Electronics World

JUNE, 1970
60 CENTS

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CIRCLE NO. 150 ON READER SERVICE CARD

Radar Sentry Alarm announces a new powerful way to stop crime . . . "Dialtronic"

Radar Sentry Alarm announces a new powerful way to fight crime. Imagine a security system that automatically and silently delivers any emergency message for which it is programmed. Dialtronic adds a new dimension to your security needs. Advanced concepts in technology and design bring you a new level of security. Providing unlimited application, the Dialtronic uses solid state circuitry to bring help immediately. Use it with existing alarm systems or any other sensing device. Dialtronic is the ideal personal protection for anyone who is vulnerable to intruders. Dialtronic will perform with never a lapse in security . . . You are assured of highly reliable protection.

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Dialtronic's built-in programmer lets you magnetically store "error free" messages on cassette type tape cartridges. Stored information is instantly available to notify proper officials, delivering correct message in each case.

Advantages of Dialtronic Telephone Communicator

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- Automatically dials the right people and delivers the correct message in each case.
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- Converts existing local alarm to central station system. Easily and quickly installed.
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- Can be used with optional wireless control.
- Home prowler alarm, fire alarm, emergency alarm for invalids. Can be programmed for any emergency.

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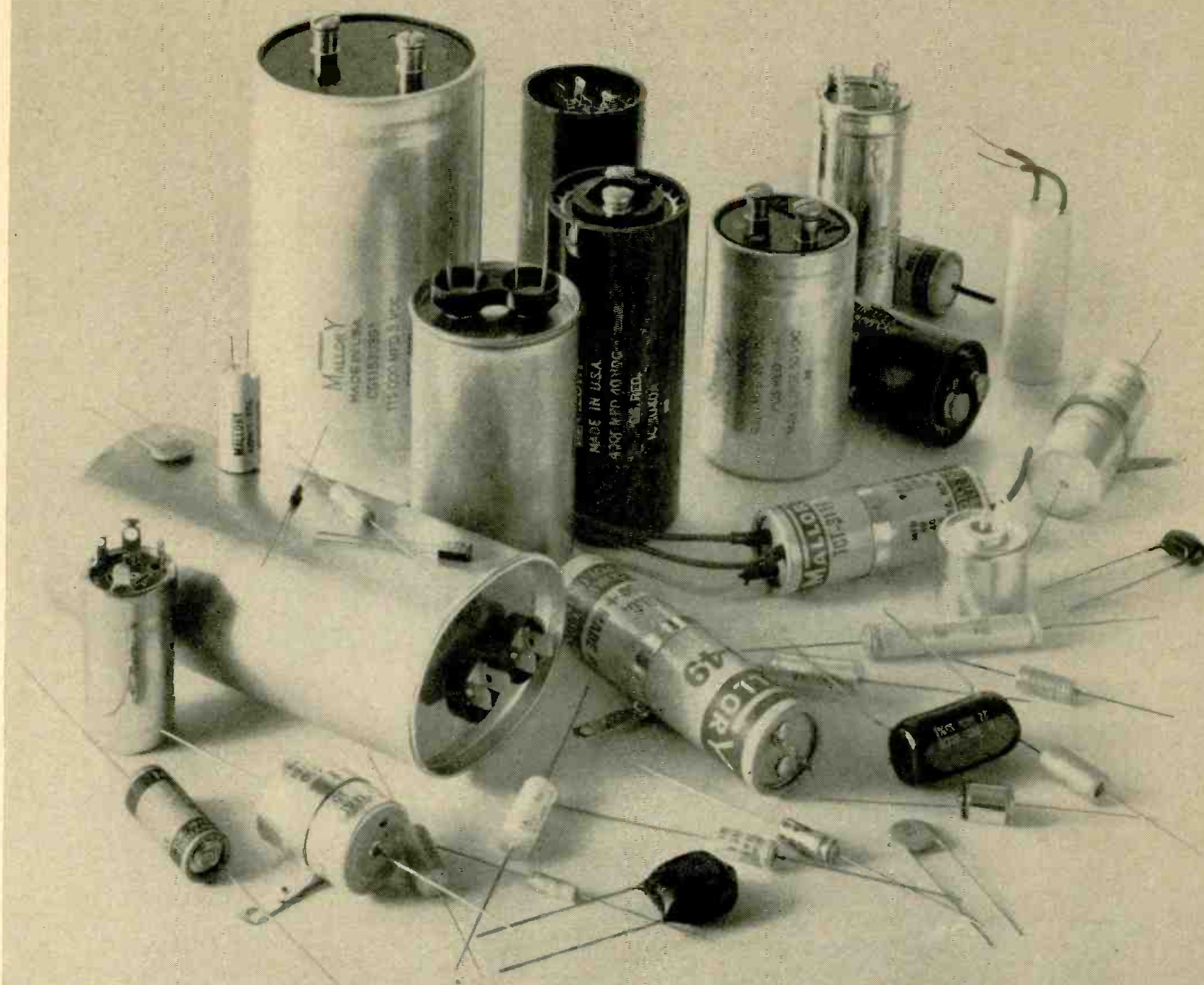

