreement with The EVR Partnership of London, joins *CBS's* EVR international team. T. Yoshida, executive managing director of *Hitachi*, affirmed his belief in EVR's future by pledging his company's resources for manufacturing and marketing EVR teleplayers for both the Japanese market and other countries throughout the world. Other members of the EVR teleplayer manufacturing team are: the *Rank Organization* for the United Kingdom, *Robert Bosch, Gmbh* for Germany, *Thomson C.S.F.* for France, *Industrie A. Zanussi* for Italy, and a consortium of *Luxor*, *Bonnier*, and *Esselte*, formed as *A.v.s. Norden* for Switzerland. The senior member of this team is *Motorola Inc.*, for North America, under license from the *CBS Electronic Video Recording Division*.

Atomic Battery

Before the Apollo 12 astronauts blasted off the moon's surface they deployed an "atomic battery" called SNAP-27 to power the experiments left on the moon. SNAP-27, which is a compact radio-isotope thermoelectric generator (RTG), was built by *General Electric's Space Systems* to provide 63.5 watts of electrical power for one year. When left on moon last year it produced 73.59 watts of power during the 170°F lunar days and 73.98 watts in the –280°F nights. Latest checks indicate that after one complete year of operation, the generator continues to provide over 70 watts of power. According to A.J. Arker, *GE's* manager of Isotope Power Systems Operation, "The SNAP-27 has exceeded all requirements and barring any unforeseen conditions on lunar surface, it will continue to generate power at the design level for the next five or six years."

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The SNAP-27 contains no moving parts and weighs 43 pounds (slightly over 7 pounds on moon). Electric power is produced by inserting a plutonium-238 heat source into a thermopile composed of lead-telluride thermocouples. The thermocouples produce electricity when a temperature difference is maintained across their length. *GE* is now in the process of designing a Multi-Hundred Watt RTG (MHW-RTG) that will generate 100-200 watts of continuous power for up to 12 years. Modular in construction, it will provide a basic building block for space power systems up to 1000 watts for advanced weather, earth resources, and communications satellites, as well as for the "Grand Tour" interplanetary exploration scheduled for late 1970's.

Just a thought, but wouldn't it be nice if we could develop similar, but less expensive editions of these batteries for such mundane things as electric cars?

Computers and Genetics

With the aid of a space-age computerized process, developed at Caltech's Jet Propulsion Laboratory, man may soon be able to get a better picture of his genetic makeup. A JPL scientific team, headed by Drs. Kenneth R. Castleman and Robert Nathan, has devised a system whereby pictures of the chromosomes in a human blood cell (46 in all) can be analyzed in three minutes—about one-tenth the time required to do the same job manually. Since the chromosomes are the tiny bodies that contain the basic patterns for life—the genes—this speedy, low-cost procedure will make it feasible to perform blood tests on newborn infants and people contemplating marriage to determine presence of any hereditary disorders. The chromosome-analysis procedure presently used is limited to only those *suspected* of hereditary disorders because it is both time-consuming and expensive.

Although the present system at JPL is too large for hospital and medical laboratory use (full-room size), design refinements currently being investigated will make it more desirable for clinical applications. It is anticipated that within a year or two commercial production of an economical chromosome-analyzing system, within the means of many hospitals and clinical laboratories, will evolve. Estimated price range for such a system would be from $50,000 to $90,000.

Coming Events

For those scientists and engineers "orphaned" by sudden demise of the defense and aerospace industries and who are looking for new fields in which to make use of their special talents, their attendance at the 17th Annual Meeting & Equipment Exposition of the Institute of Environmental Sciences is suggested. The date April 26-30, the place—Biltmore Hotel, Los Angeles, Calif. A special mix of innovative environmental programs, including a two-phase series of technical sessions devoted to earth sciences and aerospace and military environmental science programs, will be presented. There will also be an ecology oriented three-day tutorial program with certification from a California college; an air-pollution seminar; and an equipment exposition. . . . And for those who found our last month's "Scanning Electron Microscopes" article interesting and with their appetites whetted in that area, a Fourth Annual Scanning Electron Microscope Symposium is scheduled for April 27-29 in Chicago. Symposium is sponsored by IIT Research Institute. Quantitative information from the scanning electron microscope will be primary theme of symposium. Special sessions will treat dynamical techniques and applications of the SEM in practical problems. In addition, major SEM manufacturers will exhibit instruments and a special one-day workshop on "Forensic Applications of the SEM" will be held April 30, 1971, the day following the meetings. For those interested, contact Dr. Om Johari, Director, Fourth Annual SEM Symposium, IIT Research Institute, 10 W. 35th Street, Chicago, Ill. 60616.

Bits and Pieces

Rectilinear Research Corp. has installed a direct telephone line to its plant from its exhibit at SEE 70, the permanent audio-industry showroom on Park Avenue, New York. Line is for convenience of visitors who would like to ask questions of the firm's engineering, sales, or other technical personnel. Telephone will be in operation weekdays from 9:00 a.m. to 5:00 p.m. Sign at exhibit will also note hours of operation and give regular telephone number should visitors wish to contact factory at other times. . . . New York's loss is Connecticut's gain. *General Telephone & Electronics Corp.* announced that its world headquarters (composed of its executive offices and six subsidiaries) will move from New York City to new 10-story building being constructed within the Stamford Forum. Approximately 1000 employees will be affected by move. . . . Dr. Robert Adler, *Zenith Radio Corporation* vice-president and director of research, received the "1970 Consumer Electronics Outstanding Achievement Award" during National Electronics Conference meeting held in Chicago on December 7-9. Award was presented to Dr. Adler for his "outstanding contribution to the consumer electronics industry through engineering achievements." ▲

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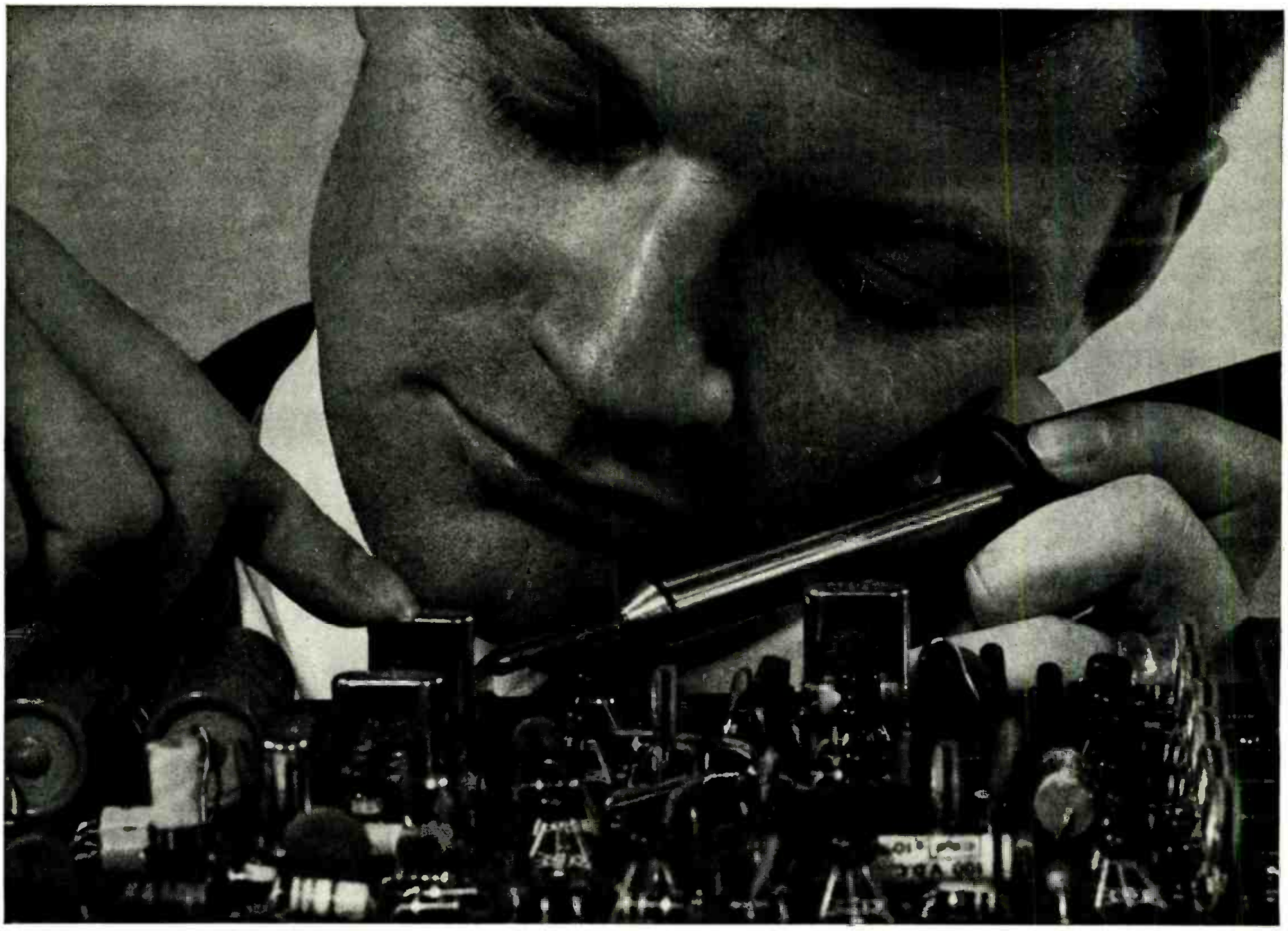

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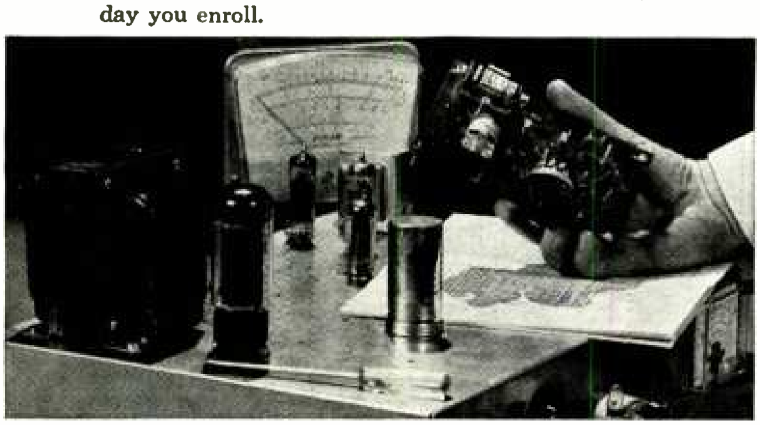

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HI-FI PRODUCT REPORT

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Harman-Kardon "Citation 12" Stereo Amplifier
Advent "Advocate 101" Noise-Reduction Unit

Harman-Kardon "Citation 12" Stereo Amplifier

For copy of manufacturer's brochure, circle No. 1 on Reader Service Page.

MANY audiophiles remember the Citation Series of components produced by *Harman-Kardon* nearly a decade ago. In those pre-transistor times, the Citation 2 power amplifier was a huge, sixty-pound brute, but it delivered over 60 continuous watts per channel with extremely low distortion. With the advent of transistors, the Citation 2 and its fellows became obsolete, but now *Harman-Kardon* has re-introduced the Citation name on its top-quality line of audio components.

The first of the new units is the Model 12, a basic stereo power amplifier. Although it is roughly equivalent to the old Model 2 in power rating, it outperforms it in every respect, but is a fraction of its size and weight. Even the price, adjusted for the inflation of the past decade, has not changed materially.

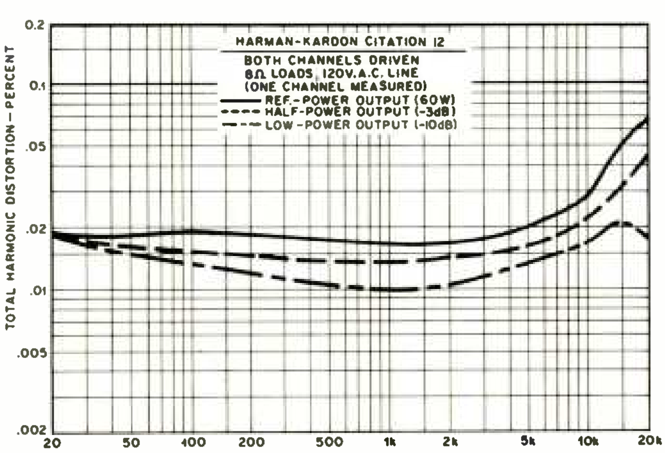
The Citation 12 is rated at 60 watts per channel, continuous output. Each channel has its own power supply, with the two sharing nothing but the line cord, so that it makes no difference whether one channel or two are driven. The packaging is compact and attractive, with all amplifier connections except the line cord coming from the front, where the four output transistor heat sinks are also located. The amplifier measures $5^{7}/_{16}$" high × $12^{5}/_{16}$" wide × $12^{5}/_{8}$" deep and weighs about 30 pounds. It has no controls—not even a power switch—and must be fully controlled from the associated preamplifier.

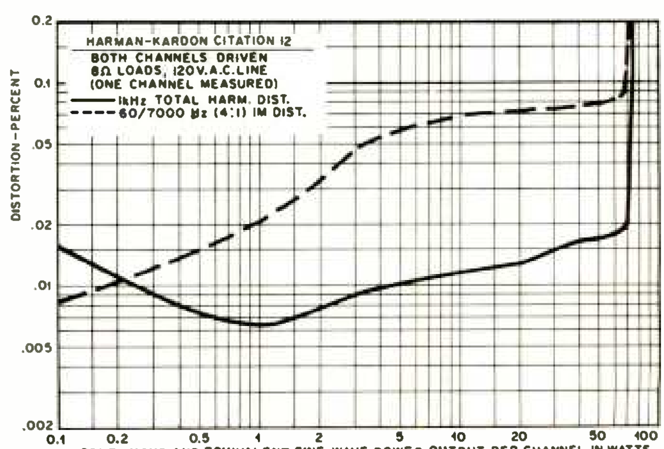
The amplifier circuit is direct-coupled throughout, except for the input blocking capacitor. The differential input amplifier receives the signal on one input (at a 30k-ohm input impedance) and the negative feedback from the output on the other. Since the feedback is direct-coupled, the average voltage across the speaker is maintained at d.c. ground, within a fraction of a volt. Following the input are the pre-driver and driver stages, and the output amplifier which uses a pair of husky silicon power transistors. Except for the output stages and power supplies, the amplifier is constructed on a single printed-circuit board.

The unit is thoroughly protected against damage from output shorts or overloads. The power-transformer primaries are individually fused, with a thermal circuit breaker in series with each fuse sensing the operating temperature of the output transistors in that channel. If it rises above 80 degrees C, the power is interrupted. In series with each speaker line is a current-limiting relay which opens when excessive current is drawn by the load and resets when the overload is removed. In addition, the output transistors are operated at about half their maximum ratings. During our extended full-power measurements, the thermal breakers opened and we repeatedly shorted the outputs to trip the relays. We did not succeed in damaging the amplifier in any way.

The rated frequency response is ±0.5 dB from 1 Hz to 70 kHz. We measured it as ±0.1 dB from 5 Hz to 50 kHz, down 1 dB at 100 kHz, and down 3 dB at 200 kHz. The unusually extended low-frequency response of the amplifier implies a very low phase shift in the audio band and this was emphasized by the response to square waves as low as 20 Hz, which had very little "tilt." *Harman-Kardon's* philosophy is that low phase shift is important throughout the audible range. This is certainly expressed admirably in this unit, whose low-frequency phase shift is unmatched by any hi-fi amplifier we know of. Its high-frequency phase shift and square-wave response are also excellent.

The amplifier is rated at less than 0.2% distortion between 20 Hz and 20 kHz at 60-watts output into 8 ohms. This was most conservative, as our tests showed. We measured the harmonic distortion at less than 0.07% under





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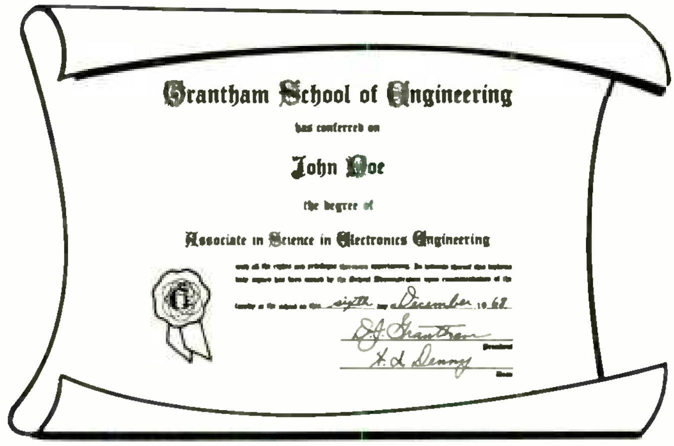

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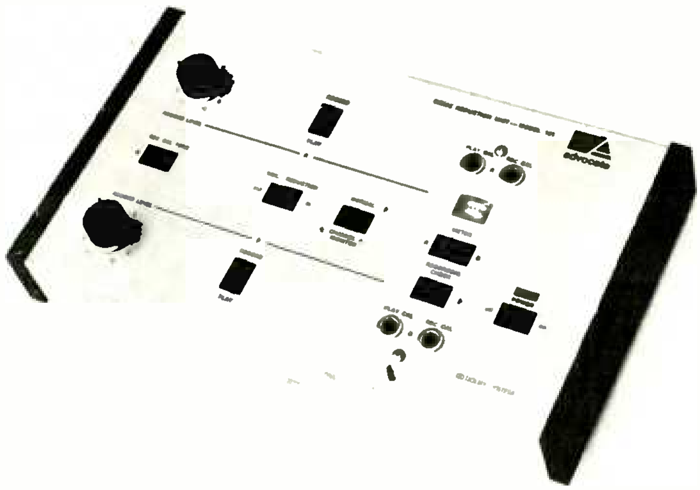
these conditions. Below about 5 kHz, it was less than 0.02% at any power up to 60 watts per channel. The 1-kHz harmonic distortion was 0.016% at 0.1 watt, falling to 0.006% at 1 watt and increasing to only 0.02% at 70 watts. The clipping power level was 74 watts, with distortion under 0.1% up to that point. Into 4 ohms, the output was 103 watts per channel; into 16 ohms it was 44 watts.

An input of 0.48 volt was needed for 10-watts output, with hum and noise 35 dB below that level. The amplifier was completely stable and remarkably free from "bugs."

Needless to say, the *Harman-Kardon* Citation 12 can drive the least efficient speaker systems without strain. Even in this day of "state-of-the-art" amplifiers, it ranks with the two or three best we have seen. It sells in kit form for $225, and appears to be simple to construct. It is also offered factory-wired for $295. A two-year warranty applies to all parts and, in the case of the factory-wired model, to labor as well. ▲

Advent "Advocate Model 101" Noise-Reduction Unit

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



THE Advocate Model 101 noise-reduction unit, a product of *Advent Corporation*, is a "B-Type" Dolby system signal processor which provides up to 10-dB of noise reduction in home tape recording. It is connected between the signal source and the recorder inputs and between the recorder outputs and the amplifier.

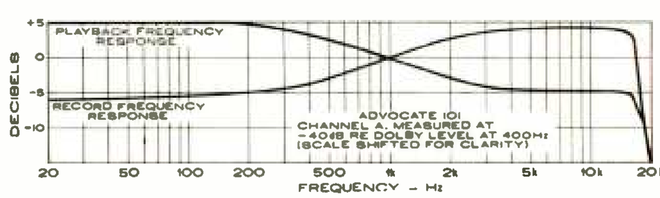
Since the same Dolby circuits are used for recording and playback, the Model 101 contains two identical sections (for the two stereo channels), with switches to change them from recording to playback modes. After calibration to standard playback and recording levels, the circuits have a flat response at 0 dB (the Dolby reference level). In recording operation, as signal level is reduced, the frequencies above 600 Hz are progressively boosted. In playback, lower signal inputs produce a roll-off above 600 Hz. Both actions are automatic, effectively instantaneous, and undetectable by the listener.

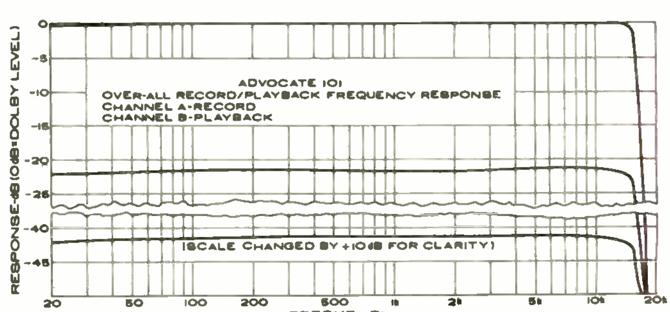
The recording and playback circuits have identically shaped but complementary response characteristics at all signal levels. The reduction in high-frequency output during playback cancels the recording boost, leaving the overall system response unaffected. However, any hiss introduced in the tape-recorder circuits is reduced by the system during playback. The maximum reduction is approximately 3 dB at 600 Hz, increasing to a value of 10 dB at 4 kHz and higher frequencies.

Since the Model 101 must be manually switched from record to playback operation, it cannot be used to monitor a program from the tape while recording on a three-head machine. This facility, as well as microphone inputs and mixing, is offered on the considerably more expensive *Advent* Model 100. The Model 101 does have a monitor switch which can be used with a three-head recorder to simultaneously record and play back through the system, but on one channel only. Since most recording will probably be done in stereo, this is of limited value, but it is convenient for comparing the noise levels with the system switched on or off. This is something that every new owner of a unit should do at least once to convince himself of the effectiveness of the system.

The Model 101 is supplied with both reel and cassette playback calibration tapes. A template fitting over the panel shows the correct control positions for playback and record calibration. Once calibrated, the process need not be repeated unless a change is made in the recorder, the type of tape used, or the settings of the recorder controls.

The calibration process is simple. The reference tape or cassette, which contains a 0-dB level 400-Hz signal, is played and the "Play Cal" adjustments are set for a reading of 8 on the meter, which is switched between channels. Then with the regular tape in the recorder, a 400-Hz, 0-dB reference signal from an oscillator in the Model 101 is recorded and played back. If the meter does not read 8, the "Rec Cal" controls are set in successive approximations until they produce the correct





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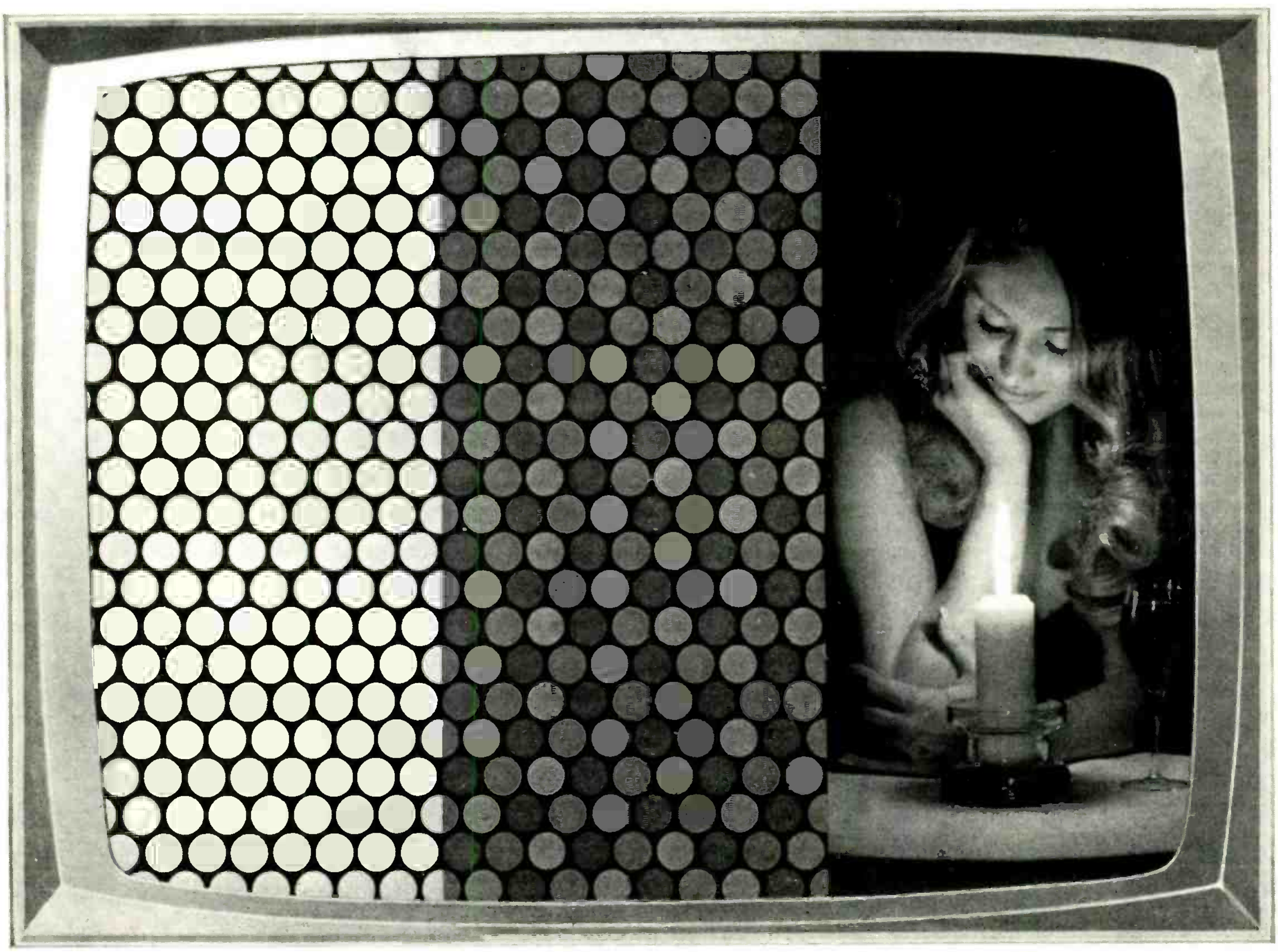

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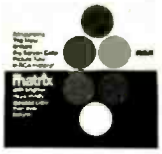

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reading. From this point on, the recorder's gain controls must not be disturbed; all recording gain adjustment is made with two controls on the Model 101. The recorder's level meters are used in the normal manner for recording.

We measured the frequency response of the Model 101 in recording and playback modes, at levels of 0 dB, –20 dB, and –40 dB. The recording and playback frequency-response curves showed the expected boost (or cut) above 600 Hz. More important is the matching of the two characteristics at all levels, which we checked by feeding the output of channel A ("Rec") through channel B ("Play"). The resulting over-all frequency response was flat, within ±0.5 dB, from 20 Hz to 15 kHz at any level from 0 dB to –40 dB. A built-in notch filter removes any 19-kHz or 38-kHz components which might exist in the output of a stereo-FM tuner, and which could interfere with proper operation. The 19-kHz response was down more than 40 dB from the 15-kHz level.

The harmonic distortion, through both sections of the unit, was less than 0.02% at 0-dB level. The IM distortion at 0 dB was 0.40%, decreasing to 0.15% at –5 dB and to 0.08% or less at levels of –10 dB or below. The noise in the output of the Model 101 was unmeasurably low, less than 100 microvolts (75 dB below the 0-dB output level of 0.55 volt). An input of as little as 25 millivolts was sufficient to produce a 0-dB recording level, and any larger signal could be reduced with no danger of overload, since the level controls were ahead of all active circuits.

We used the unit with a good-quality cassette deck and a very high quality open-reel recorder. In both cases, an impressive reduction in hiss level was realized. With the cassette machine, the signal-to-noise ratio when playing back recorded stereo-FM broadcasts was essentially that of the received signal when using the Dolby system. The open-reel machine, operating at 3¾ in/s, had less internal noise than the stereo-FM signal, so that no benefit was realized from the Dolby in this case. However, when taping mono-FM or stereo records, the Model 101 provided a dramatic reduction of hiss, with either machine.

The unit is constructed in flat, book-like format, measuring 12¾" × 7" and is 2½" high, including knobs and feet. Operating and calibration instructions are screened on the front edge of the unit, but after a brief period of use, there is no need to refer to them.