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CIRCLE NO. 130 ON READER SERVICE CARD

Electronics World

JUNE 1970 VOL. 83 NO. 6

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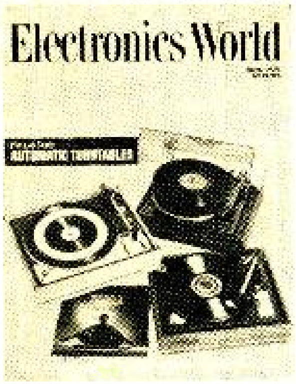

THIS MONTH'S COVER shows top-of-the-line automatic turntables from three of the five manufacturers whose products were tested for our lead story. At top left is the Dual 1219; at top right is the Garrard SL-95B; and at bottom right is a prototype of the Miracord 770 (which was not yet available for testing at the time). For details on performance and prices, refer to the article "EW Lab Tests New Automatic Turntables" by Julian D. Hirsch. Cover photograph: Dirone-Denner.

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Coming Next Month

Special Issue

LINEAR INTEGRATED CIRCUITS

Linear IC's are what's happening. You can't afford to miss this up-to-the-minute, 20-page Special Section which provides the information you will need to cope with these circuit elements. Each of the six articles comprising this section is written by an expert in his field. Dick Santilli of RCA discusses the IC in consumer products; Dr. Ronald B. Schilling of RCA's Microwave/Microelectronics Div. discusses the applications of IC's in high-frequency and microwave systems; Bob Dobkin of National Semiconductor brings you up-to-date on the newest things in IC op amps; Dieter Wurth of Sprague has a number of interesting things to tell you about hybrid IC's and how they are being used; and Motorola provides details on the relatively new monolithic multiplier, tells how it works, and gives applications.

ELECTRONICS AND METEORITES

Electromechanical and electronic instrumentation is helping us learn more about meteorites—leading to knowledge about our solar system and celestial mechanics. L. George Lawrence explains how this sophisticated instrumentation is being used—and why.

DIGITAL INSTRUMENTS YOU CAN BUILD

This will be the first in a series of articles by Donald L. Steinbach of Lockheed telling how you can learn about digital instruments by designing and building your own. The circuits the author will cover are all immediately useful on the test bench or in the lab—but, best of all—they can be built from relatively inexpensive components. Part 1 covers the digital readouts that are available and tells how to use them.

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

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Radio & Television news

By FOREST H. BELT / Contributing Editor

Importers Aren't the Only Ones

In our frequent mini-investigations we sometimes learn things we didn't expect. There's an interesting sidelight from our digging into the problem of parts and service information from importers. (We reported this in February and again last month.)

Readers have responded, detailing troubles they've had. Some defend this or that importer, saying it sent what they needed when they needed it. Those cases still seem isolated, but we do applaud importers who help independent servicers.

One reader reports he got a service manual and parts list from *Sanyo Electric Trading Co. Ltd.* in barely over a week, after writing all the way to Japan. He then ordered the parts. He says, "They sent all the parts and they were the correct parts. They were on open account and prices were reasonable." He goes on to say (and this is the kicker): "We do not get that kind of prompt service from some firms located less than 100 miles from here!!"

Letters from other readers echo this indictment: Importers aren't the only ones who give trouble. Readers report, "I can't get the right part without a lot of aggravation, waiting, and (often) expense." Others ask, "Why does a manufacturer make and sell a set and then not stock *all* the parts for it?" Or, "Half the time the part number in the service literature is wrong. There's been a substitution. And then the substitute is back-ordered because the distributor didn't know about it."

In short, it seems we're looking at a problem more universal than we suspected. Because some domestic set-makers don't supply parts and information as they should is no reason for importers to let their customers down the same way. On the other hand, just because some importers get away with poor service is no reason for U.S. manufacturers to do the same thing. We'll be watching this particular complaint, and we'll let you know what we see. We hope we see a quick improvement on both sides of the ocean.

Not-So-Unfair Law

We were pleased to learn that what we thought was about to happen in California ("Unfair Laws Department," page 13, April issue) isn't happening after all. An official of the Bureau of Electronic Repair Dealer Registration assures us that the regulation (not legislation) in question ". . . . in no way denies a serviceman his fee for making a call to the premises of a customer."

The original worry centered around the definition of a service call. But the regulation was rewritten before it was adopted. It now includes the word *inspect.* So, a service call has taken place when the dealer or his technician calls "at the premises of a customer, at the request of said customer, to inspect, repair, service, or maintain a set." All's well that ends well.

Get SMART

It's the old teach-'em-by-computer trick. But with a fancy name. Would you believe: System Malfunction Analysis Reinforcement Trainer? A subsidiary of *EDP Technology, Inc.* has an electronics-teaching computer it calls by that unlikely name. In case you can't tell from the name, its job is teaching school dropouts to fix television sets. Using slides programmed in groups, the trainer presents TV symptoms, then slides of different parts of a set. The student presses buttons to diagnose the fault through a number of logical steps.