No matter how modest or how elaborate a home tape-recording installation may be, the Advocate Model 101 would be a most worthwhile addition to it. The price is $125. ▲

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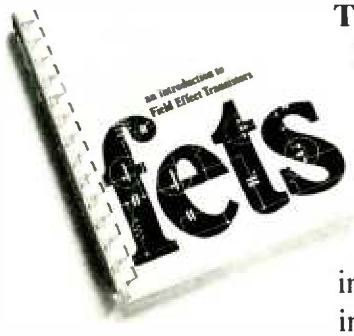

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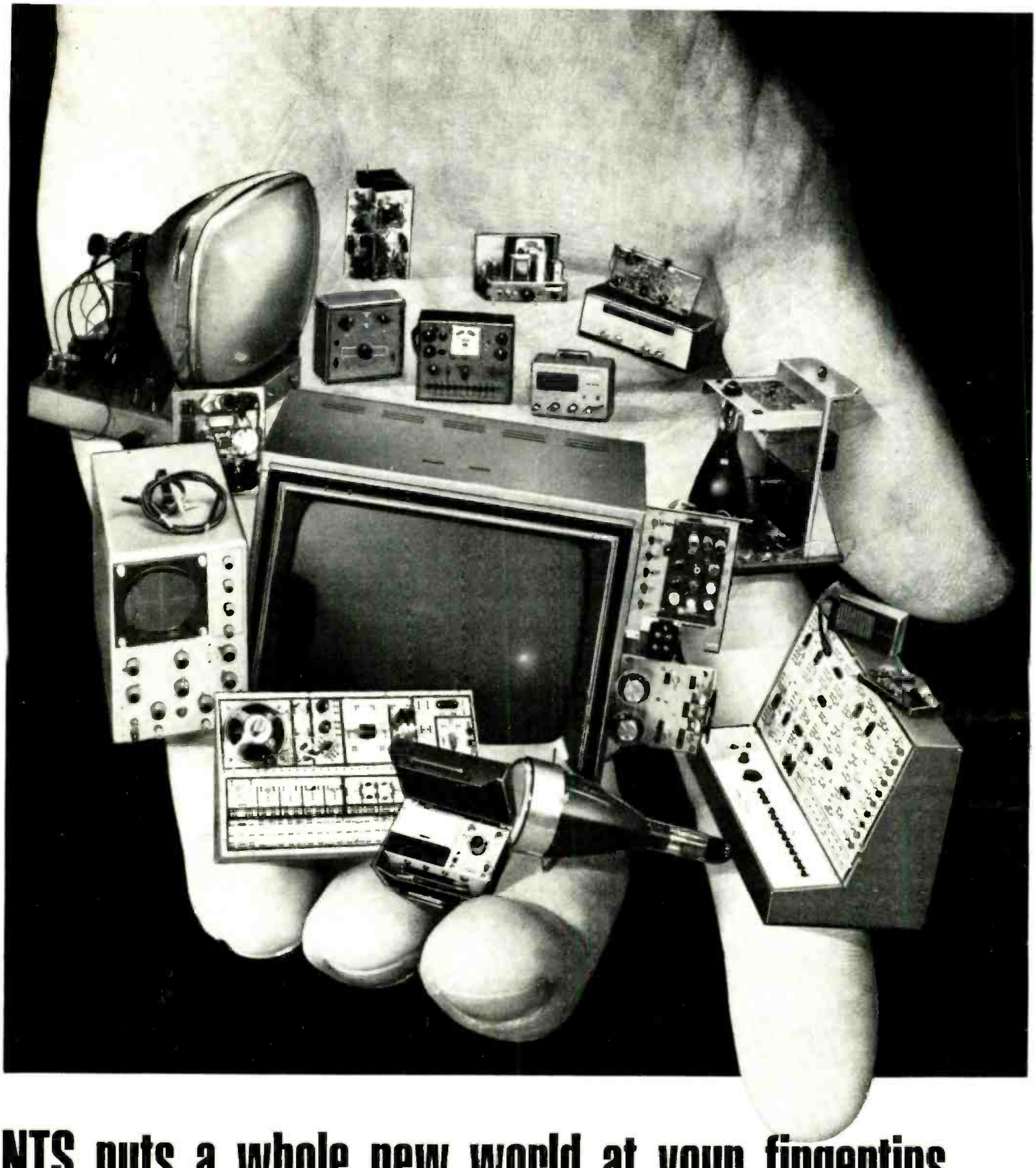

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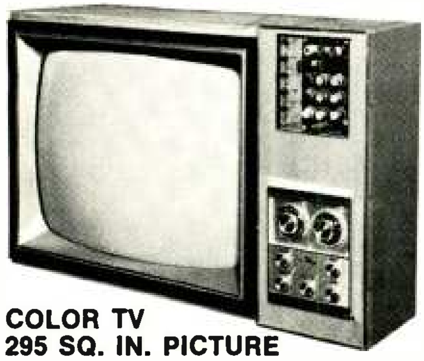

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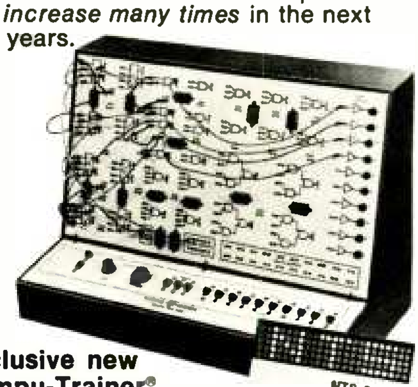

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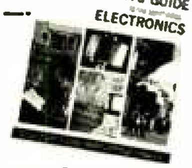

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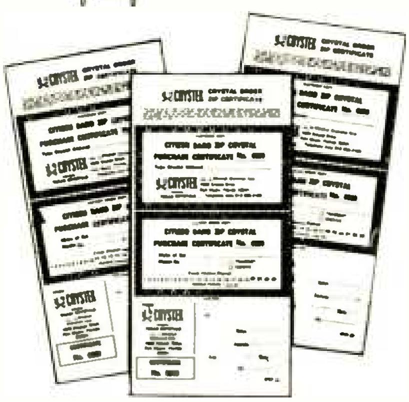

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LETTERS

MORE ON 4-CHANNEL SOUND

To the Editors:

Your December editorial, "More on 4-Channel Sound," discusses some of the possible ways of matrixing to use two channels for increased dimensional benefits. Apparently because of lack of space many of the important details of my proposals were not included and I would like to add to what has been said.

First, I have suggested that front and back sound can be added to two conventional stereo channels and reproduced with a simple connection system of two extra speakers. Second, I have pointed out that in *existing* stereo material there is frequently extra dimensional material which can be brought out with these extra speakers. Your October issue contained a very simple presentation of this second idea.

Both of these ideas utilize an optional sum speaker in front and a difference speaker in the rear. The sum speaker provides the well-known "center-channel." As pointed out in your editorial, this reduces the spread between the left and right speakers. I have suggested that they then be placed farther apart in order to restore the spread and to get the benefit of three sound sources over a wide area rather than two sound sources over a narrow area. Information which is in both channels in the same phase will add in the center speaker.

The same information will cancel in the rear speaker which is connected to produce the *difference* of the two channels. I think that at this stage of recording art we can forget about the conditions of improper phase relationships between the two channels, as mentioned in your editorial. Should one channel be incorrectly phased with respect to the other, as happened sometimes in the early days of stereo, then the front and back relationships would be incorrect in *any* matrix system. The Scheiber proposal, being a similar form of matrixing, also requires a control of the phase relationships; and source locations would be inverted if the phase of one channel were to be switched.

Your editorial mentions that if we had out-of-phase information in the two channels, the soloist would be heard in the rear speaker *and* in the two side speakers. This is quite correct and is exactly what we want to achieve if we want sound in the rear. For such cases in which it is *desired* to have a rear source, this source should be recorded in opposing phase in the two channels. Then it will add in the *difference* speaker in the rear, and it will be canceled from the *sum* speaker in the front. The sound will also appear in each side speaker (at a lower level than in the rear); but because of mis-phasing, it will have an uncertain location relative to those speakers. Therefore, the rear sound will create a firm localization. You feel that this rear sound would be unnatural, but it is not if it is recorded that way intentionally.

Again, I mention that accidental misphasing which might produce this effect is something which does not occur now. However, much existing material does have reverberant sound with random phase relationships. These kinds of sound will be beneficial when reproduced in a rear loudspeaker.

There are several practical ways to combine four channels into two by linear combination. I am sure that Mr. Scheiber and many others have done what I have done in examining the algebra of all feasible matrix combinations. I have suggested one which gives front and rear extra speakers rather than four corner speakers for several reasons:

1. It can be played back without any extra equipment (except loudspeakers).
2. A single extra speaker can be used for economy with the front speaker eliminated.
3. Conventional material exhibits improved sound when played on the configuration even though not recorded with the intention of using this arrangement.
4. It provides proper localization for headphone use with rear sound appearing at the back of the head.
5. It provides completely normal separation for conventional 2-channel playback with no inter-channel cross-feeding resulting from the matrixing.

Other matrices are not distinctively different in concept, and the end results as 4-channel systems should be almost identical with most of them. However, they all require additional equipment plus the extra loudspeakers, and they have some serious problems of conventional 2-channel stereo compatibility.

It is evident that a variable-gain system can be used with any matrix system to achieve greater ping-pong effect. Where the extra dimension is designed to add ambience, there seems little need for gain-riding. Where localization of instruments away from the front area is desired, then gain-riding has a potential function. However, gain control is a separate function from matrixing and the merits of the various matrix systems should be judged without regard to whether gain control is included.

Regardless of which 4-channel system ultimately becomes standard—matrix, 4-track, or whatever—I feel that the use of rear sound obtained by differential connection adds a new dimension to *present* stereo material. To the description in the October issue, I would like to add that the advantage of the system is at least as great on most material as the transition from mono to 2-channel stereo.

DAVID HAFLER, President
Dynaco, Inc.

* * *

FRYE IN HOT OIL

To the Editors:

I've enjoyed reading ELECTRONICS WORLD for many years. I particularly like the column by John Frye, and it's usually one of the first things I read; he has a down-to-earth way of putting problems in perspective. Maybe it was partly due to my general respect for his opinions that made me see red over the slap he took at major oil companies (November issue), or maybe it was because the major oil companies have become the general whipping boy for anyone who wants to complain about anything these days.

I've worked for a major oil company as a petroleum geologist for about 18 years, and I've seen the company take all kinds of uncalled-for abuse from self-styled do-gooders, and just downright thieves who wanted to take advantage of the fact that the big company wouldn't take an individual to court for fear of looking like a bully.

The fact is that it isn't the major companies that are in favor of restrictions on the importation of foreign oil, but the small domestic independent who wants to maintain a market for domestic production. Incidentally, we've lost all chance of ever getting cheap foreign oil—tanker rates have become so high that it's no longer cheaper to produce and ship oil to the U.S. As for the price of a gallon of gasoline; compare the increase in the cost of gasoline during the past twenty years to the increase in the cost of almost any other commodity; I think you'll find there are very few things that have increased less. Most of the increase has probably been due to taxes.

F. H. DOREMUS
Verona, Pa.

John Frye's column, believe it or not, was not about oil companies but about RCA's "ServiceAmerica." The single sentence in the column objected to was "Look how American oil interests demand and get protection from the importation of foreign-produced oil, even though that means we pay more at the gas pumps." Above was one of the milder letters we received on this remark. Evidently, oil men are touchy these days in view of the recently announced major government investigation into the increase in crude oil and gasoline prices by a number of oil companies.—Editors

* * *

C.E.T. TEST

To the Editors:

This is in reference to question 9, C.E.T. Test, Section 10, in the November, 1970 issue.

I answered (b) and according to the answers on page 80 of the December issue, I missed it. I do agree that the highest forward resistance will be between emitter and collector. However, in all my experience I have noticed that the forward resistance of the base-collector junction is *slightly lower* than the forward resistance of the base-emitter junction.

I have just checked twenty different types of transistors with my v.o.m. One transistor had equal resistances to emitter and collector from the base and the other 19 all showed lower base-collector resistance than base-emitter resistance. Both forward resistances naturally read low on my v.o.m., however, I believe that the base-collector resistance is the lower.

DON GAUGER
Tulsa, Okla.

Evidently the transistors that were checked by the authors of the test differ from those checked by Reader Gauger. We can't argue with 19 out of 20 transistors, so we will consider either answers (b) or (c) as correct for question 9.—Editors

* * *

KLH 27 HEADPHONE JACK

To the Editors:

In your December "EW Lab Tests New Stereo Receivers," you state that the *KLH* 27 was the only receiver lacking a front-panel stereo-headphone jack. Not so; there is a jack on mine at the bottom of the front panel between the two tuning dials.

RICHARD MAXON
Glen Cove, N.Y.

Reader Maxon is right. We apologize for this oversight.—Editors ▲

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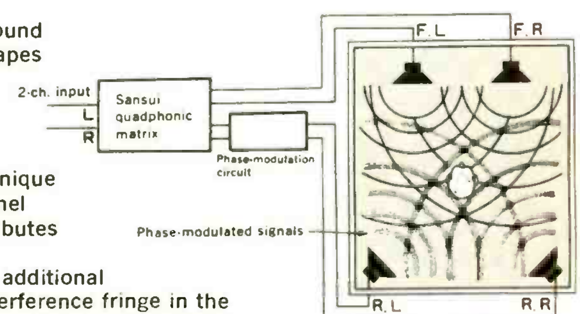
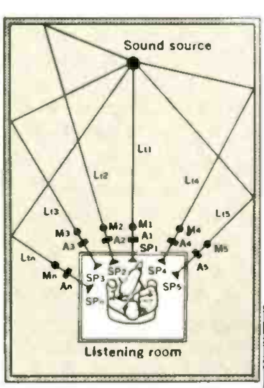


The heart of the Sansui Quadphonic Synthesizer* is a combination of a unique reproducing matrix and a phase modulator. The matrix analyzes the 2-channel information to obtain separate direct and indirect components, then redistributes these signals into a sound field consisting of four distinct sources.

This type of phase modulation of the indirect components, applied to the additional speakers, adds another important element. It sets up a complex phase interference fringe in the listening room that duplicates the multiple indirect-wave effects of the original field. The result is parallel to what would be obtaind by using an infinite number of microphones in the studio (MI through Mn in the accompanying illustration) and reproducing them through a corresponding number of channels and speakers.



The startling, multidimensional effect goes beyond the four discrete sources used in conventional 4-channel stereo, actually enhancing the sense of spatial distribution and dramatically expanding the dynamic range. Also, the effect is evident anywhere in the listening room, not just in a limited area at the center. And that is exactly the effect obtained with live music! This phenomenon is one of the true tests of the Quadphonic system.

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EW Lab Tests
New DOLBY-IZED CASSETTE DECKS

By JULIAN D. HIRSCH/Hirsch-Houck Laboratories

Results of our measurements on three of the newest models show that, whichever one you choose, the addition of Dolby circuits has made the cassette a true high-fidelity medium.

IN June, 1969, ELECTRONICS WORLD presented a report on several cassette tape decks and recorders. Our initial experience with the better-quality cassette machines convinced us of the potential of this recording medium. Having encountered reel-to-reel machines capable of high quality at 3¾ in/s, it was startling to find comparable frequency response in some of the new cassette recorders operating at half that speed.

Then, as now, the most objectionable characteristic (to a critical hi-fi ear) of cassette sound was the hiss level. This is principally due to two factors: (1) less treble roll-off in the playback equalization (as compared to reel-to-reel machines) which is necessary to extend the frequency response to 10 kHz or higher at 1⅞ in/s, and (2) the extremely narrow track width of 24 mils (0.024″) resulting from fitting four tracks on a 150-mil (0.150″) wide tape. The playback amplifier input noise is essentially the same as that of other tape machines, but the output of the heads from the narrow cassette tracks is considerably lower. For these reasons, the signal-to-noise ratio of a cassette machine is inherently poorer than that of a reel-to-reel machine.

Since that time, head designs have been improved and there are special tape formulations such as *TDK* SD and *DuPont* Crolyn, which allow more energy to be stored in the tape and have a fine-grain structure which reduces "drop-outs," another characteristic deficiency of the cassette medium. Recent tests we have made on a number of cassette decks show a dramatic improvement in their average performance level, with several of them subjectively meeting true high-fidelity standards under optimum conditions.

The noise problem remains, however. It can be minimized by maintaining a high average recording level, but this involves a compromise with distortion on high-level passages, which many critical listeners find objectionable. A logical solution is the application of the Dolby noise-reducing technique to the cassette deck, and this has now been done.

The Dolby system has been used for several years in professional recording studios and is responsible for the lower noise level on many recent stereo discs. (*See "The Dolby Noise-Reduction System—Its Impact on Recording" by John Eargle in our May, 1969 issue.—Editor*) A comparison between a five-year old record and a recent release provides proof of this fact.

Essentially, the technique employs identical signal-processing circuits, operated in a mirror-image relationship, in the recording and playback channels. Loud-signal passages are not affected by the system, either in recording or in playback. As the level is reduced, the system begins to increase the recording gain, in an inverse relationship to signal level. During playback, the gain is reduced by an equal amount so that the program balance and frequency response are un-

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Mfgr. & Model	Playback Response	Rec/Play Response (Dolby Off)	Rec/Play Response (Dolby on)	S/N (Dolby off) (dB)	S/N (Dolby on) (dB)	Wow (%)	Flutter (%)	Price ($)
Advent 200	40-10,000 Hz ±1.5 dB	50-12,000 Hz ±1 dB	50-12,000 Hz ±2 dB	48	51	0.01	0.19	260
Fisher RC-80	40-10,000 Hz ±2.5 dB	50-12,000 Hz ±1 dB	50-12,000 Hz ±1.5 dB	46	50	0.02	0.22	200*
Harman-Kardon CAD-5	40-10,000 Hz ±1.5 dB	45-14,000 Hz ±3 dB	45-14,000 Hz ±3.5 dB	47	52	0.01	0.20	230

*Includes microphone. **Note:** High-frequency response varies somewhat with different tapes.

Table summarizing the results of our laboratory tests on the three cassette tape decks listed.

affected. However, any noise introduced in the recording and playback process is reduced by the amount of playback gain reduction.

In the "A-Type" Dolby used professionally, the spectrum is divided into four bands, whose gains are individually controlled, depending on the signal level existing within each band. In this way, hum, rumble, and other low-frequency disturbances are reduced together with the usually more audible high-frequency hiss. The "A-Type" system is relatively bulky and expensive, and is obviously unsuited for home use.

Over a year ago, *Dolby Laboratories* licensed consumer-product manufacturers to use a simplified version, known as the "B-Type." Previously, *KLH* had been licensed exclusively and the "B-Type" was used in its reel-to-reel tape recorders. Now, however, a number of other manufacturers are authorized to use it. The "B-Type" system operates in a single frequency range, from about 600 Hz upwards. It reduces noise by about 3 dB at 600 Hz, increasing to 6 dB at 1200 Hz, and to 10 dB at 4000 Hz and above. The "A-Type" system provides a 10-dB reduction of noise across the full frequency range. Subjectively, as far as hiss is concerned, there is little difference between the two systems. As compared to any other previously available noise-reduction system, the Dolby is notable because it does not affect frequency response or distortion and cannot be heard in operation. It simply reduces unwanted noise, in a most impressive fashion.

The "B-Type" circuits are relatively simple and can be economically incorporated in home tape recorders and cassette machines. In recent months, three cassette decks with built-in Dolby circuits have been announced—the *Advent* Model 200, the *Harman-Kardon* CAD-5, and the *Fisher* RC-80. A fourth, from *Vivitar*, was not available in time for testing.

Critical comparisons among these three cassette decks are especially interesting since their transport mechanisms, heads, and portions of their electronics come from a single Japanese manufacturer. Nevertheless, each manufacturer has expressed his own philosophy in the total design of his product. As a result, there is little or no external resemblance among the three units, and a considerable spread in selling price. With the three recorders having so much in common, it is reasonable to ask if the differences are significant, more than skin deep, and worth the price differential. Our tests have given us a definite "yes" answer to the first two questions but, of course, the last one is for each prospective buyer to decide, based on his own needs.

We will present a brief description of each machine and performance data from our own measurements. It must be understood that we tested a single sample of each model, in each case a very early production or pre-production unit. It is quite possible that future production variations could substantially obscure some of the minor differences that we measured. However, we feel that these cassette decks are truly representative of the current stage of development in this medium.

The machines will be discussed in descending order of price. Since many of their characteristics are quite similar, they will be covered in detail in the section on the *Advent* Model 200, and only the differences will be stressed in the reports on the other two units. All the machines are decks whose outputs must be played back through separate stereo amplifiers and speakers.

ADVENT MODEL 200

The *Advent* Model 200 has the greatest flexibility of

these decks, as well as being the most expensive at $260. The cassette transport controls, operated by flat "piano-key" levers, are conventional. They include Stop/Eject, Play/Record, Record interlock, Fast Forward, Rewind, and Pause functions. The cassette is fully visible through the tinted plastic cover, so that the amount of operating time remaining can be readily estimated. There is a push-button reset, three-digit index counter. When the end of the cassette is reached, the motor stops. An automatic shut-off circuit then removes power from the motor and a light on the deck flashes to alert the user.

The Model 200 has four more levers, beside the transport controls. They include the a.c. power switch and a Mono/Stereo switch which parallels the two inputs for making mono recordings. A third lever controls the Dolby circuits, with a light signifying that they are activated. In most cases, these will be left on when making a recording or playing a "Dolby-ized" cassette, but should be switched off when playing a cassette recorded without the Dolby process, or

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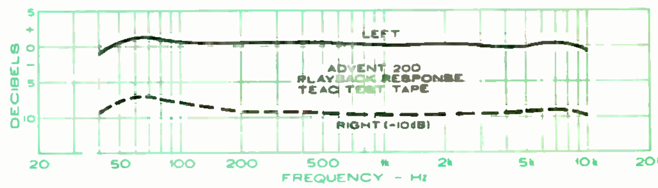
when making one which will be played on a conventional cassette deck.

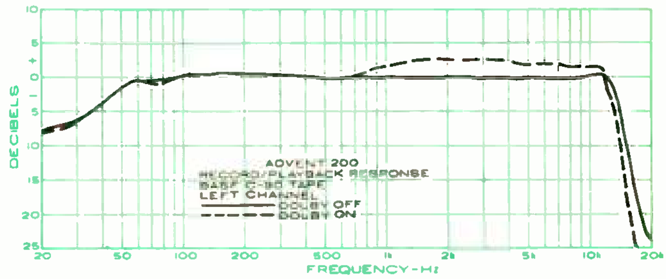
The fourth lever is marked Tape-Regular/Special, and gives the machine its special versatility. In the Regular position, the recorder's bias and equalization are optimized for standard cassette tapes such as the *3M* #271 or *BASF*. In the Special position, the recording bias and both the recording and playback equalization are changed for best results with *Du Pont* Crolyn chromium dioxide (CrO_2) tape. This tape offers advantages in signal-to-noise ratio, high-frequency response, and reduced drop-outs, and is available from *Advent* under the "Advocate" brand name. By the time this appears in print, it will be available from other manufacturers as well. The choice of bias and equalization characteristics provides an excellent compromise for *TDK* SD tape, which should be recorded with the Special setting of the Tape switch and played back with the Regular setting. This ability to get the most from any presently available tape is one of the unique features of this recorder.

Another unusual and valuable feature of the machine is the single "vu" meter. It is larger than that of any other cassette deck, well illuminated, and very accurately calibrated. Most such meters are little more than crude indicators of level; this meter gives an accurate reading of relative signal level. The meter amplifier is equalized to emphasize the higher frequencies, reducing the chance of inadvertently recording at excessive levels.

The meter can be switched to read either channel, A or B. Separate channel level controls are used for initial balance. Then, the meter is switched to read "Higher of A or B," which simultaneously monitors both channels and displays the level of the stronger one. A single master gain control sets the final recording level, without affecting channel balance.

The Dolby circuits require very precise control of recording and playback levels, not only to operate properly in a given machine, but to insure compatibility with tapes made on another machine. *Advent* supplies complete alignment facilities with its recorder, and sent us a standard-level Dolby cassette. While playing this cassette, two playback calibration screwdriver adjustments in the rear of the unit are set for 0-dB meter readings on each channel. With a blank cassette of the tape to be used in the machine, a push-button switch in the rear of the deck supplies a standard recording level signal, which is set for a 0-dB meter reading





with another pair of adjustments. The machine is set up correctly as delivered, so that a check every few months is all that is needed to keep it in tip-top shape. It is also desirable to check the adjustments if a tape of very different characteristics, such as a C-120 cassette, is used.

To demonstrate the capabilities of the unit, the purchaser of the recorder receives a cassette with several musical selections, dubbed in real time on Crolyn tape. This serves to illustrate the proper recording levels for different kinds of music, as well as to show the caliber of performance which the deck can deliver.

The measured playback frequency response, with a *Teac* standard test tape, was within ±1.5 dB from 40 Hz to 10 kHz. Over-all record/playback frequency response varied slightly with different tape formulations, but typically (with *BASF* or *TDK* SD) was +1.0 dB from 50 Hz to 12 kHz. With the Dolby circuits operating, there was a slight increase in output above 700 Hz (at a –20 dB recording level), but the over-all response was still within ±2 dB from 50 Hz to 12 kHz.

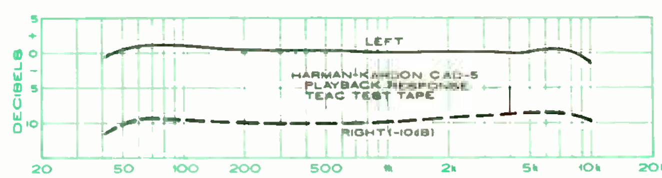
The unweighted signal-to-noise ratio was 48 dB with the Dolby off and 51 dB with it on (referred to 0-dB recording level). The unweighted wow and flutter, with the *Philips* TC-3 test cassette, were 0.01% and 0.19%, respectively.

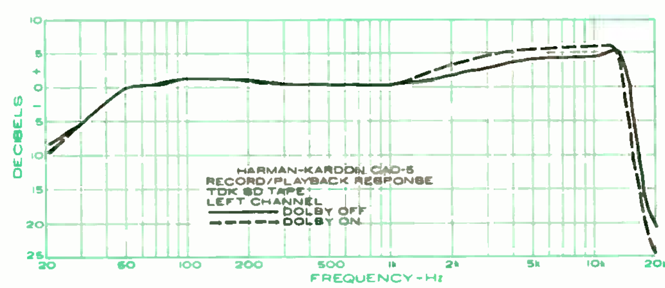
The subjective performance of the Model 200 will be discussed, together with the other units that were tested, later in the article.

HARMAN-KARDON CAD-5

In our June, 1969 cassette report, we commented on the outstanding performance of the *Harman-Kardon* CAD-4. Today, it still ranks among the best conventional cassette decks, although several others now offer comparable quality. The new CAD-5, which physically resembles the CAD-4, is actually a totally different machine, quite similar to the *Advent* unit in its design and performance. The *Harman-Kardon* CAD-5 sells for $230.

The CAD-5 transport controls are similar to those of the *Advent* 200. To make room for the added Dolby switch, the knob-operated level controls of the CAD-4 have been replaced by a pair of slider-type controls. The two meters are mounted behind a single window, with vertically oriented scales.





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Below the transport control levers are four signal lights. One is a Power On indicator. An Auto light is on when the motor is running and goes out at the end of play when the automatic shut-off removes power from the stopped motor. The Dolby light indicates that these circuits are activated. Finally, the CAD-5 has an Overload light, which flashes if proper recording levels are exceeded, even momentarily. If the overload signal is present in both channels the light flashes at +2 dB, a single channel overload of 8.5 dB is needed to operate the light.

The CAD-5 has a full complement of Dolby level calibrating adjustments in the rear, plus a switch-operated standard-level oscillator to set recording levels. It includes a two-position slide switch which changes bias and equalization for standard or CrO_2 tapes.

The playback frequency response of the CAD-5 is ±1.5 dB from 40 Hz to 10 kHz. The record/playback response was flattest with *3M* #271 tape, measuring ±2 dB from 45 Hz to 14 kHz. Using *TDK* SD tape, the highs were somewhat emphasized, with an over-all response within ±3 dB from 45 Hz to 14 kHz. The Dolby circuits produced a broad high-frequency emphasis with *3M* #271 tape, but had less effect on the response with *TDK* SD tape, which inherently produced a slight increase of high-frequency response.

The unweighted signal-to-noise ratio was 47 dB without the Dolby and 52 dB with it. The unweighted wow and flutter were 0.01% and 0.20%, respectively. The subjective performance of the *Harman-Kardon* CAD-5 cassette deck will be covered later.

FISHER MODEL RC-80

Fisher's RC-80 cassette deck is the smallest and least expensive ($200) of the Dolby-ized decks which we tested. Although it is small and light enough to be held comfortably in one hand, it presents an exceptionally business-like and professional appearance.

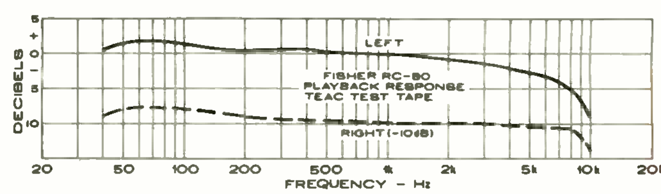
Although the transport mechanism is similar to the other two machines, the *Fisher* has "piano keys" molded flat to fit the fingertips, like typewriter keys. Combined with their very legible markings, this gives it an unusually good operating "feel." Two push-button switches control power and Dolby operation. There are signal lights for power on and recording indications, but no light for the Dolby system. *Fisher* has made a single light do double duty as illumination for the index counter and as a motor shut-off indicator. When the motor stops at the end of play, the automatic circuits remove its power and shut off the index light.

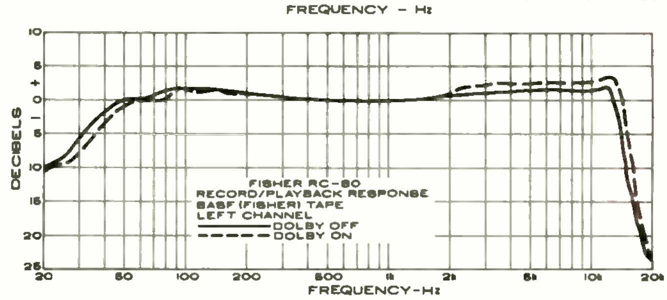
Unlike the other two decks, the RC-80 has no user-operated calibration adjustments. Playback and recording gains are set at the factory for the preferred tape (*BASF*, which is also packaged in *Fisher* cassettes). There is no special provision for CrO_2 tape.

We measured the RC-80 playback response as ±2.5 dB from 40 Hz to 10 kHz on one channel. The other channel was down 9 dB at 10 kHz. In both cases, the loss in output was principally above 8 kHz. Since our test sample was one of the first pre-production units, we surmise that this was due to a misadjustment and may not be typical of regular production units.

The record/playback frequency response was within ±1 dB from 50 Hz to 12 kHz on one channel. The other was similar but reached a peak of +5 dB at 13 kHz (referred to 1 kHz) and had considerable response up to nearly 15 kHz. Similar results were obtained with *3M* #271 and *TDK* SD tape. The Dolby circuit had the same affect on high-end response that we noted with the other decks.

The unweighted signal-to-noise ratio was 46 dB without the Dolby and 50 dB with it. Unweighted wow and flutter were 0.02% and 0.22%, respectively.





HOW DO THEY PERFORM?

To anyone whose experience with cassette machines has been limited to low-priced or portable models, the performance of these three decks will be nothing less than amazing. Only the best reel-to-reel recorders can compare to them at 3¾ in/s (and even these might not sound as quiet), and many 7½ in/s machines cannot match the fidelity of the Dolby-ized cassette decks.

All three machines can record stereo-FM broadcasts (whose signal-to-noise ratio and frequency range are generally limited by the transmission medium) with virtually no alteration of frequency response or increase in noise level. We dubbed portions of the STEREO REVIEW Demonstration Record, using the best available phono-reproducing equipment, on cassettes with the three decks and played them back for a true A-B comparison with the original program. In this test, some slight differences could be detected between the original and reproduced sound, and among the three machines.

The *Advent* Model 200 was the most accurate recorder of the group, due principally to its exceptional flatness, which is matched by only a few very good reel-to-reel machines. The reproduction was distinguishable from the original record only by a minute trace of hiss at high listening levels,

(Continued on page 77)

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Triggering Logic Circuits

By JAMES E. McALISTER

Simple circuits that can be used to keep logic circuits from being erroneously triggered by contact bounce usually associated with relays, push-buttons, and toggle switches.

THERE are many instances in which push-button or toggle switches are used to trigger logic circuits. In such cases, contact bounce within the switches themselves may lead to erratic and perhaps erroneous circuit operation.