The system sounds good for learning the principles of diagnosis and servicing. We naturally assume this is followed by further training in such manual skills as soldering, propping chassis up to work underneath them, making out parts orders and warranty tags, finding hidden test points with a scope probe, twisting the right scope knobs, adjusting the static and dynamic convergence controls, and the other techniques that make a successful technician.

Hornet's Nest in Servicing

The new *RCA Corp.* servicing organization ("Service-Business Paradox," page 17, last month) is fact. Its technicians will repair any brand of home-entertainment electronics. The new company will be managed by *RCA Service Co.* and in some localities will use its own technicians and shops (despite denials).

Heat from the independent servicing industry was predictably quick and unexpectedly vehement. It ranged from letters to *RCA* and President Nixon to threats of boycotting. Some gripes that got into print were over-reactive, contradictory, and irrelevant. Fortunately, cooler heads prevailed, and no illegal retaliation has developed. A concentrated effort is under way to convince *RCA* to stop. We doubt *RCA* will drop its plan, although some people inside the company think the plan is a serious mistake.

Powerful opposition is forming alongside the servicing associations. Parts distributors see definite problems, and are complaining to *RCA*. Also, set-makers X, Y, and Z can't sit idly by and watch *RCA* build a prospect list from owners of brand-X, -Y, and -Z sets. They may feel obligated to set up their own service establishments.

All this bodes ill for independent service. It accelerates the tendency to fewer small service shops. Complaining about it and castigating manufacturers who start their own servicing won't reverse the trend. One effective answer is greater competence among independent servicers, better promotion and advertising, and nicer relations with customers. The competition, whether it seems altogether fair or not, is getting very keen.

Technicians Get X-Ray Check

Some bench technicians still worry about exposure to soft x-rays from color chassis they have opened for servicing. The Bureau of Radiological Health (BRH) has done a survey in shops. The object was to find out which sections of a chassis radiate during servicing, how much, and what would eliminate even the slightest x-ray exposure. The survey included direct checks with radiation sensors and badge-type cumulative measurements.

Results haven't been released. The Electronic Industries Association helped with the survey and presumably will circulate the conclusions. If it seems necessary, the BRH has promised to survey shops nationwide. If any danger exists, we should know about it soon.

IC's Make a Big Hit

At the annual IEEE Show, engineers and technicians got to see how well linear integrated circuits are moving into consumer electronics. Even more specific applications are promised at the Consumer Electronics Show in New York June 28 through July 1.

One application that strikes the fancy is the *Delco Radio* thick-film approach to a modern car radio. Using monolithic IC's implanted by chip technique on thick-film substrates, it won't be long until a whole AM/stereo-FM radio can be put on one semiconductor base. The "works" will be smaller than the knobs and dial it takes to tune them. Add electronic search tuning (with varactors) in place of cumbersome tuning, and you'll have a radio smaller than a dashboard clock. It'll be easier to operate than anything we have today.

Technicians Plan Their Convention

The sixth annual convention of National Electronic Association is set. The date: July 15 through 19. The place: Stouffer's Riverfront Inn in St. Louis. This year there's a two-day business-management school, a one-day alignment school, luncheons, a banquet, a cocktail party, a dinner dance, and a flurry of other doings. An NEA Convention is always a family affair, with lots of activities for wives and kids. You don't have to be a member; NEA extends a special invitation to non-members.

Business Booster of the Month

Looking for extra income? If you live in a college town, rent TV sets to students who live in dorms and fraternity houses. One shop owner, not having a college nearby, and finding that some national leasing firm had the local hospital sewed up, built a fair-sized clientele among nurses and interns of the same hospital. A small-town dealer rents to teachers who live in town just for one school season.

Sets don't have to be new, say dealers who have tried this. But they do have to be in good condition—no scarred cabinets, slow-warming picture tubes, or squeaky speakers. The best deals seem to be monthly leases, not day-by-day or weekly.

Portables are the most in demand, but are also easily lost. Some dealers get a deposit and refund it when the set is returned. A signed lease agreement gives you something for court just in case the set "disappears."

One dealer warns, "Avoid housing projects where people are often transient. Some apartment buildings are poor-risk, too. Try to find out how long a lease has to run." ▲

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CIRCLE NO. 137 ON READER SERVICE CARD

NEWS HIGHLIGHTS

Impetus to Environmental Controls

Reacting to directive from President Nixon, the Patent Office, U.S. Department of Commerce, has instituted procedure to speed up processing of anti-pollution patents from three years to six to eight months. Priority applies to patents already in Patent Office as well as future applications. To receive special status, inventors should write to Commissioner of Patents William E. Schuyler, Jr., identifying application by serial number and filing date. Explanation of how invention can contribute to cleaning up environment should accompany request.