Contact bounce is a characteristic of switches in which the switch's contacts actually slam together (as opposed to sliding) in order to complete a circuit. Instead of staying closed, however, the contacts may actually "bounce" apart and close again. This process may repeat several times (like a bouncing ball) before the contacts actually come to rest.

When a switch is used to drive electronic circuits, a signal will be generated from the switch each time the contacts close. Therefore, if contact bounce is present, several signals may easily be generated for each physical closure of the switch. These spurious signals can lead to erroneous outputs from counters or other logic circuitry.

The effects of contact bounce can be eliminated with very few components. The classical approach is to use a simple "latching" circuit (see Fig. 1A).

With the switch in the "off" position, a "0" (ground) is continuously being applied to gate A, maintaining output 1 at "1" and output 2 at "0". Note that even if the "0" is removed from gate A's input (but not applied to gate B), output 1 will remain high because of the "0" fed back to gate A's other input by output 2. With the conditions as indicated, output 2 remains at "0" because two "1's" are being applied to gate B. Since the "0" from the switch can be removed and then re-applied to gate A without the outputs changing, the circuit is said to be "latched."

When the switch is moved to the "on" position, a "0" is immediately placed at gate B's input, forcing output 2 to "1" and output 1 to "0." The gates once again latch. If the switch contacts bounce (essentially removing the "0" from gate B), the gate outputs will not change because of the latching action ("0" from output 1 holds output 2 at "1"). The contacts may actually bounce open and back closed any number of times, but the latch will allow only one output signal to be generated (in this case a "1" at output 2). When the switch is turned "off" again the circuit will return to its initial operation (output 1 at "1" and output 2 at "0").

Anytime the circuit in Fig. 1A is used, the output signals generated for each switch position will remain until the switch position is changed. Nevertheless, there are times when it may be desirable to generate a single output pulse rather than the constant level. The circuit shown in Fig. 1B will produce such a pulse.

Gates A and B form the latch to defeat the effects of contact bounce, and gates C and D form a one-shot multivibrator. Whenever the switch is depressed, gate A applies a signal to the one-shot, causing a single negative-going output pulse. If the latch were not included, the one-shot might produce a pulse for each bounce of the contacts, even though the switch is depressed only once.

(Continued on page 63)

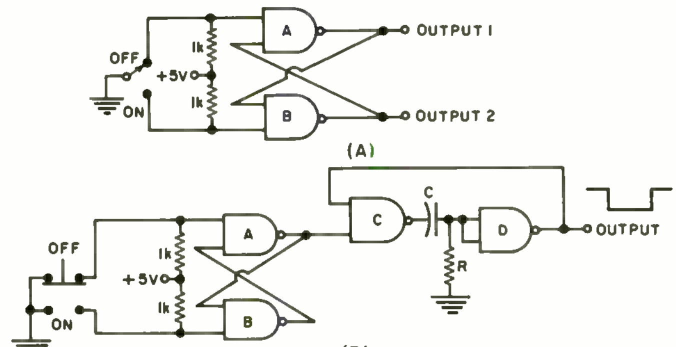
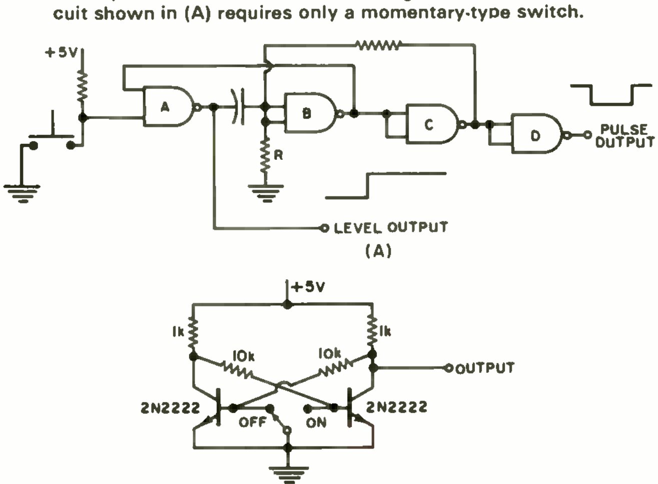


Fig. 1. Diagrams of two simple circuits (A) a bistable latching circuit and (B) a single-pulse output circuit used to eliminate effects of contact bounce (spurious signals) when triggering logic circuits with push-buttons or toggle switches.

Fig. 2. Two additional circuits used to eliminate contact bounce. (A) A single-pulse output circuit that also provides a level output and (B) a transistorized latching circuit equivalent to the one shown in Fig. 1A. Note that circuit shown in (A) requires only a momentary-type switch.



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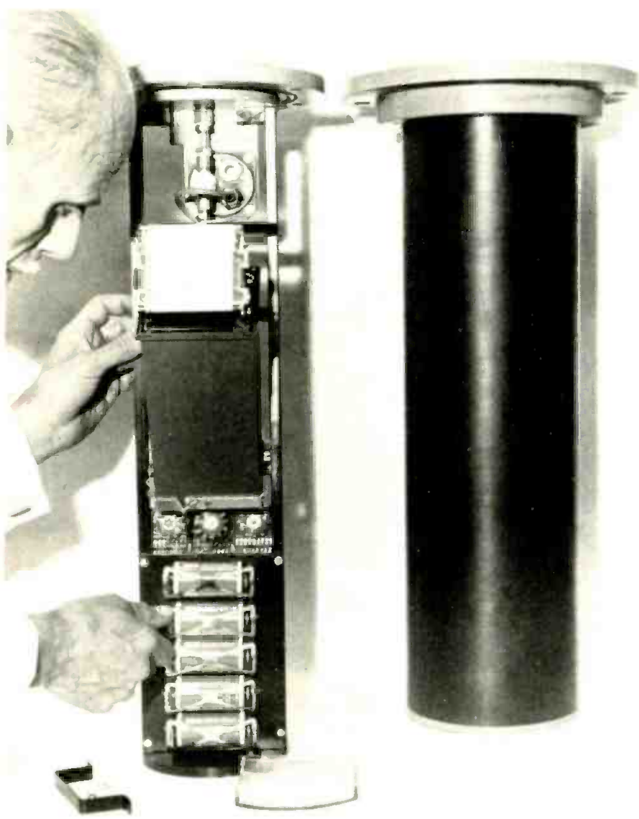

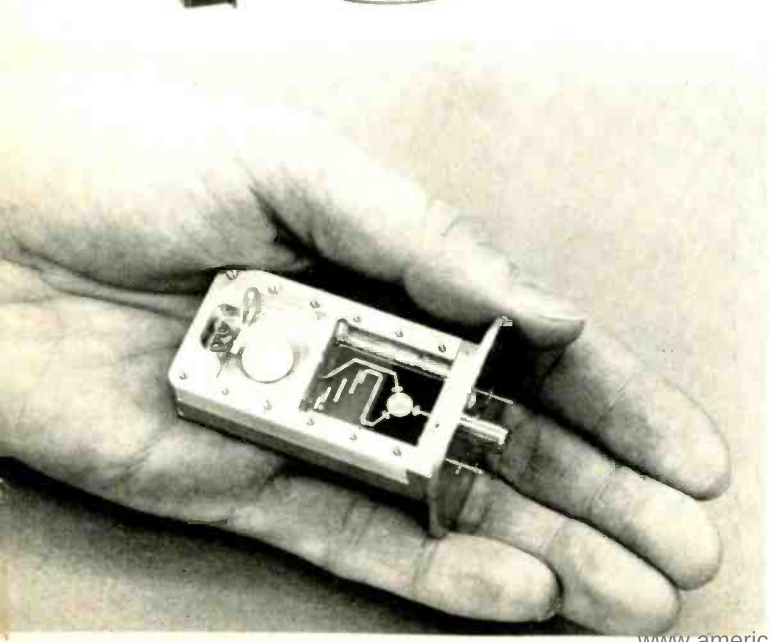

Recent Developments in Electronics

Airborne Computer System for SAC. (Top left) We are looking at a part of the computer installation aboard the Strategic Air Command's "Looking Glass" aircraft. This is the computer controller's console, with the computer itself at the left, and the input keyboard and page printer before the operator. The experimental system, designed by RCA, is the first ever developed to provide computerized information management capabilities aboard aircraft in flight. New data entered into ground-based computers at Air Force SAC headquarters can now be relayed directly and automatically to the computer installed in the aircraft. Now under development is an operationally secure data link between the plane and the ground. The data link will permit extensive tests and evaluation of air-ground communications between the computers under actual operating conditions.

Electronic Tide and Wave Recorder. (Center) The first general-purpose electronic tide and wave recorder—which is battery-operated and portable—has been developed in Britain for use in hydrographic studies. Capable of operating in water at depths of down to 100 feet, it works on the principle that a change in water level produces a change in pressure. Variations in pressure are electronically processed and then transmitted to a chart recorder within the unit for print-out. Designed to meet the need for a low-cost, accurate apparatus, the recorder shown here runs on five Mallory 1.4-volt mercury or alkaline batteries. The mercury batteries operate the recorder continuously for five weeks; the alkaline batteries for two weeks.

Microwave Radar for Autos. (Below left) Microwave IC technology has made it possible to engineer a microwave Doppler radar that is inexpensive and reliable enough to use in autos, or at least that's the claim of Hewlett-Packard Co. Entering the consumer applications field for the first time, the company is introducing a radar transmitter-receiver module that will sell for less than $150 in quantities of 1000. Possible industrial uses for the module are in intrusion alarms, automatic traffic controls, railroad speed controllers, and automatic aircraft landing systems. The device is a completely solid-state module built with hybrid thin-film integrated microcircuits. The source of microwave energy within the unit is a Gunn diode that produces 50 mW of power at 10.525 GHz. This power is coupled to the output port through a circulator. Some energy from the diode is shunted through a 10-dB coupler to a hot-carrier diode mixer, to serve as the Doppler reference signal. The returning r.f. signal, shifted in frequency as a result of its reflection from a moving object, passes back through the circulator. The circulator isolates outgoing and incoming signals, even though they pass through the same port to and from the associated antenna. The received signal, coming in from the circulator, moves through a bandpass filter to remove spurious responses, and then to the mixer, where the incoming and outgoing signals subtract to generate an audio signal whose frequency is directly proportional to velocity. All that is needed to form a complete microwave Doppler radar is the module, an antenna, a display, and a low-power source.

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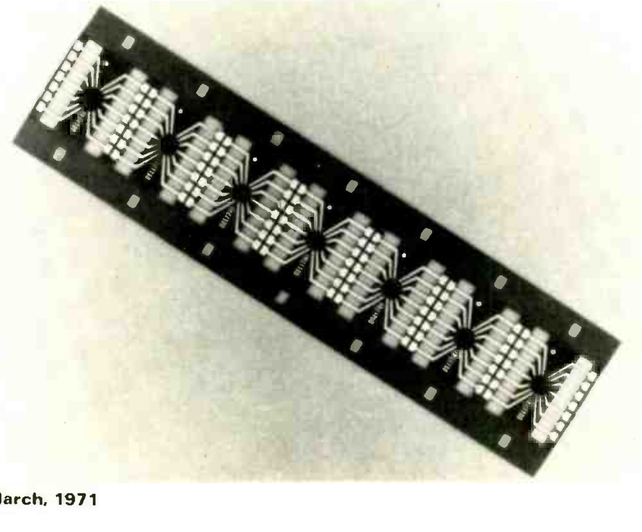
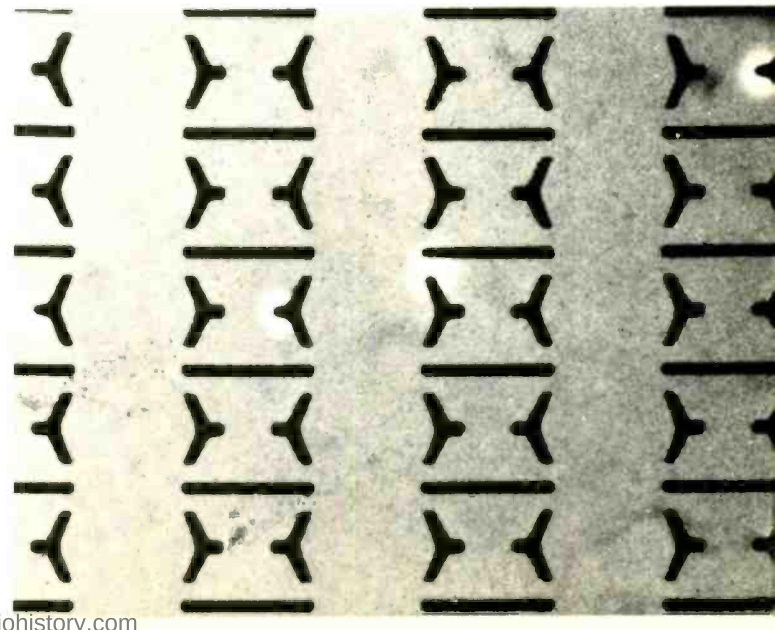
Troubleshooting Computers by Computer. (Top right) A computer service specialist at a strategically located technical center is shown using a tele-processing network and the power of a remote centralized computer to diagnose malfunctions from a distance. The specialist, working with the customer engineer at a customer location, can search data for solutions, or together, may use a data link to run maintenance programs. The output can be displayed both on the customer's and on the specialist's display terminal. The system, which is installed at IBM's Raleigh, N.C. Test Center, is accessible by phone from all over the country.

Phones for the Handicapped. (Center) The young lady in our photograph is using a telephone attachment that permits deaf or deaf-blind persons to communicate with each other. Field trials of the device started about five years ago, but regular commercial service using it have just begun in Columbus, Ohio. The Bell System calls the service "Code-Com," and charges $3 per month for the unit plus the regular charge for phone service. The attachment contains a light, a sending key, and a vibrating disc. Voice signals are converted into flashes of light and vibrations of the disc. A deaf person can watch the light flashes, while a deaf-blind person can feel the vibrations of the sensor disc. The key is used to transmit messages, using a prearranged code for simple messages or regular Morse code for longer messages.

Film-Mounted IC's. (Below left) In order to more effectively compete with inexpensive or foreign-made IC's, General Electric is using a very highly automated production and packaging technique for some of its IC's. The integrated circuits end up embedded one after another on a roll of plastic film that looks like 35-mm movie film, sprocket holes and all. The circuits, designed mainly for original-equipment manufacturers, can be cut apart with an industrial shears or even an ordinary scissors. In the new packaging method, called "miniMod," IC chips are dropped into depressions along the film. Previously printed in foil on the film is a pattern of connecting leads which mate with pads on the IC chips. The leads are bonded to the pads, and the entire chip is sealed in epoxy, forming the finished circuit package.

Magnetic Bubble Memory. (Below right) The light circles are magnified magnetic bubbles (0.0003" diameter) moving through a circuit pattern formed on a thin magnetic film of uniaxial garnet. One bubble, slightly elongated, can be seen moving from one element in the pattern to another. The technology is being used as part of an experimental shift register made at Bell Labs, where the garnet films fabricated thus far have measured about one-third inch across. Eventually this technique may permit fabricating memory devices with more than a million bubbles per square inch for use in future computer and digital-communications applications.





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Digital Instruments

Part 6—More About Electronic Counters

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

Design details that help bridge knowledge gap between the simple 3-mode counter described in Part 5 and more sophisticated counter configurations.

PART 5 of this series discussed the fundamentals of electronic-counter design and concluded with a practical three-mode, 4-MHz electronic-counter circuit. The mechanics of adding more operating modes, a discussion of measurement errors, and an evaluation of the methods for increasing the electronic counter's operating frequency should be covered before introducing a more sophisticated electronic-counter configuration.

Adding More Operating Modes

The electronic counter developed in Part 5 demonstrated that the Totalize, Frequency, and Period modes of operation can be achieved in even the most basic electronic counter; the remaining five operating modes may be readily added to the basic electronic-counter configuration. Fig. 1 illustrates basic design differences among the eight electronic-counter operating modes as outlined in Part 5. Fig. 2 details the evolution of an eight-mode electronic counter beginning with a string of decade counters and a single input channel.

Incorporating the Scale mode requires modification of the counter chain so that the output of each decade counter in the counter chain is accessible at a convenient panel connector. If a single connector is used, some means of selecting the one decade counter output that will be presented to that connector at a given time must be provided (one possible approach is shown in Fig. 3). The modification of the time base to accommodate the Multiple Period mode allows some of the time-base decade dividers to serve either as time-base dividers or as multiple-period scalers. The second input channel added for the Ratio mode is usually an exact replica of the existing original input channel, and the same second channel is used in both the Ratio and Time Interval modes. Fig. 4 shows how the various functional elements of a complete electronic counter might be interconnected *via* a mode-selector switch to provide an eight-mode electronic counter.

Measurement Errors

Time-base frequencies are usually derived from high-frequency crystal oscillators (100 kHz and up). Some electronic counters contain an internal oscillator of only moderate accuracy and stability, but include provisions for an external reference signal (at the internal-oscillator frequency) so that a high-performance "house standard" can be substituted for the electronic counter's internal oscillator. A typical commercial crystal oscillator with an accuracy of ±0.02% (*International Crystal* OX oscillator and type EX crystal) costs about $6.90; a unit with ±0.0005% over-all accuracy (*International Crystal* type OE-10 oscillator element) from -10°C to +60°C costs around $19.00. Oscillators in the 1×10^{-8} stability class carry price tags in the $400 range and, for the most exacting applications, a cesium-beam frequency standard can be purchased for something in the order of $16,000.

Since the accuracy of the electronic counter described in the January, 1971 issue is limited to the ±0.1% accuracy of the 60-Hz line frequency, the accuracy *implied* by the resolution of the 6-digit display exceeds the *real* ±0.1% measurement accuracy. For example, a 4.000000-MHz input

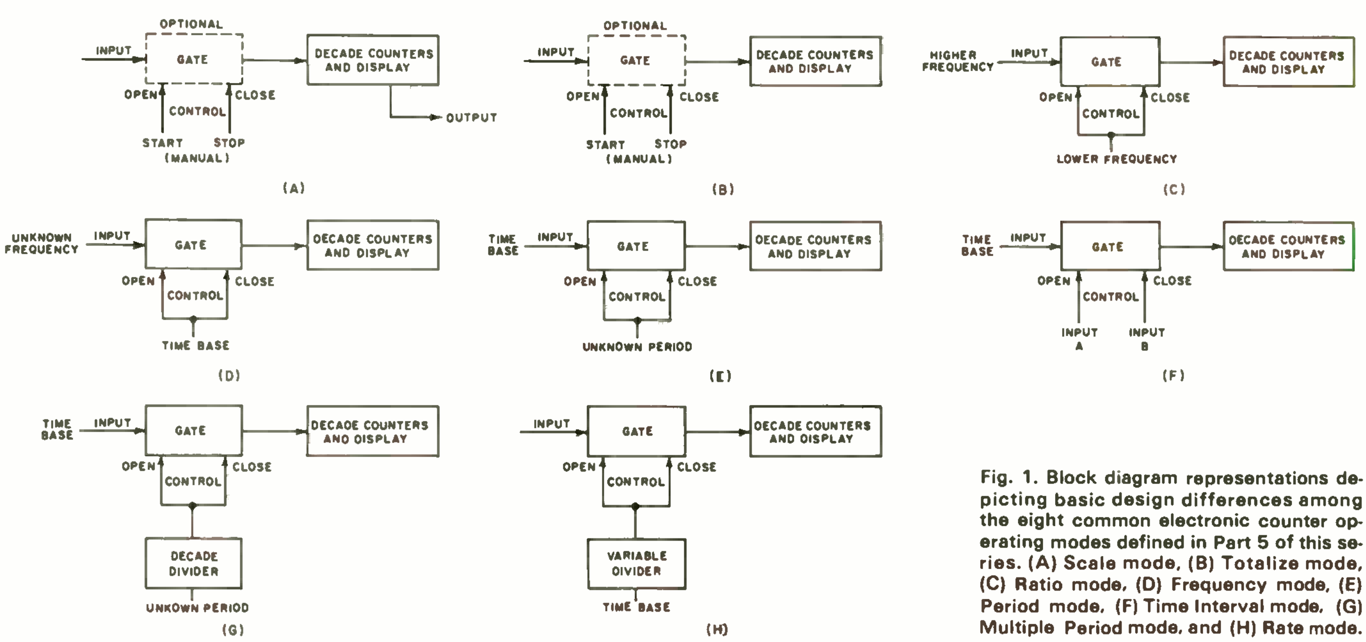

Fig. 1. Block diagram representations depicting basic design differences among the eight common electronic counter operating modes defined in Part 5 of this series. (A) Scale mode, (B) Totalize mode, (C) Ratio mode, (D) Frequency mode, (E) Period mode, (F) Time Interval mode, (G) Multiple Period mode, and (H) Rate mode.

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signal frequency counted over a 0.1-second sampling period would be displayed as 4.00000 MHz if the time base were accurate to ±0.0001% or better. If, however, the time-base accuracy is ±0.1%, the displayed count could range from 3.99600 MHz to 4.00400 MHz. The inconsistency between real and implied accuracy is a characteristic of many multi-function digital instruments—a fact that users of digital instruments must keep in mind.

The various sources of error applicable to each of the eight operating modes are identified in Table 1. The ±1 count ambiguity in the Scale and Totalize modes applies only if the optional gating is used and the effects of the ±1 count ambiguity and trigger error in the Multiple Period mode are reduced in direct proportion to the increase in the number of periods sampled. The effect of the ±1 count ambiguity on the accuracy of measurements made in the Period, Time Interval, and Multiple Period modes can be reduced significantly by gating the standard-frequency input into the time-base dividers, rather than gating the time-base divider output into the decade counters. The maximum timing error then reduces to the period of the standard frequency rather than the period of the chosen time-base divider output. However, this method does not offer any improvement over the much simpler technique of just selecting a time-base period one order of magnitude shorter than the desired data resolution.

Frequency and period are related ($f=1/T$) and one can be calculated once the other is measured. Accurate high-frequency period measurements and accurate low-frequency frequency measurements are difficult to obtain directly, so the period of a high-frequency signal is usually calculated from a frequency measurement, while the frequency of a low-frequency signal is usually calculated from a period measurement. Resolution improves and uncertainty is reduced as the measurement interval is lengthened. Nevertheless, it must be remembered that the time-base stability (the drift rate in particular) may become a significant source of error over extended measurement intervals.

Increasing Operating Frequency

There are three ways to increase the maximum counting rate (or upper operating frequency) of an electronic counter: (1) design at least part of the electronic counter around one of the higher-speed logic families such as MECL™, (2) prescale or divide the unknown input frequency prior to applying it to the electronic-counter input, or (3) mix the unknown input frequency with a known stable local-oscillator signal to produce a difference frequency within the operating range of the electronic counter. Each method has its own advantages and disadvantages.

Mixing is generally used to process input signals whose frequencies are beyond the range of even the highest speed logic. The system accuracy is a direct function of the accuracy and stability of the local-oscillator signal and care must be taken to assure that no spurious mixer outputs (at least none that lie within the frequency capability of the electronic counter) are presented to the electronic-counter inputs. The basic electronic-counter accuracy is preserved if a harmonic of the counter time-base oscillator frequency is used as the heterodyning signal for the frequency conversion. The unknown input frequency is the sum of the local-oscillator frequency and the frequency displayed by the electronic counter.

Prescaling, like mixing, translates the unknown frequency down to a frequency within the operating range of the electronic counter. The prescaler is simply a divider (or counter) such as might be used in the first stage of a high-speed electronic counter. The prescaler usually divides the unknown input frequency by ten, although any arbitrary integer division is permissible. The prescaler does not impact electronic-counter accuracy, although electronic-counter resolution is reduced in direct proportion to the prescaler division ratio. The unknown input frequency is the product of the division (prescale) ratio and the frequency displayed by the electronic counter.

Mixers and prescalers can be used as accessories to an electronic counter rather than an integral part of the elec-

(Continued on page 68)

Operating Mode	Sources of Measurement Error: ±1 count ambiguity	Time base	Trigger
Scale	X		
Totalize	X		
Ratio	X		X
Frequency	X	X	
Period	X	X	X
Time Interval	X	X	X
Multiple Period	X	X	X
Rate	X	X	

Table 1. Various sources of error applicable to each of eight operating modes discussed by author.

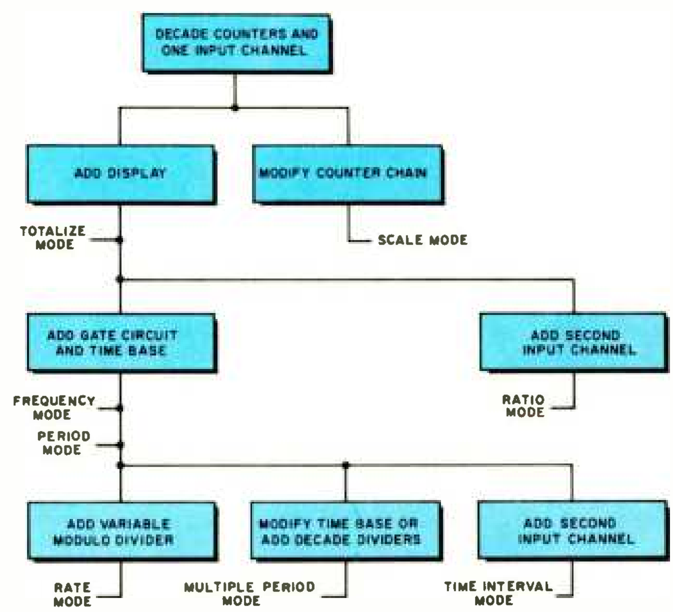
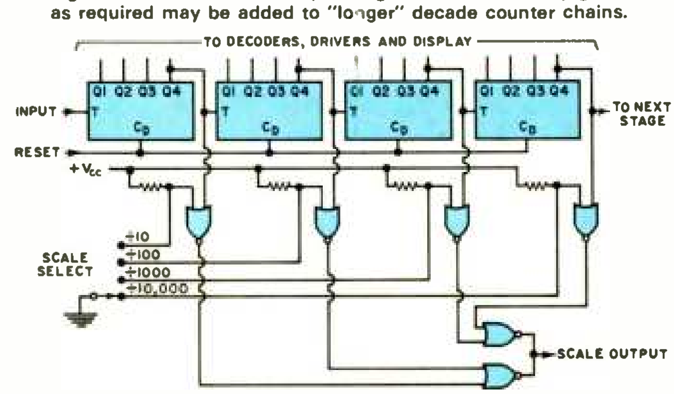


Fig. 2. Diagram showing evolution of an 8-mode counter starting with a string of decade counters and a single input channel.

Fig. 3. How a "nor" gate switching arrangement added to a decade counter provides Scale mode capability in an electronic counter. Modification provides a means of selecting one decade counter output at given time. As many gates as required may be added to "longer" decade counter chains.



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EW Lab Report

Volt-Ohm Milliammeters

By JULIAN D. HIRSCH

EW LAB TESTED by Hirsch-Houck Labs

A survey of v.o.m.'s, the technician's most widely used test instrument—including their features, performance, and prices. Laboratory measurements on eighteen of the newest models from a half-dozen manufacturers are given.

PROBABLY the single, most useful test instrument for the serviceman, technician, or experimenter is the volt-ohm-milliammeter, or v.o.m. The ability of a v.o.m. to measure d.c. and a.c. operating voltages and currents and to make point-to-point resistance or continuity checks, combined with its portability and moderate cost, make it ideal for service calls and general field use, as well as on the shop or laboratory bench.

V.O.M. Features

The v.o.m. is a passive instrument, using only a meter movement, rectifier diodes, and switched resistors for range selection. Internal batteries supply the current for resistance measurements. Early v.o.m.'s used a 1-mA basic meter movement, requiring a series multiplier resistance of 1000Ω for each volt of full-scale reading. This limited their usefulness for low-voltage measurements to low-impedance circuits where the meter current would not unduly affect the circuit conditions. Obviously, low-current measurements were limited by basic meter sensitivity.

With improved meter designs, economical manufacture of very sensitive, yet rugged, meter movements has become practical. Most modern v.o.m.'s have a sensitivity of 20 kΩ/V for d.c. measurements (50μ A basic meter sensitivity). Some v.o.m.'s have a sensitivity of 100 kΩ/V or even higher. Conventional jewel-pivot d'Arsonval movements become quite fragile when designed for high sensitivity so that most of the high-impedance meters (and many of the 20kΩ/V models as well) now use a *taut-band* suspension. A slender wire supports the moving coil and pointer and supplies the restoring torque which is provided by a flat spiral spring in pivoted meters. The taut-band suspension is inherently more rugged than a pivoted-suspension type and it has less friction; however, it is not intrinsically more accurate.

For a.c. measurements, practically all v.o.m.'s use a full-wave germanium diode rectifier. Unlike the copper-oxide or selenium rectifier used in older designs, germanium diodes have a frequency response extending well beyond the audio range, usually to 100 kHz or higher. The meter input impedance for a.c. measurements is lower than for d.c., typically 5 kΩ/V, but as high as 10 kΩ/V on some very sensitive meters that are currently available, and as low as 1 kΩ/V on one of the meters evaluated for this report.

Before the widespread use of solid-state circuits, resistance measurements were a simple matter of forming a series circuit consisting of a battery, meter (with its own internal resistances), and the unknown resistance to be measured. The meter read the current through the circuit and was calibrated in terms of external resistance. Problems can arise when making resistance measurements in transistor circuits or on a transistor or diode alone. Most ohmmeters apply at least 1.5 V to the external circuit (on the higher ranges, as much as 30 V). This is sufficient to bias a transistor junction or diode into conduction, giving a false resistance reading. If the circuit resistance appears to change when the meter leads are reversed or the range is changed, this condition can be assumed to exist. Also, some solid-state devices can be damaged by excessive current from an ohmmeter, which can reach hundreds of milliamperes on the lower ranges.

Several v.o.m.'s now feature "low-power" resistance measurements, usually on the lower ranges. The maximum voltage appearing on the test leads is on the order of 0.1 V, too low to "turn on" a semiconductor junction, and the maximum current is limited to a few milliamperes. With these meters, accurate resistance measurements can be made in transistor circuits without disconnecting the transistors. Normal or "high-power" resistance measurements are still useful, since they simplify checking the forward and reverse resistances of diodes and transistors.

Today's highly sensitive meter movements are easily damaged or burned out by overloads. Almost every v.o.m. manufacturer guards against this by placing a pair of back-to-back silicon diodes directly across the meter terminals. Even when reading full scale, the voltage drop across the meter is far below the value needed to "turn on" a silicon junction, so they have no effect on meter accuracy. A massive overload, producing a voltage sufficient to cause the diodes to conduct, causes them to shunt the meter and limits the maximum voltage across the meter to about 0.6 V. A meter protected in this way can withstand a severe overload for short periods and, if it is well made, the pointer can withstand a remarkable amount of abuse.

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Protecting only the meter movement against overload may not be sufficient since severe overloads or improper operation, such as making a resistance measurement on a "live" circuit, can burn out the precision resistors in the meter.

Fuses are used in many meters, principally to protect the ohmmeter ranges or high-current ranges. Some v.o.m's are designed with positive overload protection in the form of a relay that senses the current through the meter and opens the input circuits to the entire v.o.m. when an overload becomes excessive. Usually a button pops out of the meter case when this happens and after the overload is removed the button will latch in when pressed. This feature adds considerably to the price of a v.o.m., but may still be an economy if the meter is to see rough service or be used by inexperienced personnel.

Accuracy Specifications

For most applications, the accuracy specifications of typical v.o.m's are perfectly adequate. They are typically ±2% of full scale for d.c. measurements and ±3% of full scale for a.c. measurements, with some degradation of accuracy at frequencies above 20 kHz or on the very high a.c. voltage ranges. A few instruments, usually those with larger meters, are rated at ±1.5% or even ±1%, while very small portable v.o.m's may carry a ±3% rating. These differences are not significant for service work, but laboratory applications may warrant the higher cost of a more accurate meter. However, our tests suggest that the actual accuracy of most meters is much better than their published specifications and there often seems to be little relation between the two figures.

Two other factors can have a profound effect on the actual reading accuracy. The size of the meter—actually, the length of its scales—often limits the visual reading accuracy. One should not expect to read a hand-held meter having a 2" scale with the accuracy possible in a bench meter with a 6" or 7" scale. Even more important is the choice of scale ranges offered. Since meter accuracy is normally rated in terms of a percentage of the full-scale reading, a "2%" meter may have errors of 4% at half scale or 6% at one-third scale. Clearly, it is desirable to make a reading as far up on the scale as possible.

Any meter claiming an accuracy of better than 2% should have an anti-parallax scale. Generally this is a mirror backing in which the visual alignment of the pointer with its reflection assures a correct viewing position. The *Weston* Model 80 uses a two-layer plastic scale to achieve the same result, with somewhat easier viewing than most mirror scales.

Test Results

◀ RCA WV-517A is one of a line of five new inexpensive v.o.m.'s priced from $10 to $48.

Simpson 202 has unusual logarithmic scales. Company has very large line of v.o.m.'s. ▶

▲Triplett 100 kit contains Model 310 v.o.m. with clamp-on ammeter adapter and line separator. Company has one of the most extensive lines of v.o.m.'s available.

B&K Model 120

FEATURES: D.c. volts (±) 9 ranges from 0.3 to 6000 V, 20 kΩ/V, ±2% accuracy. **A.c. volts** 8 ranges from 1.2 to 6000 V, 5 kΩ/V, ±3% accuracy, Output ranges with blocking capacitor up to 600 V. **D.c. current** (±) 7 ranges from 60 μA to 12 A, accuracy ±2%. **Resistance** 5 ranges, center readings from 2Ω to 200 kΩ. Jewel pivot movement, mirror scale $3\frac{3}{4}$" long. **Dimensions** 7" × $5\frac{1}{4}$" × $3\frac{1}{8}$". **Weight** 2 lbs, 14 oz. Price $64.95.
PERFORMANCE: D.c. volts +0.3%, -0.7%. **A.c. volts** +0.3%, -0.4%. **D.c. current** +0, -0.4%. **Ohms** +1%, -2%. **Frequency response** 0.1%.
COMMENTS: Moderate meter overshoot (under-damped). Balance OK. Transit switch position damps meter heavily.

Medistor Model N-2

FEATURES: D.c. volts 9 ranges from 12 mV to 600 V, 20 kΩ/V, ±2.5% accuracy. **A.c. volts** 6 ranges from 1.5 to 600 V, 4 kΩ/V, ±3.5% accuracy to 500 Hz, ±7.5% to 30 kHz. **D.c. current** 9 ranges from 30 μA to 6 A, ±2.5% accuracy. **A.c. current** 8 ranges from 150 μA to 6 A. Accuracy same as a.c. voltage measurement. **Resistance** 2 ranges, center readings 300Ω, 30 kΩ. **Temperature** (with optional thermocouple probe) +68° to +460°F, +68° to -150°F. Taut-band movement, glass pointer, scale length $3\frac{1}{4}$". Fuse protection. **Dimensions** $6\frac{1}{8}$" × $3\frac{3}{4}$" × $1\frac{3}{4}$". **Weight** 12 oz. **Price** $39.95.
PERFORMANCE: D.c. volts +0.6%, -1.5%. **A.c. volts** +0, -1.3%. **D.c. current** +1.1%, -0%. **A.c. current** -1.3% (at 10 mA). **Ohms** +3%, -2%. **Frequency response** 1.3%.
COMMENTS: Selector switch relatively difficult to read. Only meter tested with a.c. current ranges. Balance shift approx. 1%. Considerable overshoot (under-damped). Manufactured in Austria.

RCA Model WV-516A

FEATURES: D.c. volts 4 ranges from 5 to 1000 V, 2kΩ/V, ±3% accuracy. **A.c. volts** 4 ranges from 5 to 1000 V, 2 kΩ/V, ±4% accuracy. **D.c. current** 3 ranges from 0.5 to 250 mA, ±3% accuracy. **Resistance** 2 ranges, center readings 27 and 2700Ω. Jewel pivot movement. Scale length $2\frac{1}{2}$". **Dimensions** $4\frac{5}{16}$" × $3\frac{1}{8}$" × $1\frac{3}{4}$". **Weight** 11 oz. **Price** $9.95.
PERFORMANCE: D.c. volts +0, -1.6%. **A.c. volts** +0, -2.4%. **D.c. current** +0, -2.1%. **Ohms** +0, -10%. **Frequency response** 0.4%.
COMMENTS: Very compact hand-held meter. No range switch; separate pin jacks for each range. Fast response, slightly over-damped. Balance shift 1%. Made in Japan.

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Although most meters are designed to give maximum accuracy in a horizontal position, their movements should be balanced so that the pointer does not shift between vertical and horizontal positions. The response time and damping of the meter movement also affect its usefulness. An under-damped meter can oscillate wildly when reading a changing level, while an over-damped meter takes an appreciable time to reach its final reading. Critical damping—a rapid pointer movement with virtually no overshoot—is ideal, but rarely found. A slightly over-damped meter is probably preferable to an under-damped movement, however.

Most meters have a ratio of 4 or 5 between adjacent scale ranges. Obviously, many readings will be well below half scale, yet above the next lower range. Compare your own special measurement needs to the ranges offered when considering the purchase of v.o.m. All other factors being equal (as they often are), this may be the deciding factor in your choice. Two meters of the group tested for this survey minimize this problem in very different ways. The *Triplett* Model 800 can divide each of its normal ranges by two, so that the gap between adjacent ranges is reduced to 2 or 2.5. In many cases, this feature could appreciably improve the measurement accuracy, at the cost of a bit more switching when selecting ranges. The *Simpson* Model 202, on the other hand, has logarithmic scales with a rated d.c. measurement accuracy of ±2% of *actual reading*. Most of its ranges are in a 10:1 ratio, giving high accuracy with a minimum of switching.

Almost all v.o.m's have a.c. and d.c. voltage ranges from about 3 V to at least 1000 V, and sometimes a high-voltage range of about 5000 V. For measurements in high-voltage circuits, it is usually preferable to use the optional high-voltage probes offered by many manufacturers. They are insulated to protect the user and contain the multiplier resistors extending the meter's range to tens of kilovolts for measurements in TV and other high-voltage circuits.

Clamp-on a.c. current probes are available for some meters. They are current transformers which allow a.c. currents from an ampere or so up to hundreds of amperes to be read on the low-voltage a.c. ranges of the v.o.m. The clamp-on probe can only measure current in a single conductor, but line-splitting adapters are available to facilitate measurements in two-conductor circuits without disturbing the wiring. One of the meters tested (*Medistor* Model N-2) is unique in having a.c. current ranges from 150 μA to 6 A full scale. However, the circuit must be interrupted for these measurements. Other probes for specialized measurements, such as r.f. voltage and temperature, can be purchased for many meters.

The accuracy of a resistance measurement with a v.o.m.

—Test Results *(Continued)*

Weston 80 has unique sloping meter face. Also available in rack-mount configuration. ▶

◀ B&K Model 120 has very low ohms scale, with mid-scale resistance reading of 2Ω.

Medistor N-2 has molded leads with locking ▼ jacks, permitting it to be hung by its leads.

RCA Model WV-517A

FEATURES: D.c. volts 6 ranges from 0.3 to 600 V, 20 kΩ/V, ±3% accuracy. **A.c. volts** 4 ranges from 12 to 600 V, 10 kΩ/V, ±4% accuracy. Blocking capacitor for Output measurements. **D.c. current** 3 ranges from 60 μA to 300 mA, ±3% accuracy. **Resistance** 3 ranges, center readings 54Ω to 54 kΩ. Jewel pivot movement. Scale length 2½". **Dimensions** 4⅜" × 3³⁄₁₆" × 1½". **Weight** 13 oz. **Price** $18.00.
PERFORMANCE: D.c. volts +1.7%, -0%. **A.c. volts** +1.2%, -1.7%. **D.c. current** +1%, -0%. **Ohms** +2%, -12%. **Frequency response** 1.7%.
COMMENTS: Compact meter suitable for holding. Fast response, moderate single overshoot. Balance shift 0.8%. Made in Japan.

RCA Model WV-518A

FEATURES: D.c. volts 7 ranges from 0.5 to 500 V, 20 kΩ/V, ±3% accuracy. **A.c. volts** 4 ranges from 15 to 500 V, 10 kΩ/V, ±4% accuracy. **D.c. current** 4 ranges from 0.5 to 500 mA. ±3% accuracy. **Resistance** 4 ranges, center readings 22 to 22 kΩ. Jewel pivot movement, mirror scale, length 2¼". "Ohms" range fuse-protected. **Dimensions** 5⅛" × 3½" × 2". **Weight** 1 lb, 2 oz. **Price** $28.50.
PERFORMANCE: D.c. volts +0.8%, -2%. **A.c. volts** +0.7%, -2.7%. **D.c. current** +3%, -0%. **Ohms** +1%, -8%. **Frequency response** 0.7%.
COMMENTS: Range switch has "Off" position. Fairly fast response, over-damped. Balance OK. Made in Japan.

Simpson Model 160

FEATURES: D.c. volts (±) 8 ranges from 0.25 to 1000 V, 20 kΩ/V, ±2% accuracy. **A.c. volts** 6 ranges from 2.5 to 1000 V, 5 kΩ/V, ±3% accuracy. **D.c. current** (±) 6 ranges from 50 μA to 500 mA, ±2% accuracy. **Resistance** 5 ranges, center readings 30 to 300 kΩ. Taut-band movement, scale length 3". **Dimensions** 4⅝" × 3⁵⁄₁₆" × 1¾". **Weight** 12 oz. **Price** $55.00.
PERFORMANCE: D.c. volts +0.3%, -0.2%. **A.c. volts** +3.8%, -0%. **D.c. current** +1.5%, -1.0%. **Ohms** +0%, -2%. **Frequency response** 0.2%.
COMMENTS: Very small, portable instrument. Legibility of scales and selector excellent. Critically damped, no overshoot. Balance OK.

Simpson Model 202

FEATURES: D.c. volts 6 ranges from 330 mV to 1100 V, 20kΩ/V. Accuracy ±2% *of reading*. **A.c. volts** 4 ranges from 11 to 1100 V, 5 kΩ/V. Accuracy ±3% *of reading*. **D.c. current** 5 ranges from 110 μA to 1.1 A. Accuracy ±2% *of reading*. **Resistance** 5 ranges, center readings 4 to 700 kΩ. Taut-band movement, mirror scale, length 7¾". Fuse protection. Meter shunted by varistor instead of diodes. **Dimensions** 6¾" ×

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cannot be expressed simply. The resistance scale is highly non-linear and accuracy is specified as a percentage of scale length, which means little to most users. If your resistance measurement is principally for continuity or rough circuit checks, accuracy is of minor importance. However, in working with power equipment, such as motors and transformers, it is often necessary to make reasonably accurate measurements of small resistances. To evaluate the suitability of a meter for such measurements, look at the resistance reading at the center of its ohms scale. Some meters have a center-scale reading of 30Ω or even more on their lowest range, while others have about a 4-Ω center reading. One of the group tested (*B&K* Model 120) has a very low ohms scale, with a center reading of 2Ω, allowing measurements down to less than 0.1Ω.

On the other hand, very high resistance measurements (of leakage paths or insulation resistance) require a high center scale reading on the highest ohms range. Values of 200 kΩ or 500 kΩ are typical, allowing rough measurements up to 20 MΩ or more. The *Simpson* Model 257, used with an external d.c. source of 100 to 240 V, can read up to about 500 MΩ.

Any v.o.m. is small and light enough to be taken into the field and most have convenient carrying handles. The larger models, with meter scales as long as 7", are clearly intended for bench use. At the other extreme are the tiny, palm-sized *Triplett* Model 310 Series 2 and the only slightly larger *Simpson* Model 160, which are ideal for carrying to the job, but whose short scales make them less desirable for regular use on the service bench.

When shopping for a v.o.m., consider its convenience for your own type of work. For example, some meters use a simple rotary switch for all range and function selection. In others, a separate switch is provided for choosing d.c. or a.c. operation, or selecting current or resistance modes of measurement. This is sometimes combined with a polarity-reversing function, or a separate switch may be used for that purpose. On some meters, the range in use can be identified at a glance; others require examination of two or three controls. The same situation exists on the meter scales, which can get rather cluttered in a multi-scale meter.

Test Program

A number of v.o.m. manufacturers were invited to submit samples for our evaluation. We proposed to go beyond the customary listing or tabulation of specifications, which is readily obtainable from manufacturers' literature. In addition, actual measurements were to be made with each meter, all under identical, controlled conditions, to see how well they lived up to their claims. (*Editor's Note: Within*

tion. Meter shunted by varistor instead of diodes. **Dimensions** 6 3/4" × 7 5/8" × 3 3/8". **Weight** 4 lbs, 7 oz. **Price** $100.00.
PERFORMANCE: D.c. volts +0%, -1.5% of reading. **A.c. volts** +1.4%, -0% of reading. **D.c. current** +0.5%, -2% of reading. **Ohms** +1%, -2%. **Frequency response** 0.5%.
COMMENTS: Only meter tested having logarithmic scales. Effective accuracy very good. Single knob range/function selector. Heavily damped for transit. Pointer movement rapid, considerable overshoot.

Simpson Model 257

FEATURES: D.c. volts (±) 9 ranges from 0.1 to 5000 V, 100 kΩ/V, ±1.5% accuracy. **A.c. volts** 4 ranges from 10 to 1000 V, 20 kΩ/V, ±2.5% accuracy. Blocking capacitor for Output measurements up to 250 V. **D.c. current** (±) 8 ranges from 10 µA to 1A, accuracy ±1.5%. **Resistance** 3 ranges with internal battery, center readings 30 to 100 kΩ. 2 ranges with external a.c. and d.c. sources of 100 to 240 V, center readings 1 MΩ and 10 MΩ. **Capacitance** with external a.c. supply of 100 to 240 V, from 2000 pF to 5 µF. Taut-band movement, mirror scale, length 3 1/4". Fuse protection. Overload relay with push-button reset. **Dimensions** 8 1/4" × 4 1/4" × 3 1/4". **Weight** 2 lbs, 9 oz. **Price** $95.00.
PERFORMANCE: D.c. volts +0.6%, -0.8%. **A.c. volts** +0.5%, -1.6%. **D.c. current** +1.0%, -0.6%. **Ohms** ±0%. **Frequency response** 1%.
COMMENTS: Exceptional high ohms capability with external supply. Fast-acting overload relay protects entire meter. Single selector for all ranges and modes. Meter under-damped, overshoots. Balance OK. Manufactured in Austria.

Simpson Model 260-5P

FEATURES: D.c. volts (±) 7 ranges from 0.25 to 5000 V, 20 kΩ/V, ±2% accuracy. **A.c. volts** 6 ranges from 2.5 to 5000 V, 5 kΩ/V, ±3% accuracy. Blocking capacitor for Output measurements up to 250 V. **D.c. current** (±) 6 ranges from 50 µA to 10 A, accuracy ±2%. **Resistance** 3 ranges with center values 12 to 120 kΩ. Taut-band movement. Scale length 4 1/8". Fuse protected. Fast-acting overload relay with push-button reset. **Dimensions** 7" x 5 3/8" × 3 1/4". **Weight** 3 lbs. **Price** $97.00.
PERFORMANCE: D.c. volts +0.4%, -0.1%. **A.c. volts** +2%, -0%. **D.c. current** +1.2%, -0%. **Ohms** +4%, -2%. **Frequency response** 0.3%.
COMMENTS: Contains separate rectifier and transistor amplifier to operate overload relay. Meter response fast, single moderate overshoot. Balance OK.

Simpson Model 269-3

FEATURES: D.c. volts 9 ranges from 0.8 to 4000 V, 100 kΩ/V, ±1.5% accuracy. **A.c. volts** 6 ranges from 3 to 800 V, 5 kΩ/V, ±2.5% accuracy. **D.c. current** 7 ranges from 16 µA to 8 A, ±1.5% accuracy. **Resistance** 6 ranges, center readings from 12 to 1.2 MΩ. Taut-band movement, mirror scale, length 6 1/8". Fuse protection. **Dimensions** 6" × 7 1/4" × 3". **Weight** 3 lb, 12 oz. **Price** $98.00.
PERFORMANCE: D.c. volts +4.5%, -0% (highest error on 400 V range; maximum error elsewhere +1.8%). **A.c. volts** +2.5%, -0%. **D.c. current** +1.4%, -0%. **Ohms** +0%, -2%. **Frequency response** -0.25%.
COMMENTS: Response very slow, over-damped. Single knob range/function selector. Balance shift approximately 0.3%.

Simpson Model 270-3

FEATURES: D.c. volts (±) 7 ranges from 0.25 to 5000 V, 20 kΩ/V, ±1.25% accuracy. **A.c. volts** 5 ranges from 2.5 to 1000 V, 5 kΩ/V, ±2% accuracy. Blocking capacitor for Output measurements up to 250 V. **D.c. current** (±) 6 ranges from 50 µA to 10 A, ±1.25% accuracy. **Resistance** 3 ranges, center readings 12 to 120 kΩ. Taut-band movement, mirror scale, length 4 1/4". Fuse protection. **Dimensions** 7" × 5 3/8" × 3 1/4". **Weight** 3 lbs. **Price** $78.00.
PERFORMANCE: D.c. volts +1.2%, -0%. **A.c. volts** +0%, -1.2%. **D.c. current** +1.7%, -0%. **Ohms** +5%, -2%. **Frequency response** 0.5%.
COMMENTS: Accuracy specification reduces to 1.75% d.c. and 3% a.c. over 67-87°F temperature range. Response rapid, slight overshoot. Balance OK.

Triplett Model 310-2

FEATURES: D.c. volts 5 ranges from 3 to 1200 V, 20 kΩ/V, ±3% accuracy. **A.c. volts** 5 ranges from 3 to 1200 V, 5 kΩ/V, ±4% accuracy. **D.c. current** 4 ranges from 0.6 to 600 mA, ±3% accuracy. **Resistance** 4 ranges, center readings 200 to 200 kΩ. Jewel pivot movement. Scale length 2 1/8". **Dimensions** 4" × 2 3/4" × 1 1/8". **Weight** 8 oz. **Price** $44.00 ($78.00 as Model 100, with current probe and line adapter, in case).
PERFORMANCE: D.c. volts +0.6%, -0%. **A.c. volts** +0.7%, -1.2%. **D.c. current** +0.7%, -0.8%. **Ohms** +0%, -4%. **Frequency response** ±0%.
COMMENTS: Smallest and lightest meter tested. With Model 10 clamp-on current probe and Model 101 current-splitting adapter, measures a.c. currents up to 300 A. Error at 3.0 A on 6-A range, -2.3% of full scale. Very legible scales and selector marking. Response very fast, critically damped. Balance OK.

Triplett Model 630-2

FEATURES: D.c. volts 6 ranges from 3 to 6000 V, 20 kΩ/V, ±2%

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How to Locate Buried-Conductor Faults

By JOHN T. BAILEY

By setting up a bridge circuit and using an a.c. v.t.v.m. as a null indicator, exact location of fault can be determined.

OFTEN an electronics technician can solve problems that stump others who would seem to be better qualified for the task. For instance, suppose a long underground power line, consisting of two-conductor Romex cable buried in soil several feet below the surface, has developed a dead short to ground or even a high-resistance short to ground. Obviously, it would be nice to know where the fault has occurred so that the entire line would not have to be dug up in order to fix it. Since this line is a 60-Hz power line furnishing power to a remote motor, lights, heater, or other similar power load, it would be logical to call in an electrician. But, chances are that an electronics technician can understand the circuitry needed to locate the fault better than the average electrician and will have the test equipment needed.

Let's assume a typical situation where you plan to connect driveway lights to 300 feet of buried Romex underground-type cable at 75-foot intervals. (Romex cable used consists of two #14 copper conductors and ground wire.) This you do, by making a splice underground at each light location, being careful to tape the splices thoroughly to exclude ground moisture. Now, *before* you put in the lamp bulbs and *before* you connect the house end to a power circuit, you make a resistance check between each conductor and a waterpipe ground with your v.o.m. But when you do, one conductor shows an infinite resistance to ground and the other shows leakage of 50,000 ohms. Of course, a fault of that magnitude isn't too serious in a power circuit. Nevertheless something went wrong and it might get worse with time so you want to fix it. Here's how to locate the fault without digging up the entire cable.

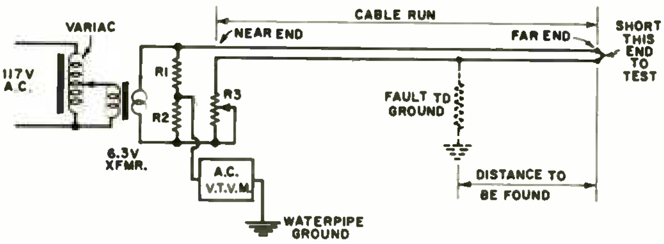
Table 1. The d.c. resistance of various copper wire sizes per hundred feet of conductor. The safe (not code ratings) current carrying capacities of these wires are also listed.

Copper Wire Size	Ohms/ 100 Feet	Safe Current (A)
18	0.6510	3
16	0.4094	6
14	0.2575	15
12	0.1619	20
10	0.1018	30

Table 2. Resistance of nichrome wire sizes that can be used to fabricate variable resistor R3.

Nichrome Wire Size	Ohms/Foot
22	1.055
20	0.659
18	0.422
16	0.260

Bridge circuit for determining exact location of cable fault.



Locating Fault

First, connect the two conductors together at the extreme end of the run away from the house. This can be done easily at the remotest lamp socket. At the cable end closest to the house wire up a Wheatstone-type bridge circuit, as shown in the diagram, using the cable conductors as two arms of the bridge. Power the makeshift Wheatstone bridge from a suitable filament transformer connected through a Variac to the home power source. Use your v.t.v.m., set at its most sensitive a.c. scale, say 1 volt, as the null detector. A 6.3-volt filament transformer will be adequate in this example, but for other conductor sizes and lengths of cable a quick check using Ohm's Law should be applied.

Table 1 shows the d.c. resistance of the various copper wire sizes per hundred feet of conductor. Be sure to double the length of the cable run to get the length of the two conductors when connected in series across the transformer. Also shown are safe current-carrying capacities for various wire sizes. In this connection it should be noted that these values are merely safe figures and not code ratings which vary with the type of insulation and other considerations. The maximum current through the cable probably will be limited by the current rating of the transformer winding. In this case, the total conductor resistance is $0.2575 \times 2 \times 300/100 = 1.545$ ohms. Since #14 conductors will safely carry 15 amperes, almost any available 6.3-volt transformer will do. The more current through the cable the more accurate the location of the fault will be.

*R*1 and *R*2 should be precisely equal. Their value is not important; 25 ohms each will do. Equality can be obtained by using a potentiometer or a wirewound resistor with a slider. The pot arm or the slider is set using the v.t.v.m. to get equal voltages across resistors *R*1 and *R*2 when they are connected across the transformer.

(Continued on page 53)

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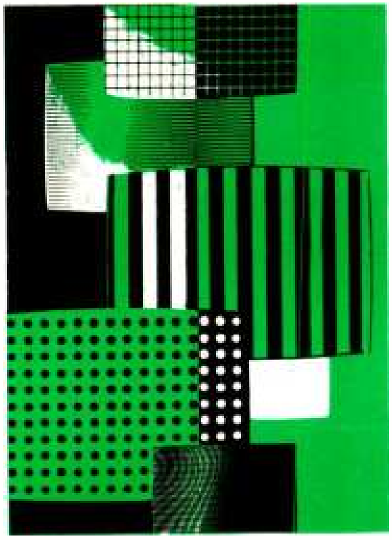
COLOR TV for 1971



By FOREST H. BELT
Contributing Editor

Part 2. Integrated circuits are coming into use in the new receivers, as are varactors for tuning and more solid-state high-voltage rectifiers. Automatic tint controls are also more common. Here are the new circuit designs and trends.

LAST month we gave an over-all picture of the new color sets and showed how more and more transistors are being used in the new chassis. Now, we will go into the use of IC's, along with other solid-state components.

Integrated Circuits

Among the companies making the greatest strides this year in color-set integrated circuits is *Zenith*. The entire color processing is integrated. Only three transistors are used, for final amplification of color-difference signals.

Fig. 1 pictures the integrated circuits and shows the plug-in Dura-Modules on which they're mounted. External circuits consist of a very few resistors, capacitors, and coils.

Fig. 2 shows what's inside the IC's. The first one, in Fig. 2A, is the chroma amp IC. Each function triangle represents several transistors, resistors, and capacitors on the IC chip.

Chroma signal from the video detector goes first to a gain-controlled broadband amplifier, the a.c.c. amp. Output of the a.c.c. amp is held at constant level by a control voltage from the subcarrier regenerator IC.

The steady chroma signal goes to a chroma level amp. Its gain can be set manually by the Color control. Some of the chroma signal is split off and fed to the subcarrier regenerator IC, where color-sync burst can be separated. The main chroma output signal goes to the demodulator IC.

The a.c.c. amp also sends a voltage to the killer stage. That voltage overrides the killer threshold voltage, operating the killer amp and letting the chroma level amp work. If no color is actuating the a.c.c., the killer cuts off the chroma level amp.

The subcarrier regenerator (Fig. 2B) takes composite chroma from the a.c.c. amp in the chroma amp IC. It's fed to a phase-control detector (a.p.c.) and an a.c.c. detector. Both are much the same in operation as their counterparts in any color section. The color-sync burst is compared with the output of a 3.58-MHz oscillator. Any variance in phase produces a voltage shift that corrects the oscillator phase, keeping it locked to the station's color subcarrier. The a.c.c. detector senses the strength of the chroma signal and produces a d.c. voltage that, applied to the a.c.c. amp in the chroma amp IC, holds chroma level steady.

Output from the phase-corrected 3.58-MHz oscillator goes through a d.c.-operated hue-control amp. This kind of stage was described earlier. It allows viewer control of subcarrier phase over a narrow range, so hue from the demodulators can be varied. The 3.58-MHz output is then fed to the demodulator IC.

The gate amp is merely a stage of buffering for a keying pulse from the flyback transformer. The pulse blanks everything off during horizontal retrace.

The demodulator IC is illustrated in Fig. 2C. This chip was used in earlier *Zenith* color sets, although packaged differently.

Chroma input comes from the chroma amp IC. The 3.58-MHz signal reaching the demodulator IC has already been phase-shifted for R–Y and B–Y injection. The solid-state demodulators produce R–Y and B–Y signals. A matrix stage produces G–Y. All three are subjected to a stage of preamplification and then fed to their respective transistor output stages, which drive the CRT where Y signal is added.

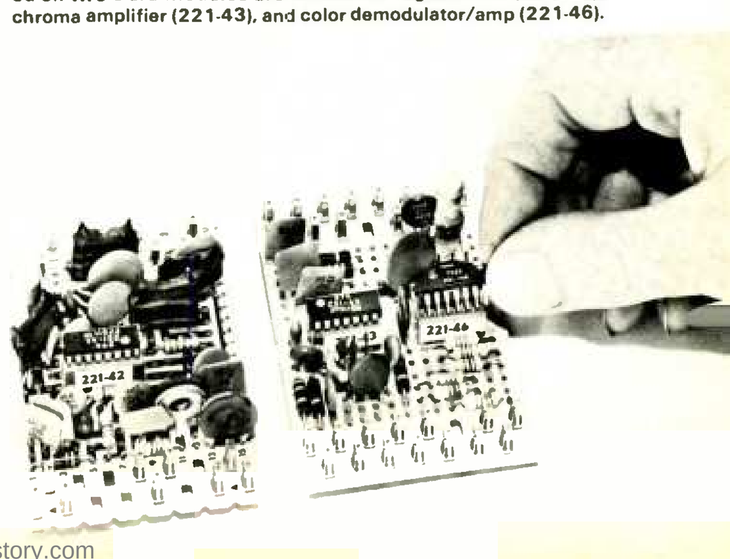


Fig. 1. Entire color processing in two Zenith chassis is carried out with integrated circuits. Three dual-in-line type IC's mounted on two Dura-Modules are subcarrier regenerator (221-42), chroma amplifier (221-43), and color demodulator/amp (221-46).