Light That Never Fails

Bell Telephone Laboratories has developed a solid-state lamp that can emit light continuously for about ten years. These lamps, made of synthetically grown gallium phosphide crystals—a transparent solid material resembling amber—are expected to be more reliable, efficient, and economical than incandescent lamps now used in telephones and display boards. Estimated life is over 100,000 hours of continuous use as compared with 10,000 hours for incandescent lamps. Miniscule amounts of this crystal give off red or green light with almost no heat when small electric current is passed through it. Small size and low power requirement makes lamp ideal for use with telephone power supplies and solid-state circuits. Combinations of these lamps could also be used as readouts replacing the more expensive high-voltage display tubes. *Western Electric*, manufacturing and supply arm of the *Bell System*, is presently studying feasibility of manufacturing gallium phosphide lamps.

Self Regulation

Starting what we hope will be a trend throughout electronics industry, Robert W. Sarnoff, Chairman and President of *RCA*, created a major new corporate post—the Office of Consumer Affairs. Herbert T. Brunn, veteran of almost 30 years executive service with various *RCA* divisions, has been appointed vice-president of this office. He will be responsible for directing a company-wide program to insure that the rights and interests of the consuming public continue to receive highest priority in all of *RCA's* diversified operations. With increasing number of consumer complaints being aired in newspapers, magazines, on radio and TV, self-regulatory practices are certainly preferable to government regulation.

Attention Women's Liberation Leagues

According to Ed Graff of *Control Data Institute*, Division of *Control Data Corp.*, Los Angeles, approximately half of all computer programmers employed in business and industry by 1980 will be women. Prediction is based on his estimate that approximately 20 percent of all computer programmers today are women and that "Women have a demonstrated innate ability to solve problems. They are more logical, patient, systematic, meticulous, better organized, and more accurate than men. These are all qualities which a good programmer must have. . . ."

Engineering Time Saver

McGraw-Hill Book Company and *United Computing Systems* recently demonstrated a new concept in publishing—providing programmed information from numerous, selected reference books stored in a computer library. Design engineers, using typewriter-style computer terminal can obtain, *via* public telephone, almost instantaneous solution to technical problems by using reference book data (equations, tables, etc.) stored in computer library. Using plain English in communicating with time-shared computer, engineer enters page and number of applicable formula and his design parameters—almost immediately receives the solution. Typically, a set of six to ten equations, requiring an hour to solve and check manually, would be solved in less than a minute by computer. As of date of writing, more than 1800 formulas from reference work "Formulas for Stress and Strain" by Raymond J. Roark have been stored in *UCS* National Datacenter Library in Kansas City, Mo. Programming of other reference books will follow.

Someone "Gives a Damn"

Instrument Systems Corp. (*ISC*) of Huntington, N.Y. has received follow-up contracts from U.S. Department of Labor to hire, teach, and train an additional 87 "underemployed" persons through MA-5 program. This brings total of former "underemployed" individuals receiving remedial education while learning and working at a trade at various *ISC* plants throughout U.S. to 300. It's not much—but it is a good beginning.

What's New Around

New eye-like closed-circuit television camera has been developed by *Motorola Inc*. Ability to automatically adapt to light variations from full daylight to darkness makes it ideal for security surveillance of parking lots, loading docks, subways, or any large, poorly lighted area. Camera provides a minimum of 500-line horizontal resolution between 0.05 footcandle scene illumination (moonlight conditions) and 8000 footcandles (bright sunlight). Obviates need for two-camera system and expensive lighting required for night-time surveillance. Price of unit, $13,350, includes 10:1 zoom lens and completely enclosed all-weather housing. For additional information, contact Jerry Ewing, *Motorola Communications and Electronics, Inc.*, 1301 E. Algonquin Road, Schaumburg, Ill. 60172 . . . and for those with peripatetic occupations, *General Telephone Co. of California*, a subsidiary of *General Telephone & Electronics Corp.*, provides a pocket-size signaling device to help maintain contact with home office. Device, called Private Page, is an 8½-ounce battery-powered radio receiver that can be clipped to a pocket or belt. To contact person carrying unit, home office simply dials assigned seven-digit telephone number on regular telephone. Dial pulses are converted at telephone company exchange into tones which a radio transmitter sends out over a 35-mile radius. Page responds by beeping, thereby signaling person to call in or proceed to home office.

Electronic Honor Roll

Radio Club of America bestows Fellowship on Senator Barry Goldwater in recognition of his more than 50 years of interest and activities in radio communications. Founded in 1909, club membership includes many leading executives and engineers in the radio and electronics industry. . . . Institute of Electrical and Electronics Engineers awards its 1970 Education Medal to Dr. Jacob Millman for his "impact in the areas of electronic devices and circuits through his outstanding textbooks and his stimulating teaching." Dr.