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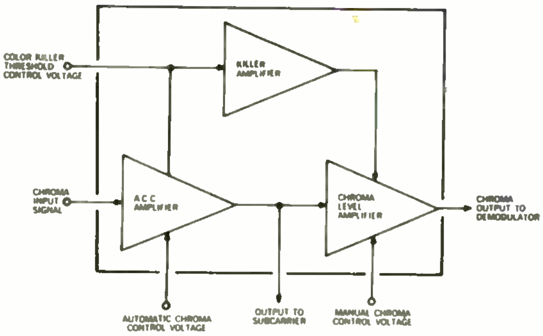
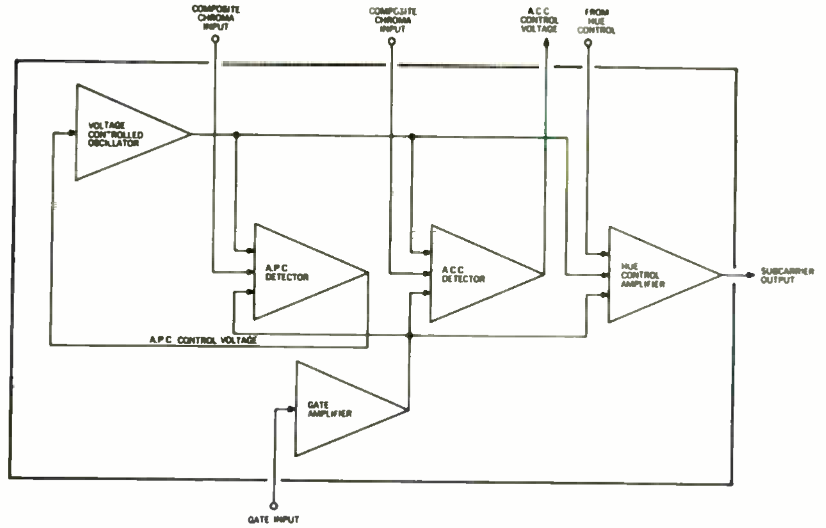
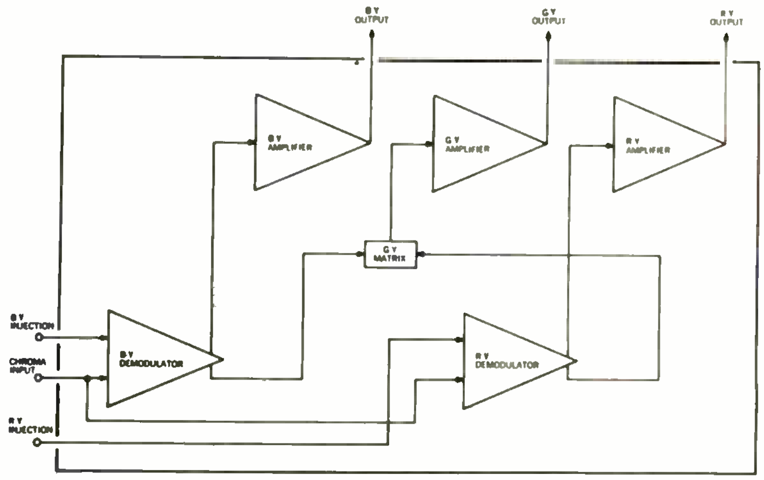


(A)



(B)



(C)

Fig. 2. What's inside the Zenith color-section IC's. (A) Chroma amplifier. (B) Subcarrier regenerator. (C) Demodulators and color-difference preamplifiers. Outputs of IC shown in (C) are connected to three transistor color-difference amps.

The *Zenith* sets and the new *RCA* CTC49 chassis represent the most elaborate use of integrated circuits in the 1971 models. But plenty of other manufacturers have IC's in some stages. They include: *Andrea, Channel Master, Electrohome, Heath, Magnavox, Midland, MGA, Motorola, Packard Bell, Panasonic, Philco-Ford, Sony,* and *Sylvania.* An analysis of how IC's are used in some of the 1971 models follows:

Sound Section (i.f., detector, a.f. preamp): *Andrea, Heath, MGA, Midland, Motorola, Packard Bell, Panasonic, RCA, Sony, Sylvania, Zenith*

Audio Amp (drives speaker): *Magnavox*

Picture Section (i.f., detector, preamp): *RCA*

Chroma Demodulator (includes R, G, B preamps): *Electrohome, Heath, Motorola, RCA, Zenith*

Color Oscillator (3.58 MHz): *Heath, Packard Bell, Philco-Ford*

Chroma Amplifier: *RCA, Zenith*

Subcarrier Regenerator: *RCA, Zenith*

Automatic Frequency Control: *Heath, Panasonic, RCA*

Vertical Oscillator: *Sony*

As you can see, the sound i.f./detector/preamp IC is by far the most popular. *RCA* was the first to use it, several years ago. Many have joined in. There are differences in the IC's used in this spot, but only minor. A few variations also appear in the stages that precede and follow this integrated circuit.

For example, *MGA* chassis CH-120 and CH-140 have a stage of transistor amplification for the sound i.f. before the IC gets it, and a stage of audio amplification between the IC preamp and the audio output transistor. The *Motorola* and *Heath* chassis use extra audio amplification before the output transistor, too. Most sound-section IC's drive the audio-output transistor directly.

The chroma demodulator IC's in all chassis are similar to the IC already described for *Zenith.* They include color-difference preamps. A single stage of transistor amplification follows for each color, then the CRT.

Modular Plug-Ins

A number of companies have pursued the plug-in road to ease of servicing. There are certain manufacturing advantages, but generally cost is not one of them. Eventually, when most of a set-maker's chassis are modular, there may be substantial savings.

Motorola began the modular trend four years ago, with the first Quasar. That basic chassis remains in the line for 1971. The newer version is called Quasar II. It is pictured in Fig. 3.

The original Quasar was also the first all-transistor color set sold in the U.S. The new Quasar II has some tubes. Actually, only horizontal sweep, high voltage, and vertical sweep stages have tubes.

Whereas previous Quasar models had ten boards, Quasar II chassis have only five. More circuits and stages are included in each board. Nevertheless, *Motorola* spokesmen say that replacement prices of the boards will not exceed the highest price for replacement boards for previous Quasar models. That was $33, somewhat less since. The Quasar II boards carry a 2-year free-exchange warranty, too.

Heath Company has also switched to plug-in modules for its newest color-TV kits. All four new models—the GR-270, GR-370, and GR-371 table and floor models, and the GR-169 portable 14-inch—are of modular construction. For an

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idea of what the chassis looks like, see the January issue. Eight of the plug-in printed boards are along the top and bottom of the hinged swing-out chassis pan; one is at the left side just below the i.f. shield cover.

Zenith has put several of its Dura-Modules into its two major new color chassis for 1971. The all-transistor 40BC50 and the mostly transistor 4B25C19 both have several of the computer-designed plug-in boards. Two of the modules were shown in Fig. 1 and the chassis they fit into is in Fig. 4.

Quite a few private brands have modular construction for 1971. This is thanks to *Wells-Gardner*, a company which makes no sets for direct sale. All its chassis go into private-label sets.

The 1971 *Wells-Gardner* line includes a 25-inch model that will be sold under several brand names. Among them are: Catalina (*White Stores*), MGA (*Mitsubishi*), Penncrest (*J.C. Penney*), and *W.T. Grant*.

The chassis is mostly tubes, but on plug-in circuit boards nevertheless. There are only four boards. Horizontal output and high voltage are on one. Vertical sweep and horizontal oscillator—and one transistor sync separator—are on another. A much larger board contains the entire color-processing section. Sound, video, and i.f.'s are on another large board.

All connections between boards and the main chassis are through plugs that attach the boards to the chassis pans. These boards are not as readily exchangeable as those of other brands because they're so large and each one contains so much of the circuits. But they are accessible for repair; you can unplug a board and take it out of the chassis while you replace parts on it.

RCA recently announced its CTC49 all-transistor chassis for 110-degree picture tubes. The chassis has 11 plug-in modules. The new AccuCircuit modules don't have prongs like the others described. The circuit board is etched right out to the edge, forming contacts that slide into gripping connectors. If you've seen computer circuit cards, you know what an AccuCircuit board looks like. (*For details, refer to our January issue.—Editor*)

JVC (*Nippon Victor*) has one chassis that uses four plug-in modules, but we have no information about their nature.

Quite a few manufacturers have for years grouped circuits this way on printed boards. But interconnections are soldered to points on the board. If the plugs used for modular boards are improved a bit to make connections more dependable, and if redesign can reduce the number of interconnections needed, almost all manufacturers will make the changeover.

Tuning with Varactor Diodes

Electronic tuning for both u.h.f. and v.h.f. is not a new idea. But the 1971 line is the first to see it in any number. Three brands have varactor tuning and a couple of experimental sets use it. Here are a few details.

Electrohome had a varactor tuner in last year's line. It's in the 1971 line too. You may remember the C8 chassis. Channels are actuated by touching a finger between a metallic bus-bar and the metallic button for the desired channel. An elaborate sensing system applies voltages to switching diodes and varactor diodes in the tuner to select the band and tune the channel. The C8 tuner gives the viewer a choice of any six u.h.f. channels in addition to the regular twelve v.h.f. channels.

The v.h.f. tuner in the company's C9 chassis is varactor-tuned and diode-switched. But neither push-button nor touch-button is used to select channels. Instead, a sliding-contact lever switch does it.

The mechanism behind the panel is deceptively simple. The sliding-contact switch has one row of contacts that connects one of the fifteen tuning potentiometers to a tuning-voltage line. Each pot is set for whatever voltage tunes that channel.

At the bottom end of the slider's travel, one potentiometer happens to be for u.h.f. manual tuning. It lets the viewer tune anywhere in the u.h.f. band by hand.

Automatic fine tuning (a.f.t.) stages in the main chassis make any minor alterations in tuning voltages to tune the station precisely. That's necessary for color and makes up for any small tolerances in pots or other components.

Also part of the sliding switch is a bar that puts a switching voltage on one of three lines—to the low v.h.f. switching diode, to the high v.h.f. switching diode, or to the u.h.f. tuner.

Another row of contacts turns on the dial light beside the lever, showing whatever channel is selected. The lighted number is silhouetted on the dial.

Sylvania, too, has a varactor tuner in the new all-transistor E01 chassis. The mechanism that operates it is an 11-button channel selector. Any button can be adjusted to tune any channel, either v.h.f. or u.h.f. That means the viewer can have any eleven channels available at the touch of a button. If the locality has fewer than eleven channels, the same station can be put on more than one button.

Each push-button operates enough contacts to apply a band-switching (or tuner-changing) voltage, apply a potentiometer-set tuning voltage, and light a channel-number indicator. A technician must preset the channels, but the tuner supplies equal tuning for both v.h.f. and u.h.f. (That's one of the advantages expected from electronic tuning. The Federal Communications Commission is demanding that u.h.f. soon tune as easily as v.h.f.)

The other U.S. manufacturer with a varactor tuner is *Ze-*

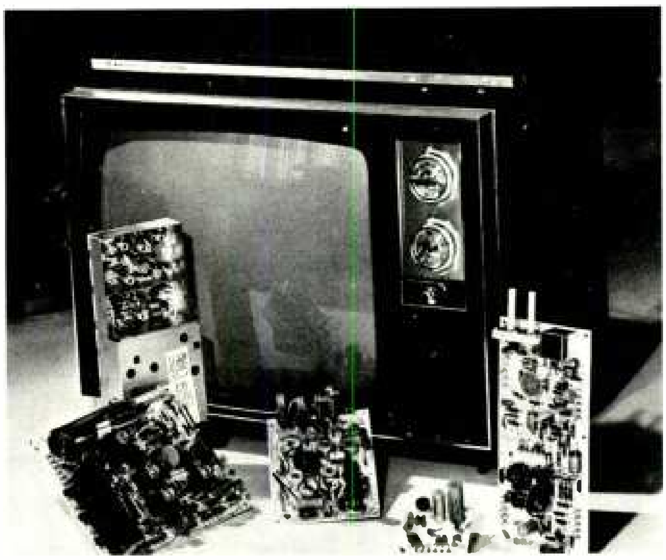
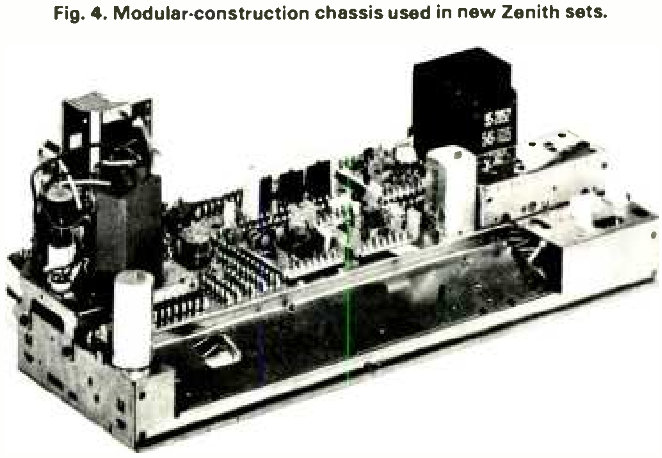


Fig. 3. Plug-in modules for Quasar II, latest Motorola color chassis. Some tubes are used although original Quasar is all solid-state.

Fig. 4. Modular-construction chassis used in new Zenith sets.



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nith. It's part of the company's all-transistor 40BC50 chassis.

It is operated from a 14-position drum. The mechanism of the drum has several functions: (1) switch bands in the v.h.f. tuner or switch to the u.h.f. tuner; (2) apply "B+" to whichever tuner is active; (3) apply voltage to the correct band-indicator light; (4) switch to a.g.c. that suits the FET r.f. amp in the v.h.f. tuner or to a.g.c. that suits the bipolar r.f. amp (something unusual) in the u.h.f. tuner; (5) change the a.f.t. pull-in range to suit the band being used; (6) apply voltage from the selected tuning resistor to the correct tuner.

The tuning resistors are part of the drum assembly. A gear connected to the fine-tuning knob can be pushed in to engage the active resistor. That allows the customer to make his own channel adjustments for each position of the drum. Each position can be programmed for any u.h.f. or v.h.f. channel.

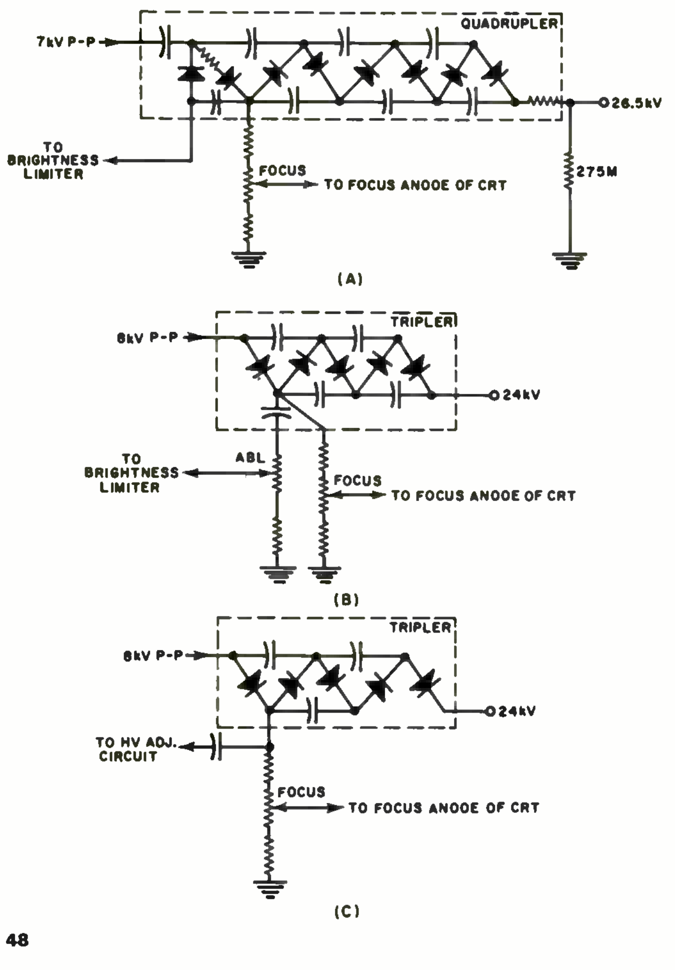
Panasonic has an experimental chassis it hopes to put into the line later in 1971. It has a varactor tuner. *Admiral* expects to have a varactor tuner in some models, but did not furnish information on it.

Automatic Tint Controls

Magnavox started it and several other manufacturers pursued the idea. In the 1971 line, there is considerable confusion because of it.

We're talking about automatic tint control (a.t.c.). The system used with some *Magnavox* color chassis takes automatic control of demodulator phase. The circuit senses the phase of signals near 57 degrees—the orange or fleshtone angle in the demodulator. If a signal in that vicinity slips a bit, making face tones become greenish or purplish, the a.t.c. corrects demodulator phase. (*Editor's Note: The* Magnavox *system was explained in our September 1969 issue.*)

Fig. 5. Multiplier-type high-voltage systems eliminate rectifying large high-voltage pulses. (A) Quadrupler in RCA CTC44. (B) Tripler in Sylvania, Zenith, and (C) Wells Gardner sets.



But this year, other kinds of systems are being described as automatic tint controls. They are not, however, like that original a.t.c. They operate on other principles.

An example is the *Zenith* Automatic Tint Guard. Briefly, the main objective of the ATG circuit is to broaden the demodulator matrix in the vicinity of fleshtones, so slight signal phase shifts don't produce such drastic hue shifts. The angle between R-Y and B-Y demodulator outputs is widened, and the G-Y output is reduced somewhat. If you turn on the ATG circuit while watching rainbow color bars, you see the red bars move slightly left and the blue bars move slightly right.

The *RCA* Accutint system operates on a different principle. One serious cause of fleshtone color shift is a change in amplitude of *Q* modulation at the transmitter. (The *Q* signal happens to be about 90 degrees away from the 57-degree angle of fleshtones.) The Accutint switch reduces the sensitivity of the set's demodulator to signals at or near the *Q* angle. As a result, variations there have little affect on fleshtones. Nothing is really lost, because colors that fall near the *Q* angle aren't so important to the eye. Besides, the troublesome variations there are usually amplitude and not phase.

At the same time, the 9300-degree (*K*) color temperature (gray scale) of the screen is lowered to 6800 degrees (*K*)—a warmer, faintly sepia shade. That, too, reduces the effects of slight color shifts near fleshtones.

General Electric has what is called Customatic Tint Lock. Except that the demodulation angle is 110 degrees between B-Y and R-Y, operation resembles the *Zenith* system. When the Tint Lock switch is in its "0" position, demodulation is normal. Moving the switch to its "1" position increases the demodulation angle between B-Y and R-Y to 130 degrees. Signals of incorrect phase don't produce as noticeable a hue change. With the switch in the "2" position, the demodulation phase angle is 150 degrees. The demodulators are then fairly insensitive to signal phase shifts in the vicinity of fleshtones.

All these systems affect other colors, too. But the warmer appearance of all colors seems to please most viewers. The pictures don't shift face tones so radically, and that's what these circuits are for. When broadcast techniques reach the state where such phase and amplitude changes are inconsequential, tint correction of any kind will be unnecessary.

Another system being called "automatic" consists of an extra set of tint and color (and sometimes also brightness and contrast) controls inside the set. They are set one way—perhaps for one station's broadcast characteristics—and the regular viewing controls another way. A switch lets the viewer pick whichever is best for any particular viewing situation. Just recognize that these "preset" systems—common on imported color sets—are not automatic tint controls.

Solid-State H.V. Sections

The concern over x-rays awhile back accelerated the use of solid-state high-voltage rectifiers and non-tube h.v. regulating circuits. The major innovation for 1971 models is a hermetically sealed solid-state voltage multiplier. It's made by *Varo Semiconductor.*

The solid-state multiplier offers several advantages. (1) No h.v. rectifier tube. (2) The critical h.v. winding on the flyback transformer is no longer needed. (3) A separate focus voltage or rectifier is unnecessary. (4) The h.v. system is easily regulated by feedback of the same horizontal output pulse that drives the multiplier, eliminating the shunt regulator tube. (5) Less wear and tear on horizontal deflection components.

Fig. 5 is a diagram of the more popular versions. The quadrupler in (A) is from an *RCA* chassis. The tripler at (B)

(Continued on page 69)

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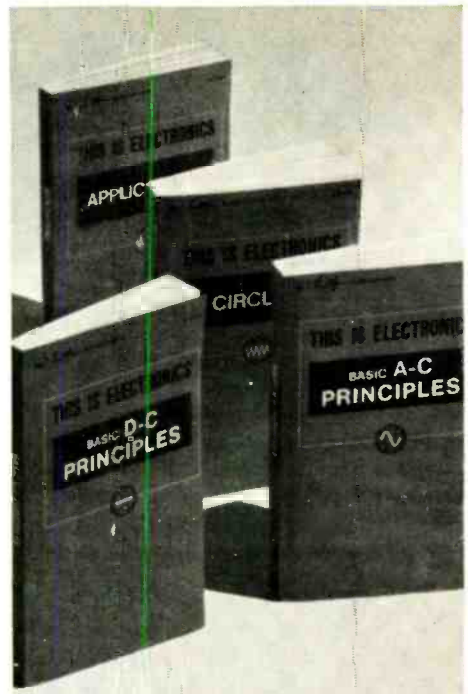

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CIRCLE NO. 128 ON READER SERVICE PAGE

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The "Perfect" Customer

A do-it-yourself rule for consumer protection: to get better service—be a better customer.

By **John Frye**

A BOISTEROUS March wind was making the metal sign suspended above the front of Mac's Service Shop squeak and rattle as the owner stepped inside and leaned his weight against the door to close it. As the roar of the wind died out of his ears, they were greeted by the sound of subdued hilarity from Matilda, the office girl, and Barney, his assistant technician, perched on her desk.

"What's all the giggling about?" Mac asked. "Don't tell me spring fever has hit both of you already!"

"Nope," Barney answered; "we're just designing the perfect service customer."

"Yeah, and when you're through with that I suppose you're going to start creating that other chimera, the Purple Cow," Mac scoffed. "What brought this on?"

"Oh, you know all the things we've been reading in the newspapers and magazines and seeing on TV about how imperative it is that customers be protected from the gouging service people," Matilda explained. "Barney and I started out trying to imagine what some customers apparently expect in the way of an ideal service technician."

"This ought to be good; let's hear it," Mac said, lighting his pipe and draping a leg across a corner of her desk opposite Barney.

"Okay," Matilda said, glancing down at the sheet of paper in her typewriter. "The ideal technician looks like a young Robert Taylor combined with the best features of Rock Hudson and Richard Chamberlain. He dresses as though he just stepped out of a colored-page catalogue advertisement of clothing suitable for work and play—razor-sharp pants creases and all—and he looks that way all day long, no matter what the temperature or how many dirty TV sets he has been inside. He has the natural good manners of Pat Boone and is as witty and entertaining a conversationalist as a talk-show MC.

"He loves children and is as good with them as a Sesame Street actor. He doesn't mind at all if they play with his tools, twist the knobs on his instruments, and pepper him with questions. If you want to run next door for a cup of coffee with the girls, he will be glad to watch the kids for you while he is fixing your TV set.

"His brain is stored with complete, detailed, and accurate knowledge of all the circuitry and weaknesses of all models of all makes of color and black-and-white TV sets, stereo amplifiers, record players, tape recorders, garage-door openers, and other miscellaneous electronic devices; so all he has to do is take a casual look at a malfunctioning piece of equipment to know instantly what is wrong with it and how to repair it—I mean repair it right there in the home, because he never, *never* has to take a TV set into the shop or go any farther than his truck parked at the curb for any replacement part he needs. He is lightning fast in his work and is as dexterous with his tools as a brain surgeon. And when he repairs something, it *stays* repaired. He has some sort of magic so that if he replaces just one tube in a set, none of the other tubes, resistors, capacitors, transformers, or other components he hasn't even touched will *dare* to fail for a long, long time.

"No, he never has to make callbacks, and he always leaves the house looking better than he found it. But best of all, his charges are no higher than they were back in 1950. He enjoys working on electronic equipment so much that he is satisfied with the pay of an illiterate odd-jobs man, even though to be truly proficient in his work he must have a technical knowledge equal to that of a lawyer or a doctor. What's more, he must maintain a technical library running into thousands of dollars; and the parts inventory he carries, plus the cost of his expensive, fragile, precision instruments runs into more thousands. No matter; he still is happy to work for peanuts."

Mac was grinning broadly as she finished. "You two have done a pretty good job, especially considering that you've had to study your subject by looking into a distorting mirror, as it were. Now let's hear what the perfect customer is like."

"We've not finished working on her," Matilda said. "You can help us. I'll read you what we've come up with so far:

"The perfect customer is an intelligent, reasonable, responsible woman. She doesn't expect her electronics equipment to last forever without needing service, and she considers the cost of such service part of the price she pays for enjoying that equipment. The original cost is merely the other part of that price.

"Being intelligent, she reads, comprehends, and *keeps* the instruction manual that comes with her clock radio, TV receiver, or what have you. She reviews this manual before she calls the service technician to make sure she has not forgotten or overlooked anything about proper operation: Is the set plugged in? Is the circuit breaker latched? Are all controls properly set? Is the antenna connected? When convinced something is really wrong, she notes the make, model number, and serial number of the unit so that she can give this to the service technician when she calls him. That enables him to have the proper service literature and parts that are likely to fail with him when he makes his call. She also describes the malfunctioning of her set as clearly and simply as she can: When did it start misbehaving? Is the trouble present on all channels? Does the condition come and go or is it present all the time? Is only the picture, the sound, or a combination of both affected? Finally she and the technician agree on when he will call, not necessarily as to the exact hour, but at least as far as the forenoon or afternoon of a particular day. This allows both parties to plan their schedules more intelligently.

"Incidentally, she realizes she's not the only person in town with difficulty and she does not request immediate service unless there is a genuine emergency. If there is a good reason for requesting speedy service, she explains that reason frankly to the technician, not trying to exaggerate the emergency."

"And when he arrives," Barney picked up the discourse, "she is home and ready for him; you know: hair freshly done, soft music on the stereo, wearing a slinky negligee—"

"That's *not* what we said!" Matilda interrupted. "We said she has removed any objects, especially those easily broken,

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from the top of the TV set. She also has her sweeper sitting handy with the crevice tool attached so that the technician can clean the interior of the receiver. That will save him the trouble of lugging his own sweeper in from the truck. But she need not spread newspapers around on the floor. He'll bring his own dropcloth. Suppose you curb your romantic imagination and stick to the script, Buster!"

"Okay," Barney agreed with a teasing grin. "Actually she should not try to entertain the technician with spritely conversation or expect him to entertain her. The ideal customer remembers his time is money—her money."

"Yes," Mac said, "and if he is like a certain redheaded technician I know, he needs every cell of his small brain to figure out what is wrong with the receiver and how to repair it. If she talks to him and distracts him from the problem at hand, it will take him twice as long to make the repair, if he is able to make it at all."

"I'm ignoring your snide remarks," Barney said loftily; "but on the subject of distractions, the good customer keeps her children out of the technician's equipment and out of his hair. It takes a better man than I am to concentrate on a convergence job while the little monsters are plugging in my soldering pencil or playing catch with tubes from the caddy. It's just as bad when they keep asking over and over: 'Why are you doing that? What does this little button do? If you're a crook, like my daddy says all TV men are, where's your gun? Oh, here it is in your tool box. It has a light on the front. Is it a ray gun?' "

Mac chuckled at Barney's description. "Know what you mean. The ideal customer corrals the children in the kitchen, nursery, or playroom while the technician is working unless she has them under better control than most mothers do these days. This not only helps the technician; it also protects the children from possible injury from sharp tools, burning tools, and irritating or freezing electronics chemicals that are usually to be found in the technician's tool box.

"Your ideal customer doesn't insist that the technician perform all work in her home any more than she insists her doctor perform an appendectomy on one of her children on the kitchen table or that the garageman do a major overhaul on her car in the carport. She does not believe he wants to take her TV set to the shop just so he can secretly charge her for work he doesn't do nor for parts he doesn't install. She realizes not all of the fragile, easily damaged equipment in his shop is portable and that occasionally something goes wrong with a set that requires the use of this shop equipment. The technician is not wild about having to remove the heavy chassis and lug it in and out of his truck several times, but occasionally he hasn't any other choice. He much prefers to service the receiver right in the cabinet if that is possible."

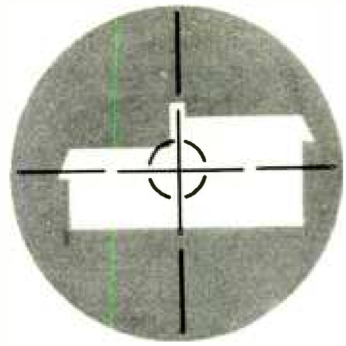
"That brings us to the subject of estimates and service charges," Matilda said. "The ideal customer doesn't hesitate to ask for an estimate of repair costs as soon as the technician has located the trouble. He certainly does not consider her 'cheap' for doing so. She, on the other hand, expects to pay for this estimate if she decides not to have the set repaired or if she wants to get another estimate, as she may want to if it involves a major expense, such as changing a color picture tube.

"She understands that locating the trouble is the most technically demanding, time-consuming part of the technician's work; and she doesn't expect free estimates from him any more than from her doctor. Also, she understands that if the technician quotes her a range of possible cost in his estimate, he is trying to protect her interests as well as his own. Quite often he can't tell if there are minor troubles with the set until the major malfunctioning is corrected; for example, a set may have had some things wrong with it before a picture tube or sweep transformer went west, and he can't know of these things until the new component is installed. The lower figure in his estimate takes care of only this major trouble. The higher figure is intended to take care of other things that may show up when the major malfunctioning is corrected. If she insists he quote a hard-and-fast figure and stick to it, he naturally will quote a figure high enough to take care of such eventualities. If the major trouble is all that's wrong, the customer is the loser."

"And if he must stick with a too-low estimate," Mac said, "he simply will not correct things he sees wrong with the set but the customer doesn't. In this case the customer is still the loser because correcting those things, when they become bad enough, will mean another service charge.

"It is this kind of callback charge that usually gets the customer hopping mad—even if the technician can 'prove' that the new trouble has nothing to do with the earlier call.

"Well," he said as he slid off the desk and stretched until his bones cracked, "we're never going to see the ideal service technician nor the ideal customer. But maybe it doesn't hurt either group to try and see itself through the eyes of the other. And it's sound psychology that the person who expects the worst of a technician usually gets it, while the customer who tries to be a good customer is the one who has least trouble with service people." ▲



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BOOKS

"73 VERTICAL, BEAM, AND TRIANGLE ANTENNAS" by Edward M. Noll, W3FQJ. Published by *Editors and Engineers, Ltd.*, New Augusta, Ind. 159 pages. Price $4.95. Soft cover.

If you are one of the hams who feels the excitement has gone out of your hobby with the advent of pre-packaged rigs, here is your chance to build part of your station equipment from the "ground up" and improve your operations as well.

The author has built and used the 73 antennas he describes in this compact handbook. Any ham can do likewise, whether he wants a simple quarter-wave vertical or elaborate yagis, quads, and triangles. The formulas for figuring antenna sizes and the instruments needed to optimize the designs and obtain maximum performance are covered.

The text is well illustrated, concisely written, and comprehensive.

* * *

"1-2-3-4 SERVICING TRANSISTOR COLOR TV" by Forest H. Belt & Associates. Published by *Howard W. Sams & Co., Inc.*, Indianapolis, Ind. 220 pages plus foldout schematics. Price $4.95. Soft cover.

This is the second volume in which the author applies his "1-2-3-4" servicing technique—this time to transistorized color sets. The method involves diagnosis, location, isolation, and pinpointing of the specific trouble by breaking the set down into sections, stages, circuits, and then individual components.

As is the case with all of Mr. Belt's writings for technicians, this volume is informal, yet informative. Servicing experience is assumed on the part of the reader so no time or space is allotted to basics. The material is well illustrated with graphs, charts, schematics, photographs, and block diagrams. Complete schematics are provided for four transistorized color-TV receivers: *Hitachi, Motorola, Sony*, and *RCA* models.

* * *

"UNDERSTANDING SOLID-STATE CIRCUITS" by Norman H. Crowhurst. Published by *Tab Books*, Blue Ridge Summit, Pa. 17214. 189 pages. Price $7.95 hardcover, $4.95 paper bound.

This volume can be used as a primer for those wanting to learn more about solid-state circuitry without having to delve into the physics of why solid-state devices work. The author covers diodes, transistors, SCR's, FET's, LED's, and voltage-sensitive elements and then discusses their applications.

The text material is well illustrated, the writing is clear and concise, and the entire presentation such that the book can be used either as a reference work or for its general information content.

* * *

"RCA SOLID-STATE HOBBY CIRCUITS MANUAL" compiled and published by *RCA Distributor Products*, Harrison, N.J. 363 pages. Price $1.95. Soft cover.

This new edition of one of *RCA's* most popular manuals contains over 60 practical solid-state circuits which range in sophistication from simple power supplies to amplifiers, counting circuits, clocks, and a wide range of novelties and gadgets. In each case, the circuit is diagrammed, a parts list provided, and a photograph of the completed project provided. PC board and drilling templates are included, along with information on suppliers of the various components that are needed.

Five informative chapters precede the construction material and deal with the theory and operation of solid-state devices, general circuit considerations, mechanical considerations, testing and troubleshooting, and suggested circuit uses.

No matter what your experience in working with solid-state circuits, there should be some project presented in this handy volume that will appeal to you—as a challenge to build or as a useful piece of equipment to have.

* * *

"ELECTRONIC COMPONENTS AND MEASUREMENTS" by Bruce D. Wedlock & James K. Roberge. Published by *Prentice-Hall, Inc.*, Englewood Cliffs, N.J. 332 pages. Price $12.00.

It is heartening to find these two MIT professors devoting the first chapter of this practical how-to-do-it manual to safety in the laboratory and the "do's and don't's" for working with electrical, mechanical, and chemical devices.

With that important start, the discussion continues with basic laboratory practices, elements of data presentation and analysis, elementary scopes, basic d.c. and a.c. meters, graphical displays, resistors, capacitors, inductors and transformers, d.c. power sources, advanced scopes, storage and sampling scopes, advanced voltage and current measurements, signal and pulse generators, frequency and waveform analysis, operational amplifiers, digital IC's, r.f. impedance measurements, coaxial cables, thermal measurements and heat sinks, and the basic characteristics of semiconductor devices.

Although originally written as a classroom text for freshman or sophomore classes at MIT, the material is basic enough and so clearly written that anyone wanting to learn measurement techniques or brush up on his own procedures will find this volume invaluable.

Lavish illustrations and the inclusion of a wide variety of "exercises" for the student offer the instructor extensive scope for presenting this material to his class.

* * *

"THE SYNTHESIS OF TRANSISTOR AMPLIFIERS" by Michael Kahn & John M. Doyle. Published by *Holt, Rinehart and Winston, Inc.*, New York. 397 pages. Price $10.95.

This is a specialized text written at the junior college/technical school level and is designed to give the student a working knowledge of the principles of amplification and of the transistor's role in providing such amplification.

For an understanding of the material the student should be familiar with a.c. and d.c. circuits, and be able to handle intermediate algebra and trig. The first three chapters cover basics, chapters 4 through 9 analyze various transistor amplifier designs, while the concluding chapter is a practical "how-to" exercise in designing amplifiers. Problems and exercises are included with each chapter.

* * *

"TV SERVICE MANUALS" published by *Tab Books*, Blue Ridge Summit, Pa. 17214. Each $7.95 leatherette cover, $4.95 paperbound.

The three latest volumes in this publisher's series of service manuals cover *RCA* monochrome receivers (by Carl H. Babcoke), *General Electric* color sets (by Robert L. Goodman), and *Sylvania* color receivers (by Stan Prentiss). All three follow the same format with special hints regarding specific models; information on adjustment, setup, and convergence; troubleshooting; tuner alignment; video circuit and audio circuit problems; remote controls; case histories and modifications; and other pertinent data.

Each manual is $8\frac{1}{2}" \times 11"$ and contains large and clear illustrations, partial schematics, and foldout diagrams of the sets being covered. ▲

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Locating Faults

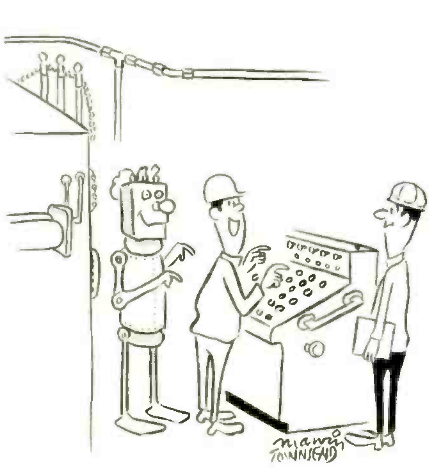
(Continued from page 42)

The maximum value of $R3$ should be not less than the resistance of both conductors in series—a little more than 1.5 ohms in this example. The best way to get a precisely adjustable resistor of low resistance for $R3$ is to set up a slide wire consisting of a short length of nichrome wire stretched out along a yardstick with a jumper of copper wire connected from one end and a movable clip on the other. Table 2 shows the resistance of nichrome wire sizes that can be used. This wire must carry the full current through the cable.

Now you are ready to measure the location of the fault. Merely adjust $R3$ until you get a null on the v.t.v.m. The resistance of the fault, whatever it is, will not affect the null of the v.t.v.m. Next, determine the resistance of $R3$. This is simple, knowing the resistance per foot of the nichrome wire used and the position of the clip as measured on the yardstick. Then solve the formula: *Distance of fault from far end* = ($R3$ × *length of cable*)/ *resistance of both conductors in series.*

For this example, suppose $R3$ turns out to be 0.384 ohm (7 inches of #20 nichrome wire); the length of the cable is 300 feet; and the resistance of both conductors in series is 1.545 ohms ($0.2575 \times 2 \times 300/100$). Therefore, the fault is located $0.384 \times 300/1.545$ or 75 feet from the far end. Dig at this spot and you will find the fault.

The application of this detection scheme is limited to the situation where there is only one fault, one good conductor not open or faulted, and both conductors are of the same size and length. It can be adapted to any situation similar to the example chosen, such as remote-control lines, relay cables, or other radio functions. ▲



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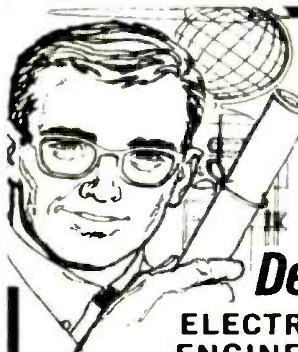

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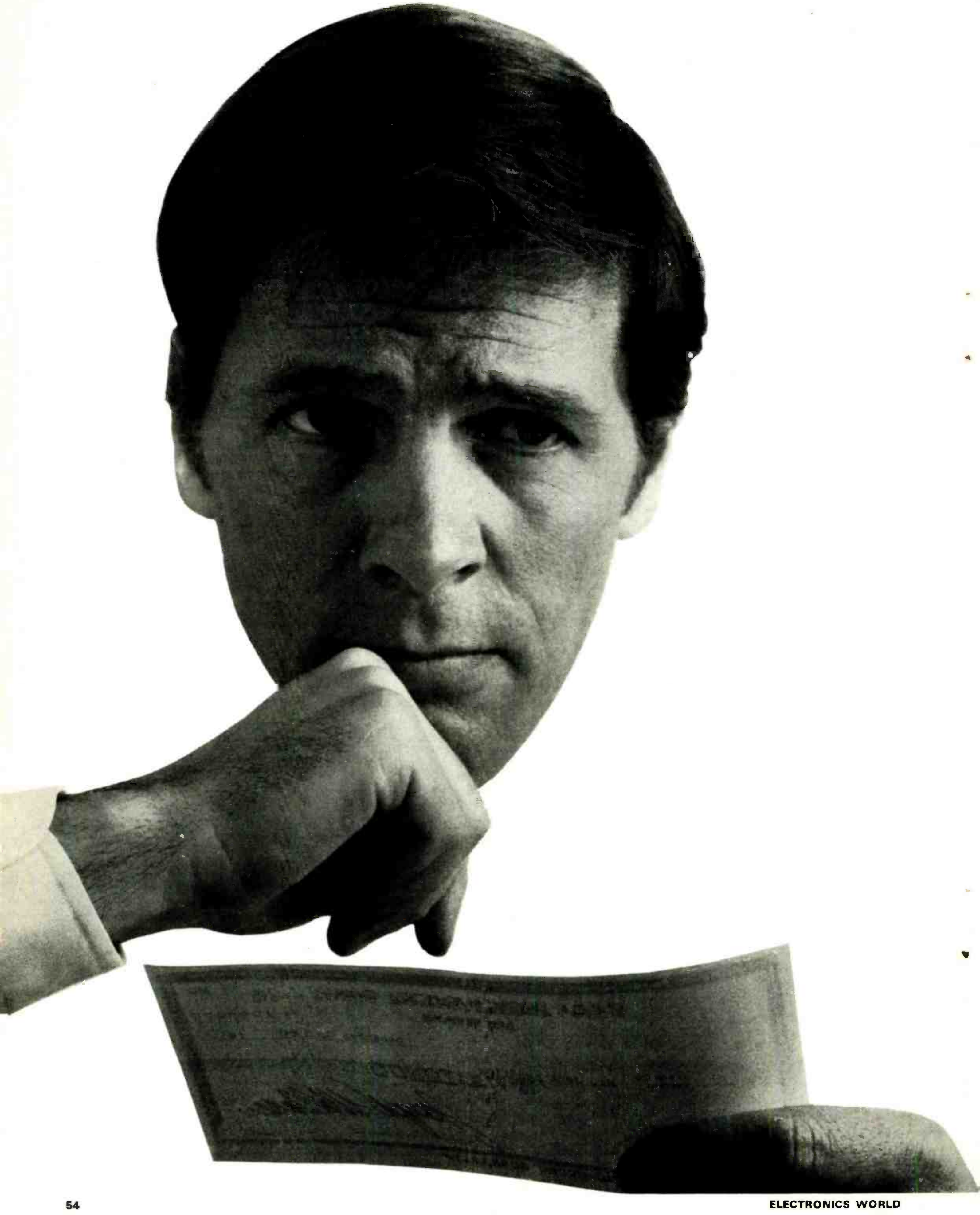

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CATV—Its Future Starts Now

(Continued from page 41)

converter is shown in Fig. 3. An earlier version is used in over 30,000 subscriber's homes serviced by *Sterling Manhattan Cable TV.* The converter is connected between the CATV wall outlet and the antenna terminals of the TV receiver. A 26-position switch selects the CATV channel and there is a fine-tuning adjustment. Channel 12 is used on the TV and 26 channels are available on the converter. Other converters are currently under development and will provide push-button or thumb-wheel switch-selector tuning using voltage-controlled capacitors and frequency-synthesizer techniques for 26 or more channels.

A complete "head-end" installation with all necessary converters and distribution amplifiers is shown in Fig. 5. Highly reliable solid-state circuits and a completely modular approach make this type of equipment an outstanding engineering achievement. Intended as a line amplifier, the solid-state unit shown in Fig. 4 can handle up to 26 channels and is also available with a variety of options. The bandpass and gain characteristics, dynamic range, channel separation, a.g.c. characteristics, and harmonic suppression achieved in much of the new CATV transmitting equipment should warm the hearts of all circuit designers.

Since CATV companies can now originate their own programs, they are also in the market for TV-station equipment, such as TV cameras and video recorders.

Two-Way Transmission

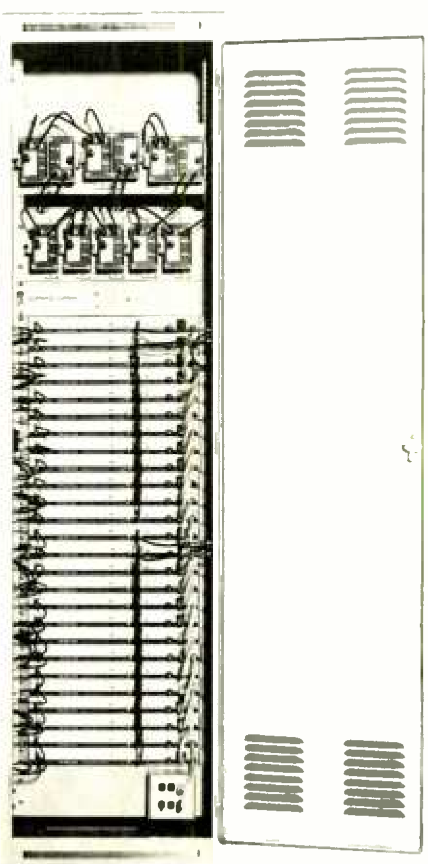
One of the key requirements of the New York City franchise is two-way transmission capability in newly installed CATV systems. Practically all new CATV installations are oriented toward two-way operation since this increases the potential services CATV can offer. This two-way transmission capability permits the monitoring of which programs a subscriber is watching or the connection of fire and burglar alarms through the CATV system. At its most sophisticated level, this capability would implement the great wonders promised by cable TV in the future, such as remote shopping, banking, and direct access to computer terminals. The two-way CATV systems are not in use yet, but plans are being made to implement this particular capability.

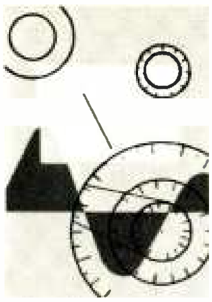
As mentioned before, *TeleVision Communications Corporation* is already installing two cables in each subscriber's home in its Akron system. A number of equipment manufacturers are now offering two-way amplifiers for trunk and line circuits and *Teleprompter,* in conjunction with *Hughes,* has a two-way subscriber terminal under development. Others are also working on a variety of two-way techniques.

There has been a lot of discussion concerning the frequency to be used for the return transmission path, with most favoring a band from about 10 kHz up to 20 or 50 MHz. No matter what the ultimate standards are, two-way cable TV will probably start in operation before the end of 1971.

The CATV industry has been reasonably profitable for many years. But now that program origination and advertising revenues will be available and now that FCC standards and regulation foster growth, the CATV industry has started on its first really dynamic growth level. Between 1970 and 1972 the number of CATV systems is expected to more than double. In the same period of time the number of subscribers should increase several-fold. A whole new generation of equipment, particularly in the area of CATV converters, amplifiers, and studio equipment, is coming on the market. It is clear then that cable TV represents one of the outstanding new growth areas of the electronics industry, a very welcome "shot in the arm" at a time when other fields of electronics seem to have reached a plateau. ▲

Fig.5. A CATV "head-end", such as this one by Blonder-Tongue, consists of all needed converters and distribution amps.





TEST EQUIPMENT

Product Report

Hy-Tronix Model 900 Automatic Transistor Analyzer

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

HERE'S a new transistor tester that is really unique. It uses a blinking display of multicolored lights along with a beeping Sonalert to identify and check transistors and diodes. Separate tests are made on the emitter-base and collector-base junctions. It's not even necessary to know whether your transistor is an *n-p-n* or *p-n-p* type; the tester tells you this by the color of the blinking display at the center of the meter scale. If there are shorts or opens in the transistor, then the light display changes to show this condition. In all there are 24 different combinations of light patterns, using one amber, two red, and two green lights, that indicate automatically the various transistor and diode faults.

Not content with the effective visual display, a beeping Sonalert can be switched in to accompany the blinking lights. This permits the operator to perform in-circuit tests, using the special 3-pronged probe, without having to actually look at the lights to determine whether the device is good.

After performing these qualitative tests, the operator sets up the instrument to use its 8-in meter for quantitative tests. Transistor *beta*, from 0 to 50 or 0 to 500, can be measured at three different values of base current. Then collector-emitter and collector-base leakage currents can be measured directly using one of the six ranges on the meter; these read from 100 mA down to 1 μA full-scale. Finally, there is an Ident function provided, which indicates to the user whether his transistor is a germanium or silicon type.

We used the tester to check a large number of transistors and diodes and it quickly identified and checked them all for us. Although the unit will not check FET's, it can handle just about every other signal or power transistor and diode in current use. For in-circuit testing, as long as the transistor under test has over 270 ohms across its junction, the Model 900 will not be affected by the surrounding circuitry.

The tester is from *Hy-Tronix Instruments*, a new division of *Vanguard Electronic Tools*, manufacturer of pencil soldering irons. It is ruggedly built and the heavy anodized extrusions used as side panels make the instrument look and feel like it comes from a tool company. The case measures almost 9-in wide by 7-in high by 4½-in deep and it weighs almost 7 lbs. A number of IC's are used in the instrument for switching, logic, and to drive the indicator lamps. An a.c. power line is required for operation.

Price of the Model 900 is $287 plus $15 for the in-circuit test probe. ▲

E. F. Johnson Model 250 CB Transceiver Tester

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

WITH all the illegal operation on the Citizens Band these days, we welcome any piece of CB test gear that will help keep responsible CB'ers operating on the right side of the FCC Regulations. *Johnson* has recently come

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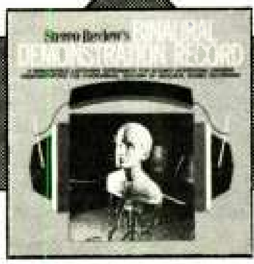

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out with a multi-function CB transceiver tester that should help do this job.

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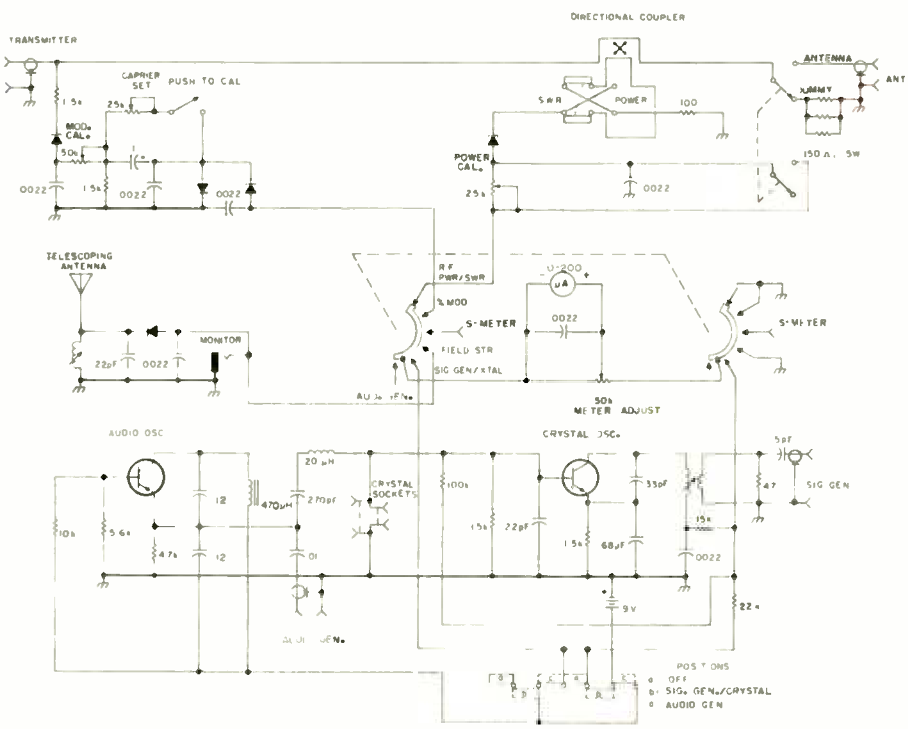
A built-in 50-ohm dummy load permits the operator to make tests and adjustments off-the-air and, without changing cables, switch to his antenna in order to transmit normally. Hence, the transmitter is always kept fully loaded. As can be seen in the diagram below, there is also a built-in audio and r.f. generator, and a crystal-activity tester for CB crystals. Comparative field-strength readings with different antennas or transmitters can also be made using the tester's built-in 42-in telescoping whip antenna.

A detailed instruction manual supplied with the instrument tells how to make all the measurements as well as indicating any modifications required in order to install the unit as an S-meter for your transceiver.

The transceiver tester is all solid-state, operated by a 9-volt transistor-radio battery, compact in size, and readily portable. Price is $49.95. ▲



Sencore PM-157 A.C. Power Monitor

For copy of manufacturer's brochure, circle No. 5 on Reader Service Page

EVERY service or lab bench should have some means of monitoring the incoming a.c. line voltage used to power the equipment being worked on. Some troubles in TV receivers for example are directly related to excessive or insufficient line voltage, so the line should certainly be checked in case of such troubles. Of course, it is possible to use an accurate v.o.m. to check the line, but it is usually undesirable to tie up such a meter which must be used for routine troubleshooting. More convenient would be an a.c. line monitor that is left permanently connected across the line.

The new *Sencore* PM-157 is such an instrument. This power monitor has an a.c. receptacle on its front panel into which the equipment being worked on can be plugged. Not only does the meter monitor the line voltage on an expanded-scale to an accuracy of ±2 percent (at 115 V a.c.), but it will also check on the a.c. line current drawn through the a.c. receptacle or through

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separate test leads. There are three ranges of line current that can be measured: 1 A, 3 A, and 10 A. In addition, the power in watts at 115 volts is indicated on the meter. Finally, several scales are provided for checking fuse resistors of various sizes.

The heart of the PM-157 is a 1-volt full-scale a.c. voltmeter (actually a d.c. movement connected to a full-wave bridge). The meter is connected across a voltage divider and through a pair of back-to-back silicon diodes to read line voltage. The diodes do not start to conduct until the voltage across them is greater than 0.5 volt, and this effectively suppresses the zero and low-voltage readings, permitting the scale to start at about 65 volts. Maximum reading is 135 volts. To measure line current, the meter is shunted across 1-ohm, $1/3$-ohm, and $1/10$-ohm series resistors. A 10-A circuit breaker is used in the instrument to protect it and the equipment that is plugged into it.

Price of the *Sencore* PM-157 a.c. power monitor is $69.50. ▲

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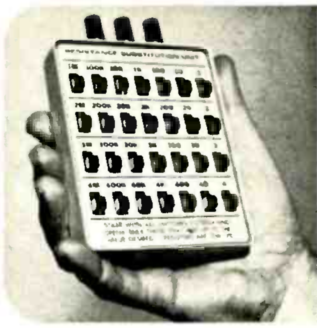

Resistance Substitution Unit

Useful for circuit design and development as well as instrument repair and trouble shooting. Supplies 1 ohm to 11,111,110 ohms in 1 ohm steps. Comes in 4" x 6" x ½" case and furnished with a set of 30" leads, banana plug to alligator clips. **$48**

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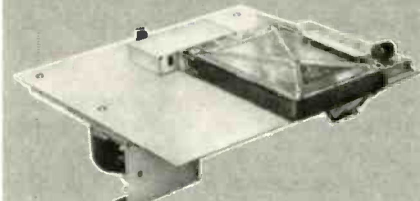

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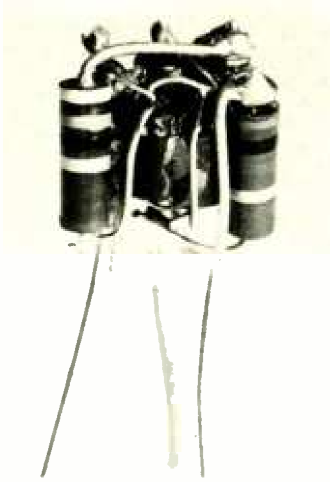
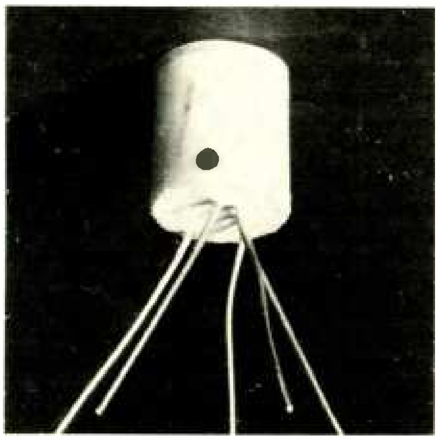
Before potting, here's the module.





After potting, it looks like this.

Make Your Own
Integrated-Circuit Modules

By FRANK H. TOOKER

IC modules can be assembled using potted-in-epoxy discrete components, along with ultra-compact assembly.

DO you have a particularly useful and frequently used circuit that you wish some manufacturer would make up as an integrated circuit? Well, maybe it can't be done economically at the present state of the art. But you can take a worthwhile step in the direction of miniaturization by putting the circuit together as an "integrated-circuit module," using discrete components and an ultra-compact assembly, then potting in epoxy. It's easy, it saves space, it's moisture-proof, and the potted components are protected against damage.

Take a look at the schematic in Fig. 1, for example. This is the potted part of an audio-frequency amplifier and sine-wave clipper. Used in the circuit of Fig. 2, it has a high input resistance (similar to that of a vacuum tube), low distortion, a signal voltage gain of 60, and a frequency response that is down only 2 dB at 20 Hz and 100 kHz. An input signal of 10 mV provides a clean output signal of 0.6 volt. Double the values of the input capacitor and the by-pass capacitor, and the frequency response will be extended down to 10 Hz.

Run the input signal level of this circuit up to somewhere between 0.5 and 0.75 volt, to overdrive the amplifier severely, and the output signal becomes a square wave—quite acceptably rectangular and symmetrical, if the input signal is a clean sine wave. As a sine-wave clipper, the circuit of Fig. 2 operates well over a frequency range of 50 to 5000 Hz.

Furthermore, the encapsulated circuit can be used with a 9-V, 12-V, or 18-V power supply, as shown in Fig. 3. To use it with a 12- or 18-volt supply, all that is needed is an additional resistor to increase the collector load resistance. Required values are given in the inset table of Fig. 3.

As may be noted from an inspection of the table, the gain goes up directly as the supply voltage and load resistance are increased. With an 18-volt power supply, the signal voltage gain is 120. To stay within the breakdown voltage limits of the transistors, the setup should not be used with supply voltages higher than 18 volts. Sine-wave clipper operation is not recommended at potentials higher than 9 volts.

Obviously, the circuit of Fig. 1 has all the characteristics of usefulness that would make a very worthwhile integrat-

Fig. 1. Schematic diagram of the module.

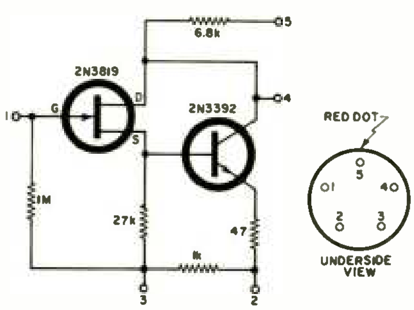


Fig. 2. Amplifier or clipper connections.

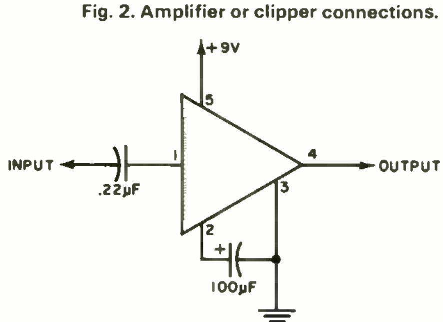
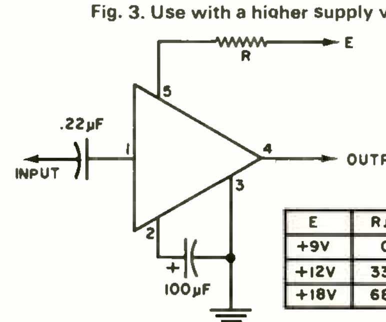


Fig. 3. Use with a higher supply voltage.



E	RΩ	GAIN
+9V	0	60
+12V	3300	90
+18V	6800	120

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ed circuit, if it were only possible to form it that way. Using discrete components, it can be put together very compactly, however. As the photo shows, the author's assembly is a mass of transistors and resistors cemented tightly together. Even though half-watt resistors were used in this particular unit, it pots in a plastic cup measuring only $5/8''$ in diameter by $3/4''$ long, outside dimensions, with space to spare for an additional resistor should the circuit have required it. If quarter-watt resistors had been used, the assembly could have been made into a much smaller package.

Despite the compact assembly, the amplifier is perfectly stable, even when being severely overdriven for use as a sine-wave clipper. After all, if integrated circuits can get by with their ultra-compact assemblies, we should be able to get by with something like this! We can, and we do. Just bear in mind to keep input components and leads as separated as possible from output components and leads.

Whether you pot this or some other circuit, it is always advisable to breadboard the circuit first. Transistor characteristics vary from one unit to another, even those having identical type numbers, and breadboarding enables the selection of resistor values that will give optimum performance of the set-up. Use exactly the same components in the final assembly.

For the final assembly, you will need a miniature soldering iron and a few tiny heat sinks. Some of the transistor leads will be as short as $1/8''$. In general, it's best to cement a component in place, let the cement harden, then perform the lead-shaping and soldering operations. It takes a little longer doing it this way, but you will end up with a structure that is compact and least likely to develop a short-circuit somewhere, either before or during the potting process.

Clear epoxy resin, hardener, and pigments for coloring, are available from marine-supply outlets and from *Sears Roebuck*. The secret of using epoxy successfully for potting or for cementing is to follow the manufacturer's directions exactly. Measure the resin and the hardener accurately and mix them together thoroughly. You can do this more easily and most effectively with a small flexible spatula rather than with a stiff wooden paddle. Put a small amount of the epoxy mixture in the bottom of the cup, fit the assembly of components into it, then fill the cup to the brim.