Millman, professor of electrical engineering at Columbia University's Engineering School since 1952, is best known for co-authorship of one of electronics industry's "bibles"—"Pulse, Digital and Switching Waveforms." No newcomer in the matter of honors, Dr. Millman received Citation for important war work in radar from Office of Scientific Research and Development in 1945; was elected a Fellow of both the IEEE and American Physical Society; received two Fullbright grants; and was honored with the "Great Teacher Award" in 1967 by the Society of Older Graduates of Columbia University. . . . J. Frank Leach, Vice-President and Group Executive, *Amphenol Components Group, The Bunker-Ramo Corp.*, was elected Chairman of the Board of Governors of the Electronic Industries Association (EIA). Officially takes office in June, 1970, succeeding Mark Shepherd, Jr., Chairman and Chief Operating Officer, *Texas Instruments Inc.*

Color TV to Color Film

New "Chromabeam" system developed by *3M Company* converts color-television images (live or video tape) into 16-mm color photographic film. System uses an electron-beam recorder (EBR), newly developed color printer, and commercial black-and-white and simple color positive film processing. EBR reproduces red, green, and blue components of color video signal onto standard black-and-white master separation film. Using a special color sequencing procedure, color printer recombines color components to recreate original color video image and converts 60-field-per-second television rate to 24-frame-per-second motion picture rate. Obvious advantages of this system are: ease of producing film copies for mass distribution; storage-ability; retention of dye colors (separation masters are black-and-white); and ease of editing. First production unit planned for mid-1971 and will be priced at approximately $100,000. Potential market for "Chromabeam" system includes broadcast and cable-TV stations, educational institutions, advertisers, etc.

Coming Events

For manufacturers, engineers, designers, and suppliers interested in learning about printed-circuit technology, four-day seminars will be held by *Sylvania Electric Products Inc.* in East Orange, N.J. (May 18-21); Washington, D.C. (May 25-28); Garden City, N.Y. (June 8-11); and in Boston (June 22-25). Seminar will cover design, fabrication, and application of circuit boards. Cost of seminar is $345 which includes student reference guidebook and luncheons. Contact *Sylvania* Training Services, 63 Second Ave., Waltham, Mass. 02154 for additional information . . . and for those engineers, scientists, and managers who would like to learn how to select and use the most effective minicomputer for their particular needs (prior knowledge of computers not necessary), a seminar "Minicomputers—Application of Small Computers to Research, Development, and Manufacturing," will be presented at the Pheasant Run Lodge in St. Charles, Ill. on May 31-June 3, 1970. Seminar is sponsored by National Electronics Conference (NEC) Inc., a non-profit educational organization dedicated to advancing the science and application of electronics. Registration fee is $390 and includes seminar notes, meals, and hotel room. The NEC will hold its annual (26th) Conference and Exhibition December 7-11 at the Conrad Hilton Hotel, Chicago. . . . Devotees of microelectronics may be interested to learn that the 4th International Congress on Microelectronics will be held in Munich, Germany on November 9-11. Approximately 1000 professionals from all over the world are expected to attend. Besides technical papers from Russia and Europe, papers from U.S.A. on MOS circuits, complementary structures, computer-aided design, packaging, and opto-electronics, and from Japan on magnetic semiconductors integrated circuits for consumer electronics, and high-efficiency linear circuits will be presented. ▲

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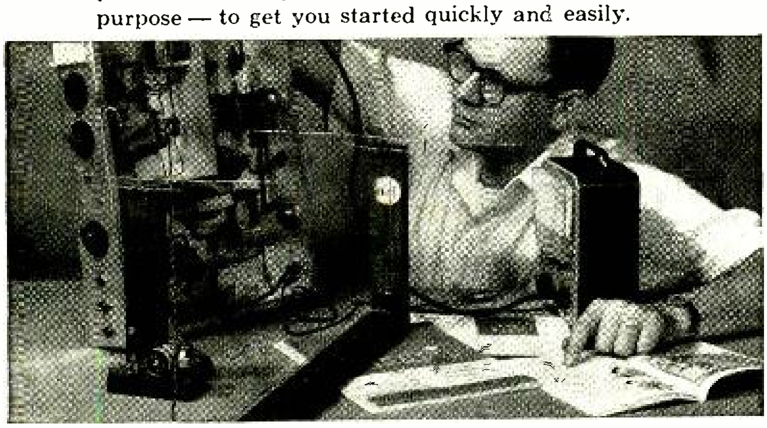

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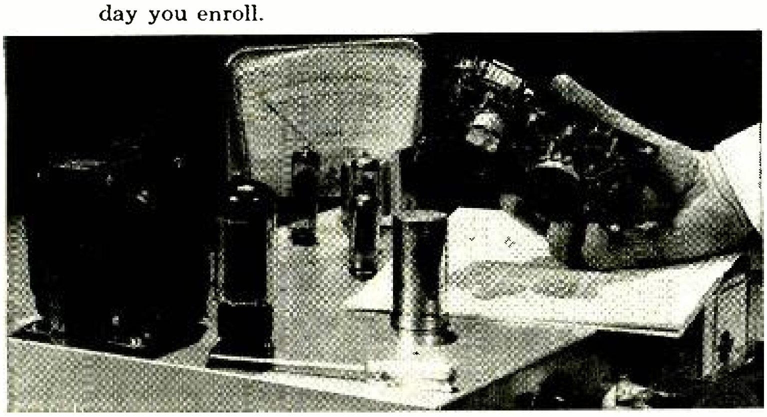

Designed-For-Learning Equipment

Like this phone-cw transmitter (Kit #7 in the Communications course) is engineered from chassis up to demonstrate principles you must know. NRI does not use modified hobby kits for training, but the finest parts money can buy, professionally and educationally applied.