Finally, mark the side of the cup with a dot of red fingernail polish to identify the positive power-supply lead, then put the whole thing aside where it will be undisturbed for the time required for hardening. ▲

Triggering Logic Circuits

(Continued from page 29)

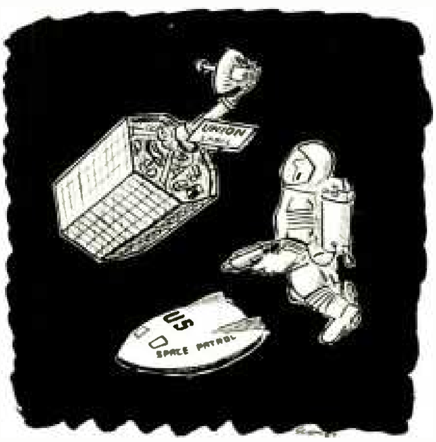
There is one disadvantage to using a latching-type configuration as in Figs. 1A and 1B—a double-throw switch is required. If it is desirable to use a single-throw switch, another approach must be taken.

Fig. 2A shows a one-shot which will generate a single output pulse for an input pulse. Once an output pulse has been started by placing the switch input to gate A at "0," a "0" is fed back to gate A from gate B. This feedback essentially latches gate A for the duration of the output pulse. Consequently, gate A will remain latched and will not respond to spurious inputs caused by contact bounce as long as an output pulse is in progress. Thus, the output pulse itself must be longer than the duration of the contact bounce (5 ms is a safe pulse length). Note that the circuit of Fig. 1B is not restricted to a certain pulse length, but it does require a double-throw switch.

If an output level (rather than a single pulse) is desired, the circuit of Fig. 2A can also be used to supply it. The output of gate A gives a "1" output when the switch is depressed, and a "0" fed back from gate B holds gate A's output at "1" during the period of contact bounce. After contact bounce has ceased and the input rests at "0," gate A's output will stay "1" for as long as the switch remains depressed. In this case, too, the output pulse must last longer than the contact bounce.

A transistor circuit may also be used as a latch (see Fig. 2B). This circuit is equivalent to the logic-gate latch in Fig. 1A.

The circuits discussed here are actually quite simple, but extremely effective. Since contact bounce is the rule, rather than the exception (especially in low-cost toggle and push-button switches), one of these circuits should be employed whenever a switch is used to excite counting and timing circuits which might interpret contact bounces as inputs. ▲



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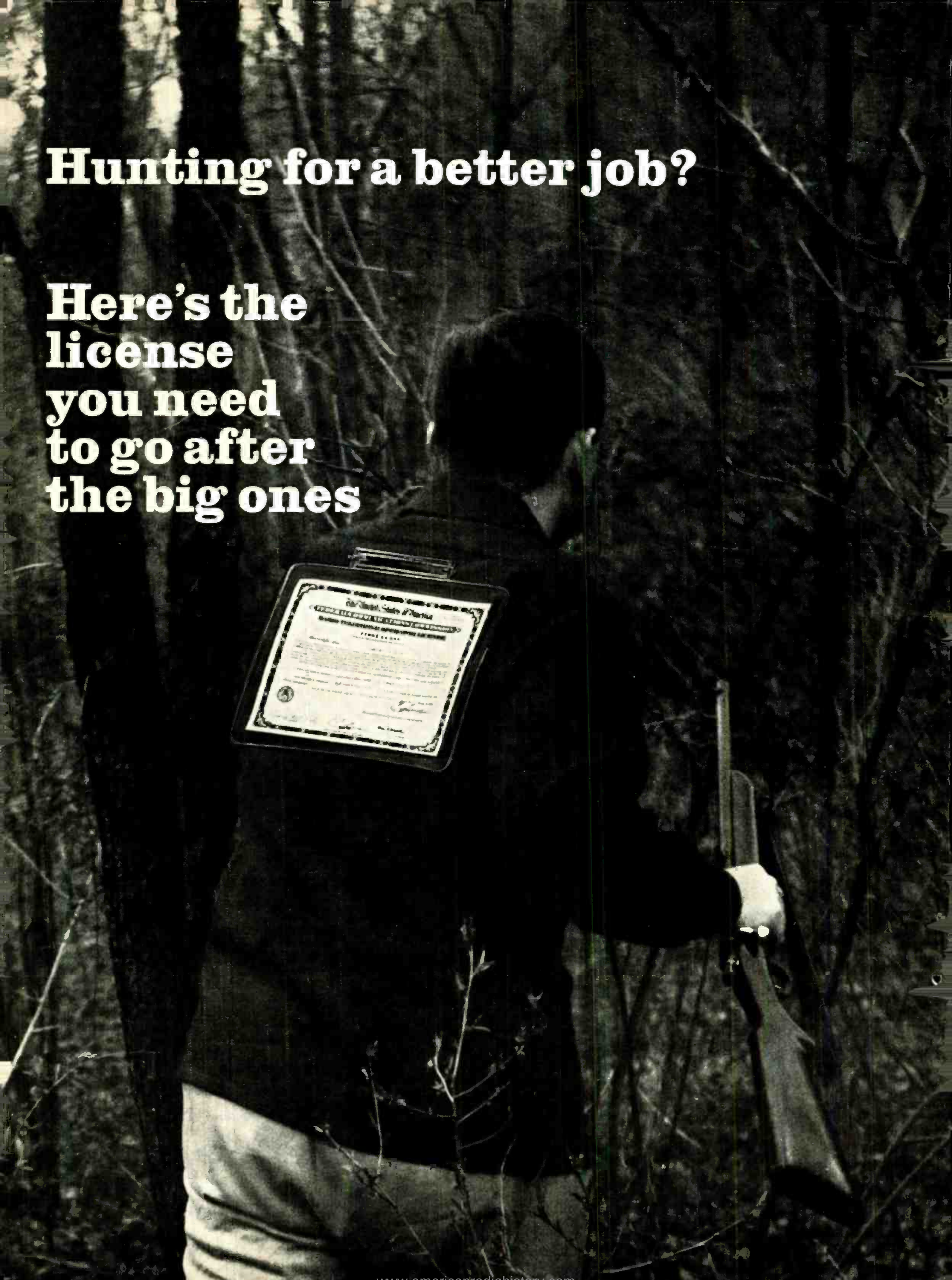

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Eugene Frost, Columbus, Ohio, was stuck in low-paying TV repair work before enrolling with CIE and earning his FCC License. Today, he's an inspector of major electronics systems for North American Aviation. "I'm working 8 hours a week less," says Mr. Frost, "and earning $228 a month more."

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Digital Instruments

(Continued from page 33)

tronic counter, thus providing an added degree of system flexibility and easing electronic-counter packaging restrictions. Spurious mixer products do not occur with a prescaler but the mixer is, in general, capable of operating at a higher frequency than the prescaler. Neither the mixer nor the prescaler requires a gate between the unknown signal and its input.

Designing the first stages of the electronic counter around high-speed logic elements is certainly the most straightforward approach, although the high-frequency input signal must be gated (to preserve resolution) and several inter-family translators are required unless the entire counter is designed around the same logic family. This direct approach is the most convenient operationally, since the unknown frequency can be read directly from the electronic-counter display without further mental computations.

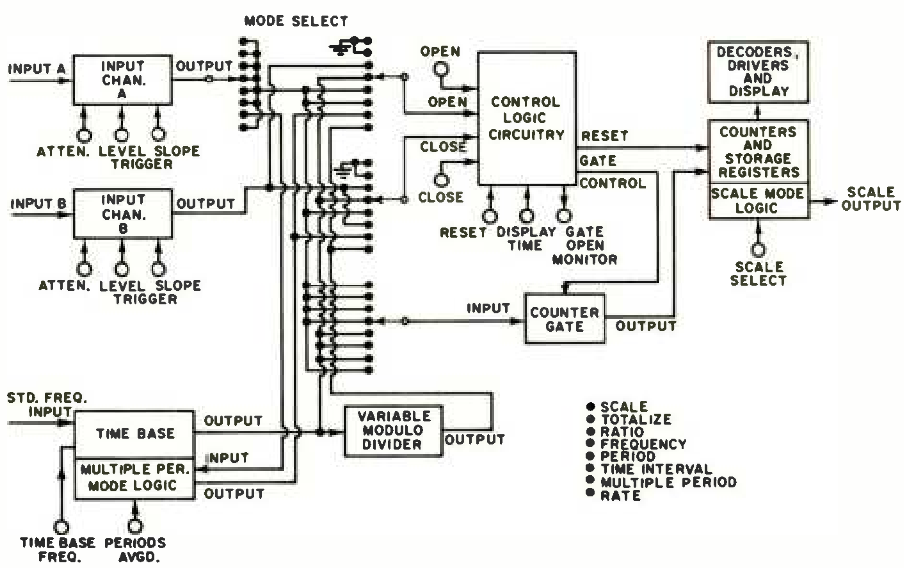
There is obviously no one single approach best suited to extending the frequency range of an electronic counter—and all three methods are often used in a single counter system. The basic counter is usually designed to accept a moderately high input frequency to avoid reducing the resolution unnecessarily through the use of large-ratio prescalers or to ease the mixer selectivity requirements. A typical counter system might use RTL IC's for frequencies to 4 MHz, coupled with TTL (10 MHz), DTL (20 MHz), or ECL (40 MHz) IC's in the first decade counter stage. An external ÷10 prescaler could extend the upper frequency range to 100 MHz, 200 MHz, or higher.

High-speed is not a requirement of all eight electronic-counter operating modes since some modes are useful only at relatively low frequencies. Furthermore, some of the functional blocks within the electronic counter do not operate at high speeds even in a high-speed electronic counter. The highest frequency present within the time base, for example, is the time-base oscillator frequency (typically 1 MHz) which is clearly independent of the operating mode or the operating speed of the electronic counter. Thus, neither the logic elements within the time base nor the logic elements within the Rate mode variable divider are required to operate at frequencies greater than (typically) 1 MHz.

The Period, Time Interval, and Multiple Period modes are useful only for those measurements where the period of the unknown input or control input is much greater than the period of the highest frequency available from the time base. Thus, if the highest time-base frequency is 1 MHz, none of the elements in the electronic counter is ever required to operate at a frequency greater than 1 MHz during Period, Time Interval, or Multiple Period measurements. Even restricting the maximum input frequency of the Multiple Period mode decade divider (usually part of the time base) to 1 MHz rarely results in any operational inconvenience.

The remaining five operating modes (Scale, Totalize, Ratio, Frequency, and Rate) are, however, often used for high-frequency measurements and the electronic-counter system must be capable of high-speed operation in these modes. High-speed operation in these five operating modes requires that the electronic-counter input channel (s), gating circuitry, and the first one or two decade counter/display stages be designed for high-speed operation unless prescaling or mixing is used to reduce the input frequency that is applied to the circuit. ▲

Fig. 4. Switching and functional blocks required to create an 8-mode electronic counter.



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Color TV for 1971

(Continued from page 48)

is in certain chassis of both *Sylvania* and *Zenith*. The tripler in (C) is used in some models made by *Wells-Gardner* for private brands: Catalina, MGA, and Penncrest, among others.

Here's the principle, as illustrated by Fig. 5A, as an example. A 7-kV pulse from a high-voltage winding of the flyback transformer is coupled to the first full-wave diode pair. On the positive swing, one diode conducts. The other conducts on the negative excursion, and adds to the charge that built up from the first excursion. The first capacitor (bottom) soon accumulates a charge equal to full p-p voltage.

After the first several cycles, the diodes all along the chain have produced the same effect. The charges on the capacitors at the top are added to the negative excursions and applied to the capacitors at bottom. As a result, there are four capacitors in series along the bottom, each with 7 kV of d.c. across it. Being in series, the four voltages add, making 28 kV. The time constant is long, which allows the accumulated d.c. to stay near the peak value of each pulse. Losses lower net d.c. output to 26.5 kV.

The ground return for the high voltage is through the brightness-limiter transistor. Thus the limiting circuit is accurately sensitive to beam current drawn by the picture tube.

A voltage tap between the first two capacitors gives a d.c. source of about 7 kV for focus. A resistive divider network that includes the Focus control drops the voltage to the 4.5 to 5.5 kV needed by most color picture tubes.

The triplers in Figs. 5B and 5C operate much the same way, except a higher-voltage pulse is used. Again, the 8-kV d.c. voltages develop—after a few cycles—across the three bottom capacitors. In series and working into a long time constant, the voltages add up to 24 kV.

The version in Fig. 5C eliminates some of the capacitors. Still, the d.c. voltages across the capacitors (after a few cycles) are in series. So, the output is again 24 kV. As before, the focus voltage comes from a tap at the first of the three "sections."

The new design trends covered in this article and in last month's Part 1 show what the various color-TV set manufacturers have been doing to make their receivers perform better, be more reliable, and easier to service. It's now up to the consumer to decide whether he wants a color set in the first place and whether he can afford to buy one in the second. Set makers are hoping the answer to both questions is "yes." ▲

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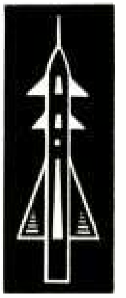

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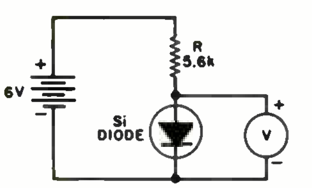
By GORDON GREGG

Temperature characteristics of silicon diodes make them ideal sensors for monitoring the ambient or power electronic-equipment temperature.

SILICON diodes make good temperature sensors. Used in a probe on a cable, an accurate remote-reading thermometer, with direct readout on a panel meter, can be built rather easily. In this application, practically all silicon junction diodes of all types will work. The instrument can be used to monitor temperatures outdoors, in attics, of photographic solutions, refrigerators, ovens (below about 200°F), and power electronic equipment.

The effect used is the forward voltage drop of a *p-n* junction at a constant current. The current, typically 1 milliamp, is a value above the knee of the *E-I* curve. The curve of forward voltage drop *vs* temperature is a characteristic of the semiconductor itself rather than of the mechanical construction of the diode; and semiconductor-grade silicon is a very pure and uniform material.

Fig. 1 shows the basic circuit, stripped of all frills, together with voltage *vs* temperature data. Between 0° and 100°F, the voltage changes by 182 millivolts. The supply does not need to be precisely regulated because the voltage drop varies more slowly, percentage-wise, than the current. An ordinary zener regulator and a fixed series resistor, *R*, are adequate for normal use. If a battery supply is used, mercury cells are recommended.

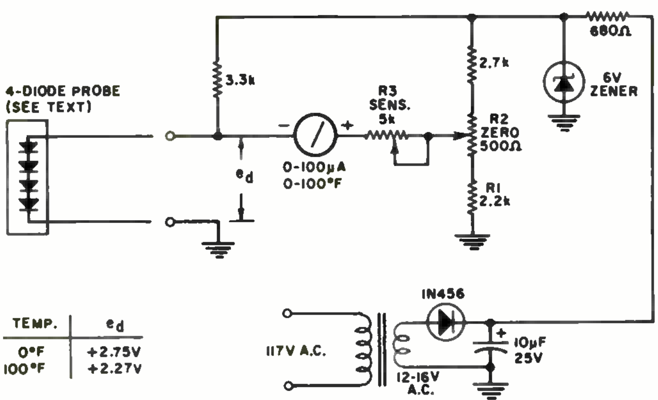


°C	°F	V-mV
−18	0	688
0	32	650
10	50	629
21	70	606
38	100	506
66	150	411
100	212	270

TEMP. COEFFICIENT OF V = 2.11 ± .06mV/°C = 1.17 ± .03mV/°F

Fig. 1. Schematic diagram of a basic silicon-diode thermometer circuit and forward voltage drop versus temperature data.

Fig. 2. Schematic showing a complete, practical remote-reading thermometer circuit using a four-diode (in series) probe.



Complete Circuit

Fig. 2 is the complete circuit of a practical diode-thermometer. Four diodes, in series, are used in the probe in order to get a wider range of signal wattage to operate the meter. A simple rectifier and transformer power supply, with a zener regulator, is used. Mercury cells can be used, without the zener, but then a "push-to-read" switch should be included. Current drain on the battery supply (not counting the zener) is 2.3 mA. The indicating meter is connected in a bridge circuit so that "zero" can be positioned at will and the desired temperature range spread out over the whole scale. The "Zero" pot, *R*2, sets the location of the temperature range on the meter scale. These are screwdriver adjustments, set only once. Good-quality wire-wound pots and high-quality film-type or wire-wound resistors should be used. With the zener regulator, as shown in Fig. 2, a change in line voltage of 10 percent induces a meter reading error of about 1°F.

The sensor diodes (Fig. 3) are glass-cased 1N916's, obtained from a surplus source. They are soldered in series in a bundle, and the free leads soldered to the end of the cable. The whole bundle is then dipped in coil dope or other insulating material to protect the probe when it is calibrated in a water bath. Suitable diodes include the 1N456-1N464, 1N482-1N488, and 1N4383-1N4385 series. Silicon rectifiers will do, too. For the cable, two-conductor speaker wire is handy. The cable shown in Fig. 3 is Teflon-insulated subminiature coax picked up in a scrap-metal yard. Cable length doesn't matter. It could be 100 feet.

The circuit was built into a 6" × 2" × 3½" utility box. Considerations of wiring capacitance and insulation leakage are pretty well out of the picture since the highest frequency involved is around 1/10th Hz and the impedances are all low.

Calibration

The only equipment needed to calibrate the meter is a conventional thermometer, to be used as the standard, and two temperature sources. The cold source is a glass of ice water which will remain between 33°–40°F as long as some ice is present. The high source, for the 0°–100°F range, is a glass of lukewarm water at around 100°F. First place the thermometer and probe (making sure that the insulating

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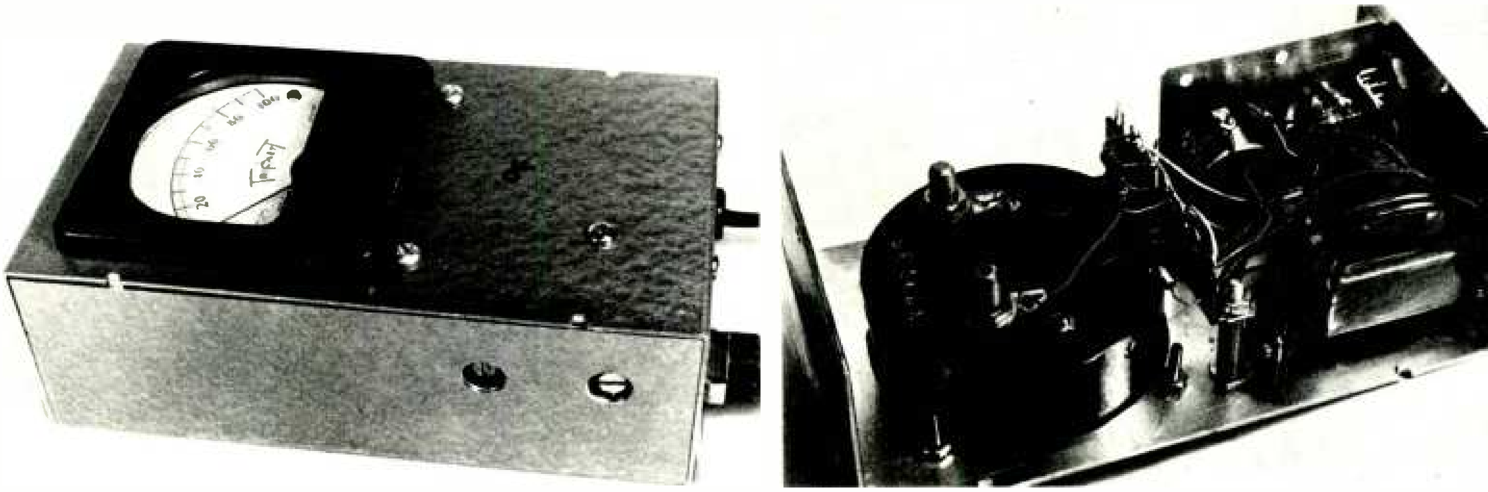


(Left) External and (right) internal views of the solid-state thermometer built by the author.

coating on the diode probe has dried) into the ice water. Stir and then adjust "Zero" pot *R*2 until both instruments (thermometer and meter) agree. Then put the thermometer and probe into the lukewarm water and set "Sens." pot *R*3 until both instruments are once again in accord. Since the cold source is not at 0°F, this procedure should be repeated four or five times for best accuracy. The solid-state thermometer is now ready for use.

Variations

To extend the range to, say, 0–100°C, or 0–150°F, merely add a 5k-ohm resistor in series with "Sens." pot *R*3 and then make the necessary changes on the meter face.

The data in Fig. 1 was calculated at the National Research Council of Canada, where some dozens of various diodes were tested (see "Semiconductor Diodes and Transistors as Electrical Thermometers," by A.G. McNamara in the *Review of Scientific Instruments*, Vol. 33, pgs. 330–333, 1962). Diode temperature probes are especially useful in a physics or chemistry lab that is equipped with potentiometric-type chart recorders. With such recorders, the elementary circuit of Fig. 1 is all that is required. The "Zero" and "Span" controls on the recorder take care of the rest; 0–120 millivolts d.c. is an input range that fits these instruments nicely.

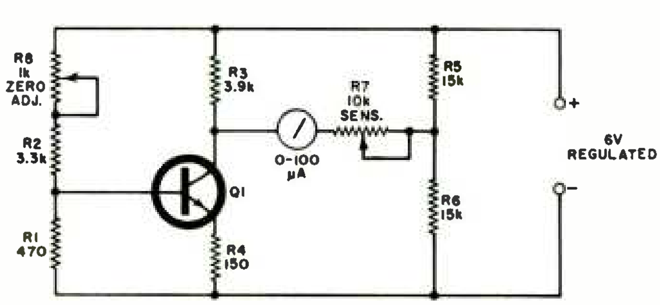
For panel-meter readout, however, 120 millivolts is inconveniently low. A typical 100-μA panel meter has an internal resistance of around 800 ohms and so needs 80 millivolts full-scale. This internal resistance is all in the copper-wire coil of the meter, and copper resistance changes by about 4 percent per 100°C. Not a lot, but something; we don't want the meter doing thermometry on its own. In normal practice, the copper effect is swamped out by using a low-temperature-coefficient external multiplier resistor that is several times higher in value than the meter resistance. This we do here, getting more volts of signal full-scale by using more diodes in the probe. There is no advantage in using a more sensitive meter, such as 0–50μA, because in practical meters the internal resistance goes up a little faster than the full-scale current goes down.

Germanium junction diodes can be used in place of silicon, but offer no particular advantage. The forward drop is smaller and the temperature coefficient is a bit lower. At 0°C (32°F), the drop is about 340 millivolts and the coefficient –1.83 $\pm$0.07 millivolt/°C (compared with –2.11 $\pm$0.06 for silicon). To use the circuit of Fig. 2 with germanium probe diodes, merely change the value of *R*1 from 2.2k-ohms to 1k-ohm.

It is also possible to use a transistor as a temperature sensor and get some amplifying action out of it at the same time, although the general stability of the circuit is not as good as with diodes. Fig. 4 shows a transistor circuit, adapted from the referenced article. The forward drop of the base-emitter junction of transistor *Q*1 varies with temperature the same as any silicon junction. Due to the low impedance of *R*1 in the base-emitter circuit, the transistor is effectively connected in a common-base configuration; therefore, collector leakage current is not amplified. The collector current, which is nearly the same as the emitter current, produces a relatively large voltage drop across collector load resistor *R*3, providing a fairly adequate signal on the order of 2 volts to work the meter. The meter is in a bridge circuit, generally like that of Fig. 2, using *R*5 and *R*6 to provide a return point. Sensitivity is set by *R*7 and zero by *R*8. Almost any silicon transistor, such as the 2N697, 2N708, or 2N929, will work. The operating point, however, is highly dependent on the supply voltage, which must come either from mercury cells or a double-regulated, temperature-compensated zener supply. ▲

Fig. 3. The diode-probe used with the solid-state thermometer. Sensor diodes are shown soldered in series in a bundle at end of Teflon-insulated coax.

Fig. 4. Solid-state thermometer circuit using a transistor as an amplifying sensor instead of a diode. This circuit requires more stable resistors and power supply than circuit of Fig. 2.



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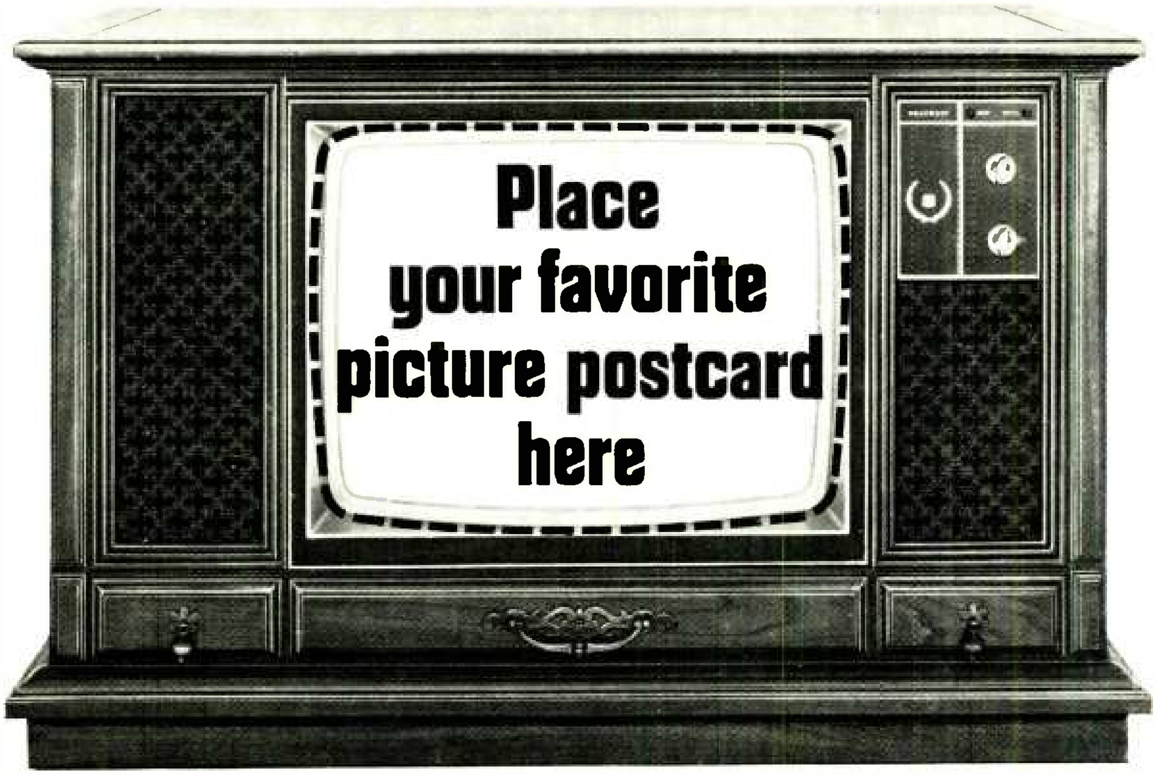

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(B)

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(C)

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(D)

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COMPONENTS • TOOLS • TEST EQUIPMENT • HI-FI • AUDIO • CB • COMMUNICATIONS

STEREO MUSIC SYSTEMS

A new line of compact music systems, offering various options to meet individual requirements, has been introduced as the "Festival" series.

Available in eight models, all units feature AM/stereo-FM tuners with usable FM sensitivity of 2.7 μV (IHF) and stereo-FM separation of 30 dB. Each model includes a four-speed record changer equipped with a statically and dynamically balanced tonearm and magnetic pickup. A choice of speakers is offered with all models. Four of the models include a stereo tape cassette recorder which plays and records in mono or stereo and records from AM, FM, stereo-FM, phono, and microphones.

The Model 445 is the top of the new line and

provides 110 watts output. Complete details on this and other models in the line will be supplied on request. Harman-Kardon

Circle No. 6 on Reader Service Page

C8 TRANSCEIVERS

A new line of hand-held CB transceivers designed for both personal and commercial use has been put on the market.

Three of the models are rated at 5 watts, one at 2 watts, one at 1 watt, one at 500 mW, and one at 100 mW. The 5-watt line includes the Models T-1000 (23-channel operation), T-909 (any 6 of 23 channels), and T-808 (any 6 CB channels). The Model T-707 provides 2 watts of power and has delta tuning. The Model T-606 is rated at 1 watt and offers any 6 of the 23 CB channels. Two three-channel models are available as the Model T-505 (500 mW) and the Model T-404 (100 mW).

Complete information on these new portable transceivers and details on available accessories to be used with them are available on request. Fanon

Circle No. 7 on Reader Service Page

TRANSISTORIZED RADAR

A transistorized radar no bigger than a breadbox has been introduced as the Model 2900. The new unit has an unusually compact indicator to simplify installation in tight quarters found aboard most smaller vessels. Its rotating antenna is protected from the weather and is kept from fouling halyards by an over-all, lightweight plastic radome. The antenna assembly is $33\frac{1}{2}$ inches in diameter and weighs only 48 pounds in spite of the fact that elements of the transmitter and receiver are installed in it.

For ease of servicing, the complete antenna assembly can be removed by loosening one knurled hand nut and unsnapping a quick-disconnect cable. The electronic portion can then be taken below decks adjacent to the indicator for tune-up or alignment.

Range is 32 miles and the radar generates 7 kW of power to bring in targets at long range. The unit will operate from line voltages of 12, 24, 32 volts d.c. and 110 volts a.c. Raytheon

Circle No. 8 on Reader Service Page

MIXER MODULES

A new "Mixable Mixer" which permits the custom design of a mixer/preamp with up to six inputs, as needed, from the firm's standard modules is now available as MIX-6.

This flexibility provides the systems engineer with design freedom to create exactly the input/output configuration required or to change the configuration as needed. Modular construction also permits the integration of telephone, microphone, and program preamps with signaling or alarm tone generator. Control functions such as priority paging, remote volume control, or volume limiting are also available as standard plug-in modules.

Among the functions available in standard modules are: high and low impedance microphone preamp; 600-ohm balanced input preamp; remote volume control; volume limiter; and siren, chime, or yelp tone generator.

Spec sheets, price lists, and other detailed information (including a complete list of modules) are available on request. Bell P/A

Circle No. 9 on Reader Service Page

P.A. AMPLIFIER

Two lines of public-address amplifiers, one using tubes and the other transistorized, have been introduced recently.