...here's how you get it with unique NRI training at home

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LETTERS

ULTRA-LOW-FREQUENCY WOOFER

To the Editors:

After reading your article on the "Novel Ultra-Low-Frequency Woofer Enclosure" appearing in the May issue, there are several comments I feel would be in order.

The low-frequency reproducer (LFR) pictured is an experimental prototype and bears little resemblance to the production model. In keeping with *Elektra Amplidyne Research's* policy of providing the consumer with the finest in sound reproduction and component styling, the production model will be sold in an oiled walnut cabinet with grille cloth covering the radiating panels. To insure optimum performance, we have developed an entire electronics package to be used in conjunction with the LFR. This package includes an electronic crossover with a 24-dB-per-octave (16-64 Hz) active filter. The amplifier and speaker have been designed to provide maximum performance without danger of failure.

Roger S. Jones
Director of Research & Product Dev.
Elektra Amplidyne Research, Inc.
Levittown, Pa.

* * *

IMPORTED-SET REPAIRS

To the Editors:

In regard to the "Radio & Television News" item "Back to the Factory Repairs" (Feb., 1970 issue), the Panasonic people do not belong in the "we made it; you bought it; too bad Charlie Brown" group.

Parts are readily available from the Los Angeles parts depot; orders are accurately and promptly filled. Furthermore, warranties on units purchased overseas are honored by the company Stateside. They pay promptly as agreed on warranty service to their authorized service dealers.

The parent company is *Matsushita* of Japan.

I speak from experience. A lot of American firms could learn from *Matsushita*.

David H. Stratton
Santa Barbara, Cal.

* * *

SILICON TRANSISTORS AS ZENERS

To the Editors:

I am writing in regard to the article in your January issue entitled "Using Silicon Transistors as Zeners." While the author is correct in his basic premise that the base-emitter junction can be used as a zener diode (a characteristic which has been widely used for years), I hope he hasn't misled some of your readers.

In the statement concerning maximum usable current being a function of the package dissipation, Mr. Charles is apparently unaware of the fact that even though semiconductor manufacturers would like to think it so, transistors are not totally homogeneous masses. When a junction is operated in an avalanche mode (and particularly a junction not made specifically for this type of operation), this inherent lack of homogeneity creates areas of current constriction (hot spots), ultimately resulting in a short. In view of this fact, base-emitter diodes used as zeners must be current-limited in such a manner as to restrict the avalanche current to *no more than* 50% of the rated base current of the particular transistor. The specifications on low-power transistors rarely provide the base-current limit, but as a rule it can be assumed as being 20% of the rated collector current.

One other feature which Mr. Charles fails to point out is the fact that built-in temperature compensation can be obtained by using the collector base junction also. This is shown in Fig. 1 at the bottom of this column.

In this illustration, the base terminal is unused, and the polarity applied between collector and emitter is *opposite* that used in normal transistor operation. This provides the negative temperature coefficient of a forward-biased collector-base junction and the positive TC of the emitter-base "zener" junction. The TC's will offset each other only at one particular current level, which varies widely between device types: this, however, does provide more than a modicum of compensation, so it's a great deal better than none at all.

My article in the September issue of Electronics World (p. 42) illustrates

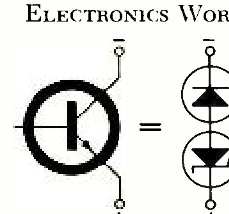


FIG. 1

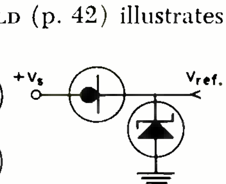


FIG. 2

the use of a constant-current diode as part of a stable reference voltage. The diagram shown in Fig. 2 is an example of how this is used with zeners.

In this case, the supply can vary from (V_z + 3 V) to (V_z + 100 V) and still maintain a constant current through the zener. If the current chosen is that in which the zener exhibits a near-zero TC, this makes the best of all types of voltage references, unless significantly more complex circuitry is used.

Lou H. Garner
Torrance, Cal.

* * *

SOLID-STATE V.O.M.

To the Editors:

For any of your readers interested in constructing the excellent FET v.o.m. circuit by Jim Ashe and John Eisenberg in the January issue, I make the following recommendations and corrections.

The 1N914 is not a zener diode as suggested in the parts list, but a high-speed switching diode available from *Poly Paks* at 10 for $1.00. The 2N2497's are incorrectly shown in the schematic to be *n*-channel FET's, but they are *p*-channel.

The 10-ohm value shown for *R16* is accurate in theory only. The resistances of the meter leads and circuit wiring must be taken into consideration when determining the value of *R16*. The value should be around 9.7 ohms. I recommend the substitution of a low-value pot for the fixed resistor which then can be adjusted for half-scale meter deflection on the X1 ohm range during calibration of the completed unit.

Since *R10-R15* are difficult precision resistors to obtain, I made the following modification. Do not connect *R10-R16* across the terminals of switch S3. Substitute the following values: *R10*, 10 megohms; *R11*, 1 megohm; *R12*, 100k ohms; *R13*, 10k ohms; *R14*, 1k ohm; *R15*, 100 ohms; *R16*, 9.7 ohms or low-value pot, all ½ watt 1%. Connect one lead of each resistor to the "+" terminal of *B1* and connect the other lead of the resistors to the appropriate terminals of S3 as indicated in the schematic. I was able to obtain inexpensive surplus resistors in the listed values as accurate as 0.1%.

A panel ohm-adjust pot is a desirable feature in a v.o.m. but was not included in the article. I used a 50k-ohm pot in series with *R24* to provide a panel ohms adjust.

I recommend 2 watts or better ratings for *R33* and *R34* since the voltage drop across them is considerable and they get quite hot.

You cannot appreciate this solid-state v.o.m. unless you have been using a v.t.v.m. for years and have had to wait five minutes after turning it on to use it because of warm-up drift.

Bruce S. Schwartz
Interlaken, N. J. ▲

HI-FI PRODUCT REPORT

EW LAB TESTED

by Hirsch-Houck Labs

Concord Mark III Recorder
Advent Loudspeaker System

Concord Mark III Tape Recorder

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

THE *Concord* Mark III tape recorder is a three-speed, three-head machine with separate recording and playback electronics. The playback amplifiers use IC's in their input stages, and the rest of the electronics employs standard transistor circuits. The bias oscillator operates at 200 kHz, the highest frequency we have seen in a home audio tape recorder.

The recorder uses new pressure-sintered ferrite heads, which are claimed to be extremely wear-resistant, and have an extremely wide frequency response. Our tests certainly confirmed the latter.

The Mark III also has a unique switchable noise-reduction circuit. From the schematic, it appears that it attenuates the line-output levels in the absence of a signal in the playback system.

The tape transport uses a single hysteresis-synchronous motor for capstan drive, with belts and mechanical brakes operating the take-up and supply reels. The operating tape speeds are 7½, 3¾, and 1⅞ in/s.

When we measured the over-all record-playback frequency response of the recorder, the advantages of its new heads were immediately apparent. With 3M type 202 tape operating at 7½ in/s, the response was impressive: about ±2 dB from 25 to 20,000 Hz on one channel, and about ±1.5 dB from 30 to 20,000 on the other. The NAB playback response at 7½ in/s with an *Ampex* test tape was within ±1 dB over its full range from 50 to 15,000 Hz. The 3¾-in/s test tape response was ±2.5 dB from 50 to 7500 Hz.

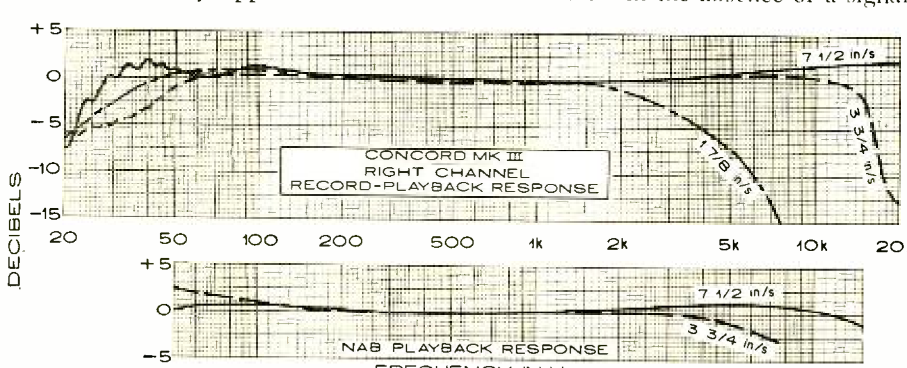
At 3¾ in/s, the record-playback response of the better (right) channel was ±2 dB from 40 to 15,500 Hz. The other had some high-frequency roll-off and measured ±3 dB from 25 to 11,500 Hz. The 1⅞-in/s speed fell somewhat short of the rated 9000-Hz response. It was ±2.5 dB from 25 to 3500 Hz, and was down about 7.5 dB at 5000 Hz relative to the lower mid-range level.

The wow and flutter were, respectively, 0.015 percent (the residual level of our test tape) and 0.05 percent, among the lowest figures we have ever measured on a tape machine. Operating tape speeds were exact, and about 2½ minutes were required to handle 1200 feet of tape in the fast-forward and rewind speeds.