The "S" tube line offers two microphone/two auxiliary, master, treble, and bass controls with a trumpet saver in models rated from 10 to 100 watts. The "ST" transistorized line provides

four channel inputs which may be used for either microphone or auxiliary inputs (4 inputs), master, treble, and bass controls with trumpet saver also in power ratings from 10 to 100 watts. Grommes/Precision

Circle No. 10 on Reader Service Page

110-WATT STEREO RECEIVER

The Model 636 AM/stereo-FM receiver incorporates the company's "Perfectune" automatic tuning circuitry, lights on the front panel to indicate reception of AM or FM, and a full complement of front-panel controls.

Virtually all solder joints have been eliminated in the construction of the 636 by use of a tension-wrapped electrical connection technique, which effects a permanent bond. According to the company, such connections are resistant to vibration, shock, and aging and provide better contact than traditional solder joints.

Silver-plated FET's are used in the front end and in the tone control for a maximized range of tone-control adjustment. The all-silicon output circuitry provides maximum power. H.H. Scott

Circle No. 11 on Reader Service Page

CASSETTE DECK

The new Model A-24 cassette deck features automatic pinch-roller disengagement by means of a special end-of-cassette sensing circuit which not only stops the cassette but completely disen-

gages the mechanism, thus avoiding flats and deformation of the critical drive components. The deck also has its own input selector for tuner or line sources or can be connected into an existing stereo system.

Operation is simple and foolproof with piano-key push-buttons to control stop, rewind, record, play, non-latching fast-forward, cassette pop-up, and instant pause functions. There are dual clutch-type record and output controls for optimum balance and level adjustments in all modes.

The Model A-24 includes a dual vu meter for accurate level and balance during recording or playback and a 3-digit counter for easy indexing of selections within the cassette or locating them for cueing. A pause button provides editing facilities with push-button simplicity.

Frequency response is 40-12,000 Hz ± 3 dB and S/N ratio is 45 dB or better. The two heads (erase and record/playback) provide 4-track, 2-channel stereo capability. The deck operates from 117-volt, 60-Hz power source and measures $13\frac{5}{8}$" wide $\times$ $9\frac{5}{8}$" deep $\times$ $4\frac{3}{4}$" high. Teac

Circle No. 12 on Reader Service Page

V.H.F./FM MARINE UNIT

The Model B is an all solid-state v.h.f./FM marine radiotelephone with 25 watts maximum permitted power output. There are 12 two-way communications channels plus ESSA weather reception facilities.

The unit features G-10 glass epoxy circuit boards rigidly mounted with plug-in connectors, pretested components machine soldered for trouble-free operation, a front-mounted speaker, push-button channel selection, an any-position mounting cradle with quick-release catches, reverse-polarity protection, fully adjustable gate squelch, MOSFET receiver front-end, silicon transistors, IC's, and a 1-watt transmitter power switch.

The radiotelephone measures 10" wide $\times$ $12\frac{1}{2}$" deep $\times$ $3\frac{1}{2}$" high and weighs $8\frac{1}{2}$ pounds. Simpson Electronics

Circle No. 13 on Reader Service Page

CB BASE STATION

The "Cobra 25" is a 23-channel, solid-state transceiver which has been specifically designed for use as a base station wherever reliable communications must be maintained, according to the company.

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An FET mixer stage eliminates crosstalk and the circuitry includes ceramic filters and IC amplifiers. Other features include delta tuning for reduction of off-channel interference, a speech compressor, 5 watts input and 4 watts output, crystal-controlled transmit and receive on all 23 channels, and two front-panel meters (power/S and s.w.r./modulation).

The receiver is a dual-conversion superhet with a switch-controlled noise limiter, a.g.c., better than 50-dB rejection of spurious signals, and facilities permitting the unit to be used as a p.a. system.

The station is housed in a tan case with black die-cast front panel. It measures 13" × 5½" × 9" deep and weighs 11½ pounds. It operates from 117 V, 60 Hz. Dynascan

Circle No. 14 on Reader Service Page

MARINE POWER HAILER

The "Seacall" power hailer has been designed to permit voice communications between vessels separated by distance or over the sounds of inclement weather. It can also be used for communicating with a marina when docking. An automatic control permits the device to be used as a fog horn that sends out a continuous signal every 3 seconds, or it can be operated manually.

Included is an intercom control for use as a complete intra-ship intercom system, an intrusion alarm, an auxiliary control for tape player and FM tuner, and a jack for separate remote unit for the flying bridge.

Of watertight construction, the unit measures 9" d. × 8¾" w. × 3½" h. and has a maximum power output of 70 watts. Unimetrics

Circle No. 15 on Reader Service Page

MULTI-CONTROL ROTATOR

A new antenna rotator which can be controlled from two, three, or four different rooms has been introduced as the Model 9513.

Dual or triple controls are available on the 9513 semi-automatic rotator drive and control set. Any of up to four control units can be used to operate the drive unit. Any competent electronics technician can modify the 9513 rotator for multi-control use. All that is required is that a 130-μF capacitor be replaced by a 65-μF capacitor and the control units be interconnected as instructed. Channel Master

Circle No. 16 on Reader Service Page

LORAN-A RECEIVER

A new loran-A receiver which provides complete facilities for both manual and automatic tracking of loran-A signals has just been introduced as the Model 6809.

The compact unit (10½" wide × 9½" high × 12" deep) uses integrated-circuit techniques, improved time-averaging capabilities, and automatic indication of loran time delay independent of manual switch settings. It also permits easy determination of time delay through a direct digital readout on the face of the CRT.

Requiring only 35 watts to operate, the automatic tracker provides effective operation in weak-signal areas, according to the company. It has a differential gain adjustment of over 70 dB and the ability to provide spurious-free operation under adverse conditions. Mieco

Circle No. 17 on Reader Service Page

STEREO TAPE DECK

A three-motor, three-head stereo tape deck has been added to the Sony line as the Model 640.

The new unit incorporates many of the features found on the more expensive Model 650 including a record-equalization selector switch, a die-cast tape guide and head block mounting

frame for permanent alignment of critical transport components, front-panel sound-on-sound and echo controls, and microphone and line mixing. It also features mechanical memory capability which permits timer-activated recording, playback, and shut-off; and positive-acting lever-type transport controls. Superscope

Circle No. 18 on Reader Service Page

PREAMP/AUDIO EQUALIZER

The "Citation Eleven" solid-state preamplifier/audio equalizer control center is fitted with six push-button switches for secondary functions as well as five control knobs and five slide controls for audio equalization.

There are speaker-switching facilities and two low-impedance headphone receptacles which are activated when the preamp is connected to a power amplifier. Conventional tone controls have been eliminated in favor of a professionally calibrated five-position audio equalizer. The equalizer is calibrated to operate over a narrow spectrum which permits precise adjustment of tone at the exact frequency at which adjustment is required.

Frequency response is 2-200,000 Hz ±0.5 dB with corresponding square-wave rise time at 20,000 Hz of 1.0 μs in all functions. Square-wave tilt at 20 Hz is less than 3 degrees and harmonic distortion at 2 V r.m.s. output from 20-20,000 Hz is virtually unmeasurable, according to the company. Harman-Kardon

Circle No. 19 on Reader Service Page

V.H.F./FM TRANSCEIVER

The "V-Com" hand-held v.h.f./FM transceiver is designed to be fully compatible with other FM systems operating in the 148-174 MHz range.

The circuit is all solid-state and uses IC's for the i.f. amplifiers and second mixer to insure greater reliability. Both mechanical and crystal filters are used for improved selectivity. The unit operates from an internal rechargeable Ni-Cad battery pack.

The transceiver comes with a leather carrying case with two straps, earphone and holder, flexible whip antenna, a 3" speaker which doubles as a microphone, battery and battery charger, and one set of crystals of the user's choice. Varitronics

Circle No. 20 on Reader Service Page

STEREO TUNER/AMPLIFIER

The new Model 8 AM/stereo-FM tuner-amplifier combines the essential features of the company's Model AU999 control center and

amplifier with those of its Model TU999 stereo tuner.

The 200-watt direct-coupled amplifier (IHF music power) is driven by both positive and negative power supplies, uses negative feedback down to d.c. for steady damping. Continuous power at 4 ohms is 160 watts. Response is 5 to 50,000 Hz ±1 dB with distortion less than 0.3% total harmonic and less than 0.4% IM.

Tuner sensitivity is 1.7 μV IHF and the circuit features three dual-gate FET's in a 4-gang front-end with two r.f. stages. The i.f. amplifier uses 3 IC's while a crystal filter is used in addition to a block filter.

Complete specifications and additional information are incorporated in a 6-page folder which will be forwarded on request. Sansui

Circle No. 21 on Reader Service Page

KITS FOR PC BOARDS

The do-it-yourself construction of prototype printed-circuit boards and the hands-on approach to training are now possible with the introduction of two versions of a hand-tool kit and two new 8½-inch high, double-sided collage mounting boards in double or quad height.

According to the company, the larger surface areas and greater flexibility of the new collage boards allow users to collect logic functions from a group of modules. Each of the hand-tool kits, housed in a sturdy plastic carrying case, is complete with all the tools and equipment needed to construct solid-state boards. Included in the H816 kit are fifteen 16-pin IC wire-wrap sockets, 75 wire-wrap pins, a 30-gauge hand wire-wrap tool, a 30-gauge hand unwrap tool, a wire stripper with spring, and 10 feet of 30-gauge insulated wire.

Complete information on these units is available on request. Digital Equipment

Circle No. 22 on Reader Service Page

CONFERENCE-CALL SELECTOR

A new conference-call selector which lets the user dial his own conference calls immediately and at any time without prior booking with the telephone company operator has been introduced into the United States by Orient Electronics.

The unit plugs into all 5-line push-button telephones. No batteries or external power is required. Of solid-state design, the unit is compact and lightweight. It measures 7" wide × 2" high × 5" deep.

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To operate, the first party is dialed on outside line No. 1 and the corresponding switch on the unit is flipped to "conference." Then the process is repeated for lines 2, 3, 4, and 5. When the conference is over, the switches are returned to the "normal" position and the phone is ready for regular operation. Tradeship

Circle No. 23 on Reader Service Page

BATTERY-POWERED SCOPE

A new dual-trace, high-frequency scope that draws only 18 watts and can operate up to 6 hours on internal batteries without recharging has just been introduced as the Model 1701A.

Designed for all types of service and maintenance applications, the scope offers delayed

sweep, a full 6 × 10 cm display, and a frequency range of d.c. to 35 MHz. Its lab-scope performance, coupled with easy portability, makes the unit attractive for various applications. The company suggests that a computer service engineer will find it more convenient to move the scope around a large installation if he doesn't have to bother with a line cord. Since it is small enough to slip under an airliner seat, it is handy for traveling service engineers. With its front-panel cover housing power cord and probes and with the batteries installed, the scope weighs 35 pounds and without cover and battery it weighs 24 pounds. Hewlett-Packard

Circle No. 24 on Reader Service Page

SCR/TRIAC/DIODE TESTERS

A new series of SCR, Triac, and diode testers is now available as the ST-90, ST-100, and ST-110.

The ST-90 is a low-cost unit designed to provide shop and field personnel with a capability to perform a wide range of dynamic tests. The ST-100 offers all of the features of the ST-90 plus selected forward and reverse blocking test voltages from 200 to 500 volts in standard semiconductor-industry increments. The ST-110 includes the features of both the other models with the added ability to program all tests to the exact manufacturers' specifications for the device being tested. This unit can be used as an incoming inspection instrument as well as a laboratory tester for matching SCR's and Triacs. Alfred-Thomas

Circle No. 25 on Reader Service Page

TRANSISTOR TRANSFORMERS

A kit of nine miniature transformers, designed for the latest solid-state circuitry, is now available as the Model 500K selector kit.

The kit encompasses a broad range of impedance values, power-handling capacities, and physical sizes. This kit of open-frame transformers was designed to save engineers valuable time in optimizing breadboard circuitry for servo, audio, instrumentation, and control applications.

Impedance matching values range from 600 ohms c.t. to 50,000 ohms c.t. Primary and secondary may be interchanged to give an even greater selection of impedance ratings. Transformer sizes range from $\frac{1}{4}$" × $\frac{3}{8}$" × $\frac{3}{8}$" to $\frac{3}{4}$" × $\frac{3}{4}$" × 1". Microtran

Circle No. 26 on Reader Service Page

NEW V.O.M. LINE

A new line of five general-purpose v.o.m.'s with broad application in the electronics servicing, educational, experimenter, and industrial production and maintenance markets has been announced.

All of the meters in the new line feature meter movements that have protection diodes to prevent damage from accidental overload, precision range resistors (±1%) to insure accuracy, 3-color easy-to-read meter scales, and high-impact plastic cases.

The five models are the WV-516A, WV-517A, WV-518A, WV-519A, and WV-520A. Detailed technical information on all of these units is available for the asking. RCA Commercial Engineering

Circle No. 27 on Reader Service Page

HAND-HELD TRANSCEIVERS

A new line of hand-held CB transceivers that offers solid-state performance and reliability has just been introduced. Four models cover all CB needs from 3-channel, 100-mW units for moderate-range communications to a full 5-W, 23-channel rig.

The top of the line is the Model CCT-4, a heavy-duty unit for commercial or personal use. It offers full 23-channel operation with all crystals supplied, at full 5 watts with 100% modulation.

Each of the units features an FET front end, IC's, superhet receiver with tuned r.f. amplifier, ceramic filter, delta tuning, a.g.c. and noise limiting, an S/r.f. meter, and separate speaker and dynamic microphone for maximum noise response and undistorted communicating. Courier

Circle No. 28 on Reader Service Page

TUNER CARTRIDGES

Two new cartridge tuners for automotive stereo tape players have been added to the Audiotex line. They are an AM-FM tuner and a stereo-FM tuner. Both are designed to slip into the cartridge loading slot of all automotive 4- and 8-track tape cartridge players.

The AM-FM tuner, Model 30-3075, is powered by an internal 9-volt transistor-radio battery. The stereo model, 30-3076, is similar to the

AM-FM unit and has a stereo/mono mode selector switch as well as an indicator light that flashes on when a stereo station is being received. A special switch on the bottom of the tuner adjusts the input circuitry for nearby and distant FM stations. GC Electronics

Circle No. 29 on Reader Service Page

PAGING PROJECTORS

Two newly designed, low-cost paging projectors, the 12-watt PA12 and PA12F, have just been introduced to the market. Both units feature computer-calculated horn flare, a design factor that provides excellent response characteristics and dispersion. A newly designed diaphragm and voice-coil assembly, plus a powerful Alnico V magnet structure, make it possible to drive the horns to the desired sound-pressure level with less amplifier power.

The PA12's round horn provides a nominal 130-degree dispersion angle. It may be oriented in any desired position in a vertical plane by loosening a single wing-nut on the mounting base. Frequency response is 325-14,000 Hz. The PA12F is a compact re-entrant type designed for flush mounting between ceiling joists or wall studs. Its frequency response is 500 to 14,000 Hz. Electro-Voice

Circle No. 30 on Reader Service Page

TRIGGERED-SWEEP SCOPE

The B&K-Precision Model 1460 triggered-sweep oscilloscope permits viewing the entire complex TV color signal or any portion thereof, including the vertical interval test signal (VITS) and the backporch of the horizontal sync pulse,

with the color-burst information, all automatically synchronized and locked in. Two sweep-selector positions, TVH and TVV, enable the user to switch back and forth and see steady patterns of horizontal and vertical signals, without any adjustments being made.

Except for the CRT, the 1460 is solid-state. The instrument measures 9" × 10" × 17" deep and weighs only $7\frac{1}{2}$ pounds. A combination direct and 10:1 probe is furnished with the instrument. Dynascan

Circle No. 31 on Reader Service Page

RECEIVER/TAPE PLAYER

A solid-state AM/stereo-FM receiver and 8-track tape player has been introduced as the Model WTP-802. It features 80 watts of peak music power and a blackout dial when playing tapes.

The unit includes two high-efficiency $6\frac{1}{2}$" woofers, encased in an air-tight cabinet, and 3" tweeters. Slide switching is included for easy settings and power/loudness control. Speaker, auxiliary, and phono jacks on the new unit are RCA pin types.

Finished in polished walnut with a chrome panel, the cabinet measures $5\frac{1}{2}$" × $18\frac{1}{2}$" × $10\frac{1}{4}$". The weight is 25 pounds, including speakers. Weltron

Circle No. 32 on Reader Service Page

MARINE RADIOTELEPHONE

The Model 608 v.h.f./FM marine radiotelephone features a molded handle which protects against protruding knobs and allows for easy removal and carrying. The white molded Cycolac front panel with integral carrying handle, gold mesh speaker grille, and blue case with color-matched microphones are designed to enhance the appearance of most boats.

Featuring six and one-half channels with an r.f. output of 8 watts, the unit is suitable for pleasure craft, workboats, and small commercial vessels. It is completely transistorized and meets

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or exceeds requirements of the FCC, EIA, and the Canadian DOC, Class V. It comes with mounting tray, microphone, and crystals for channel 6 (ship-to-ship), channel 16 (Safety), and ESSA Weather Broadcast. Comco

Circle No. 33 on Reader Service Page

STEREO COMPACT

The Model KS-505P compact features a PE-2010 automatic turntable, an AM/stereo-FM receiver, a Pickering V-15/AT-3 cartridge, diamond stylus, and a "Dustamatic" brush.

Power output is 60 watts at 4 ohms (±1 dB), 20/20 watts at 4 ohms (r.m.s.), and frequency response is 20 to 20,000 Hz ±2 dB. Input for a second phonograph and terminals for a tape recorder give the KS-505P expansive possibilities. FM sensitivity is 2.5 μV (IHF), capture ratio is 4 dB, and IHF selectivity is 35 dB.

Optional two-way speakers incorporating 6½" woofers and 3" cone tweeters are available in pairs. An optional deluxe dust cover is also available. Kenwood

Circle No. 34 on Reader Service Page

MANUFACTURERS' LITERATURE

SPEAKER BOOKLET

A 20-page booklet on speaker parameters and design philosophy, plus a catalogue section listing specifications on the company's speakers and audio components, has just been published.

Lavishly illustrated with photographs, graphs, IM distortion charts, polar patterns, radiation patterns, and mechanical specifications, this is a veritable handbook of speaker design. McIntosh

Circle No. 35 on Reader Service Page

INDUSTRIAL ELECTRONICS

The 1971 edition of the Industrial Electronic Components Catalogue (#FR-71-1) containing nearly 1700 items is now ready for distribution.

The new 84-page catalogue has been extensively revised and expanded. It lists such diverse hardware items as connectors, adapters, alignment tools, clips, plugs and jacks, binding posts, cable clamps, and cable ties—all available in OEM quantities.

A broad selection of the company's chemicals is also included as well as such items as nylon and metal mounting hardware, PC materials, PC connectors, spacers, switches, test prods, production-type wire strippers, grommets, and lacing cord.

A special appendix provides part-number cross-references which allow purchasing agents to identify parts made by other suppliers. GC Electronics

Circle No. 36 on Reader Service Page

TV ANTENNA BROCHURE

A four-page, four-color brochure covering its line of "Color Crossfire" u.h.f./v.h.f./FM, v.h.f./FM/stereo-FM, and v.h.f./FM antennas is now ready for distribution.

In addition to picturing and describing each antenna, details are provided on the special components making up the antenna designs. Channel Master

Circle No. 37 on Reader Service Page

TV ANTENNA CATALOGUES

Three new catalogues detailing a complete line of home and MATV products have just been released for distribution.

The 16-page home-products catalogue contains specifications and photos of mast-mounted preamplifiers, broadband amplifiers, amplified signal dividers, u.h.f. converters, antenna rotators, antennas, and miscellaneous home-TV system accessories. (Catalogue 70-62)

The 30-page MATV products catalogue contains detailed information on preamplifiers, broadband amplifiers, filters, traps, multiplexers, tap-offs, MATV electronic accessories, and hardware items. Information on the FSM-2 field-strength meter and its accessories is also included. (Catalogue 70-72)

The 16-page engineered MATV systems products catalogue includes specifications, descriptions, and photographs of single-channel amplifiers, low-noise preamplifiers, custom converters, tap-offs, and a complete line of 75-ohm test equipment. (Catalogue 70-82)

Requests for any of these catalogues will be honored. Please specify by number the catalogue desired. Blonder-Tongue

Circle No. 38 on Reader Service Page

HOME MUSIC SYSTEM

A 20-page brochure which describes and pictures the various components which can be selected to make up a "Musicom" home music/intercom system is now available.

The stereo entertainment center consists of a master unit with amplifier/tuner, cassette player/recorder, and a record changer; a record/tape storage cabinet; speakers; and optional intercom facilities designed to match and work with the entertainment center components. Nu-Tone

Circle No. 39 on Reader Service Page

R.F. POWER TRANSISTORS

RCA's Solid-State Division has just issued an 8-page catalogue describing its r.f. transistor product line in a series of matrices which combine product groupings by output power and frequency with suggested applications.

Transistors designed for 12.5-volt operation are detailed separately for easier reference. Information on high-reliability types of microwave IC's is also included.

For a copy of RFT-700G, send your letterhead request to RCA Commercial Engineering, Harrison, N.J. 07029.

CABLE-FAULT LOCATOR

A handy, pocket-sized, 60-page booklet on locating buried cable faults is now ready for distribution. The booklet starts off with basic and general rules to follow and then discusses the use of the Model 2785 fault locator.

Detailed explanations are given as to the use of the receiver and then transmitter matching. How to locate cable path and depth is detailed with diagrams and then examples are given of eleven different problem situations and how to solve them. Rycom Instruments

Circle No. 40 on Reader Service Page

SHORT-WAVE "PRIMER"

A pocket-sized "primer" on short-wave listening, prepared especially for DX-ers, beginning and advanced short-wave listeners, hi-fi buffs, travelers, and radio hams, is now available without charge.

Entitled "Short-Wave Puts You Where It's At," the multi-colored primer takes the reader through the many adventures he can experience with short-wave; explains graphically and in simple terms the meaning of short-wave; and tells the reader what he can hear on short-wave and what to look for in a radio to receive short-wave broadcasts. Hallicrafters

Circle No. 41 on Reader Service Page

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12, 27	Harman-Kardon
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41	Jerrold
43, 46 (bottom)	Zenith Radio Corp.
46 (center)	Motorola Inc.
58	Blonder-Tongue
59	Hy-Tronix Instruments
60	E. F. Johnson
61	Sencore

Dolby-ized Cassette Decks

(Continued from page 28)

with *BASF* tape. With Crolyn tape, even this small defect was virtually eliminated. We could not hear any loss of treble, although the recorder response fell off above 12 or 13 kHz. Probably the program material had little content up there, and since we used an excellent wide-range record, the practical utility of the cassette deck is merely emphasized.

The *Harman-Kardon* CAD-5 and *Fisher* RC-80 sounded identical, as far as we could tell. Both had a trace of brightness, which could only be detected in direct comparison with the record, and a very low hiss level which was only audible at rather high listening levels. The brightness and hiss, which was subjectively slightly greater than that of the *Advent*, were due to the slight peaking of the highest frequencies.

All three machines were easy to use and their flutter level of about 0.2% was not audible, even on the usually revealing piano and organ passages.

It seems quite clear that, while all three recorders are capable of truly hi-fi performance, the price differentials among them are related to their flexibility and adaptability to various tape characteristics. For the user who does not wish to concern himself with the technical details of Dolby circuit performance, or experiment with CrO_2 tape, the *Fisher* machine offers superb performance for $200, not matched by any other machine of that price that we have tested. The *Harman-Kardon* deck offers similar performance, with the addition of facilities for CrO_2 tape and for the user to periodically adjust the Dolby levels or optimize them for a different tape formulation (although the playback gains should not be adjusted without a standard Dolby level cassette). *Advent* has gone all the way, giving the user everything he needs to keep the instrument in its proper operating condition. In addition, the *Advent* metering system is the most satisfactory we have seen.

Whichever one you choose, the Dolby-ized cassette deck has finally made the cassette a true high-fidelity medium. No reel-to-reel recorder we have seen which sells for the price of any of these cassette machines surpasses their performance from a subjective, listening standpoint. And, when it comes to convenience, the cassette has a powerful advantage. Commercially recorded cassettes will soon be available with Dolby processing, allowing the Dolby playback circuits of these recorders to be used with equal effectiveness with pre-recorded or home recorded cassettes. ▲

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GENERAL INFORMATION: First word in all ads set in bold caps at no extra charge. All copy subject to publisher's approval. Closing Date: 1st of the 2nd month preceding cover date (for example, March issue closes January 1st). Send order and remittance to: Hal Cymes, ELECTRONICS WORLD, One Park Avenue, New York, New York 10016.

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

CITIZEN BAND radios, SSB, AM, Swan, CB, Amateur. Accessories, Free catalogue. Dealers send letterhead for factory prices. Call 714 894-7755. Baggy's Radio, 6391 Westminster Ave., Westminster, Calif. 92683.

JAPAN & HONG KONG DIRECTORY. Electronics, all merchandise. World trade information. $1.00 today. Ippano Kaisha, Ltd., Box 6266, Spokane, Washington 99207.

ELECTRONIC Ignition. Various types. Information 10¢. Anderson Engineering, Epsom, N.H. 03239.

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COLOR converter for B&W television. Electronic patented system. Free brochure. Bele Electronics Corp., 111 Northeast Second Avenue, Miami, Florida 33132.

TELEVISION-Instant starting! Convert receivers for pleasure-profit! Schematics, complete instructions. Guaranteed $3.95. DLW Company, 1304 Magnolia, Richardson, Texas 75080.

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BACKGROUND MUSIC: ORTRONIX HARMONIX Receiver adaptor. 13 Tran. 9 diode unit complete with power supply in attractive cabinet, $44.50, w/o cabinet, $37.50. Schematic & Inst. incl. BRANBRO, Box 1735, Winter Park, Fla. 32789.

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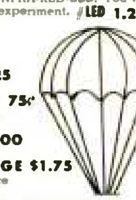

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18A**	.09	.15	.19	.29	.39	—	—	—	—
20A	.23	—	—	.59	.75	1.13	1.35	1.73	2.10
40A	.38	—	—	1.35	1.80	2.25	2.70	3.15	3.60

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1500 PIV RECT. STUD 1 AMP 25¢ EA.

PRV	25	50	100	200	400	600
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100	.40	.70	1.00
200	.70	1.10	1.40
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400	1.10	1.60	2.20
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Silicon Power Rectifiers

PRV	3A	30A	12A
100	.09	.30	.50
200	.16	.35	.80
400	.20	.45	1.20
600	.30	.70	1.50
800	.40	.85	1.80
1000	.55	1.10	2.20

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200	.07
400	.09
600	.11
800	.15
1000	.20

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50	.25	.28	.60	
100	.30	.38	.85	3.50
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100V	1.50	1.60	1.75	1.95
200V	1.75	1.85	2.00	2.20
400V	2.00	2.10	2.25	2.45
600V	2.50	2.60	2.75	2.95
800V	3.00	3.10	3.25	3.45

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100	.25	.30	.35
200	.40	.45	.50
300	.60	.70	.80
400	.75	.85	.95
500	..	..	1.00
600	..	..	1.30

TRIACS

PRV	1 AMP	3 AMP	6 AMP	10 AMP	15 AMP
100	.40	.50	.75	1.00	1.20
200	.65	.75	1.00	1.40	1.80
300	1.00	1.10	1.25	1.90	2.20
400	1.30	1.40	1.80	2.30	2.60
500	1.60	1.80	2.10	2.75	3.10

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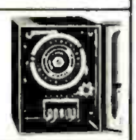

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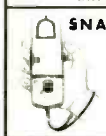

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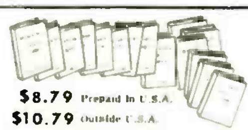

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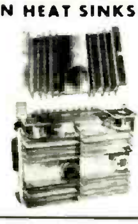

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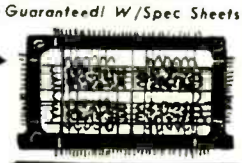

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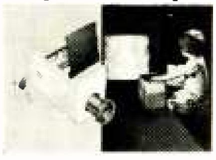

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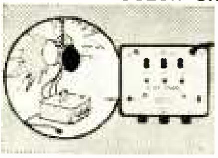

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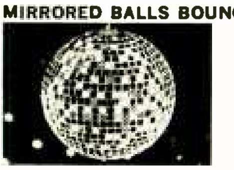

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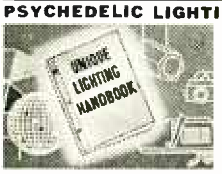

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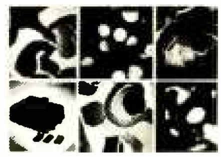

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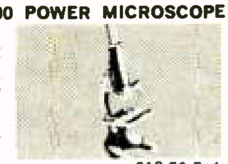

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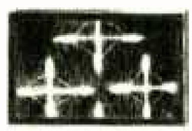
Psychedelic Light Show



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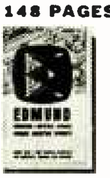

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ELECTRONICS WORLD

March 1971

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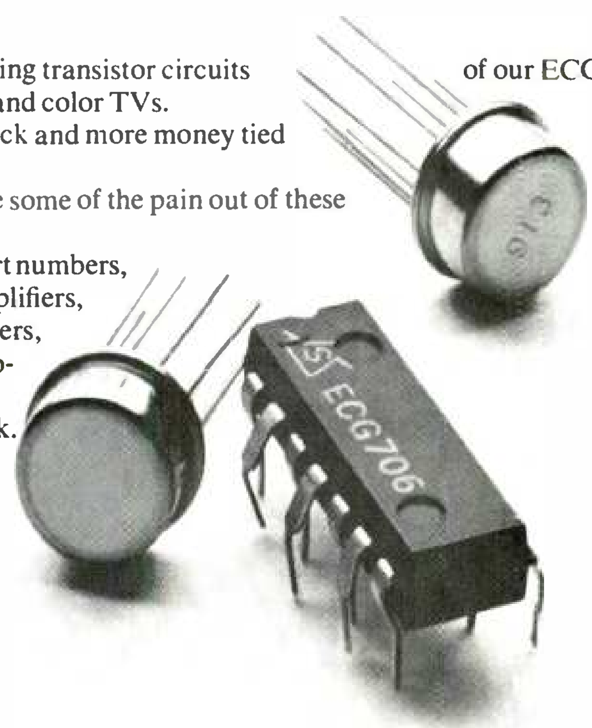

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