At maximum gain, a signal of 0.17 volt at the high-level inputs produced a 0-dB recording level, with a corresponding playback output of 0.7 volt. Harmonic distortion was 2 percent at this level, rising to the standard 3 percent reference level at +3 dB (nearly the maximum meter reading). The signal-to-noise ratio referred to this level was better than 60 dB with the Range Expand circuit operating, and about 50 dB with it off.

With a blank tape, we observed a drop of more than 10 dB in noise when the circuit was activated. The circuit drops the over-all playback gain by about 10 dB in the absence of a signal, effectively eliminating all audible hiss (which is already a very low −50 dB level) during pauses in the program. Any signal present in the playback amplifiers restores the gain. By listening at high volume levels, we could hear the hiss drop out about 2 seconds after the end of a recorded program. The recorder provided one of the quietest backgrounds in the absence of signal that we have heard (or should we say "not heard"?).

In all other respects, the unit was equally satisfying. Its frequency response and over-all cleanness of sound left little to be desired. The Mark III is easy to use and comes installed on an attractive wooden base with a removable plastic dust cover. The best news of all is its price—under $260. ▲



Advent Loudspeaker System

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

IN view of the fact that Henry Kloss was a co-founder of *Acoustic Research*, and the "K" of *KLH*, it is not too surprising to find him heading a new company with an imaginative approach to high-fidelity product development. *Advent Corporation* has announced its first product, a loudspeaker system with several noteworthy features, and there is promise of several other interesting items (not speakers) in the near future.

Building on years of experience in developing speakers, the company has devoted its initial efforts to producing a relatively low-cost system with performance rivaling far more expensive units. It is an 8-ohm, two-way system, using an acoustic-suspension woofer in a relatively large sealed enclosure. Its dimensions of 25½" by 14¼" by 11½" are probably the largest that could be accommodated on a bookshelf, even a specially designed one. However, it is equally adaptable to floor mounting, in which case its size can be considered as an advantage, from an aesthetic standpoint.

The woofer diameter is nominally 10 in. The cone surround is a specially processed polyurethane, instead of the rubber-like materials used on most highly compliant cone suspensions. The tweeter has a 2-in phenolic-impregnated paper cone, offering wide polar dispersion and extended frequency response. A three-position toggle switch on the rear of the cabinet selects normal high-frequency

response, or reduced or extended highs to suit the user's preference. The high-frequency adjustment is moderate, amounting to about ±2 dB at frequencies above a few kilohertz, but is clearly audible in its effect.

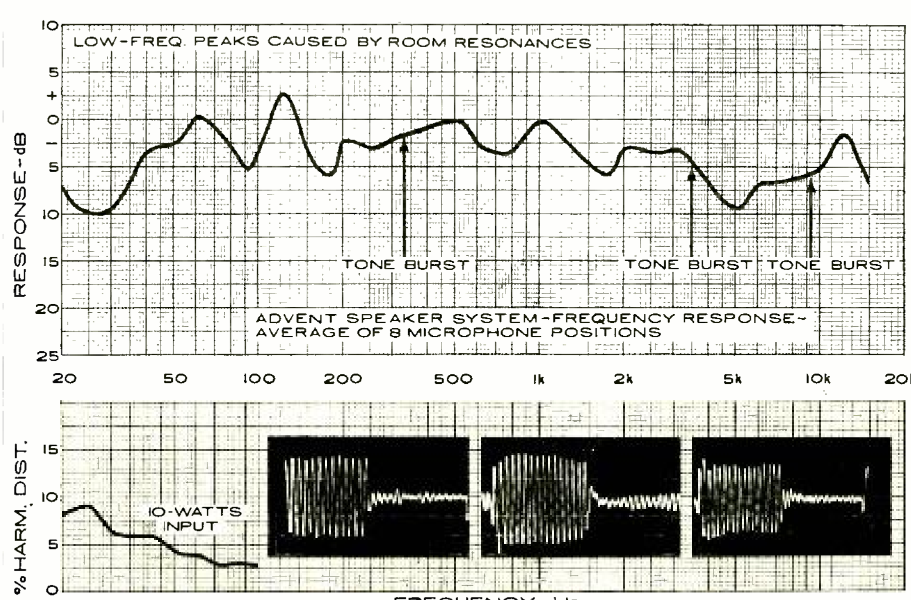
The indoor frequency-response curve, obtained by averaging eight microphones throughout our test room, is noteworthy for its smoothness and extended range. It is difficult, if not impossible, to separate the effects of the room at low frequencies from the true response of the speaker, but even without attempting this, the response measured within ±5 dB from 20 to 15,000 Hz (ignoring a slight peak at 120 Hz which we could definitely attribute to the room). The shape of the curve above 6 kHz corresponds almost exactly to the calibration curve of our microphone, which indicates that the true response of the speaker is virtually flat to well beyond 15 kHz.

The low-frequency performance of the speaker system is even more impressive than its high end. The flat, extended response to below the lowest audible frequencies is genuine, not the result of added distortion products which can make an inferior speaker seem better than it really is. The harmonic distortion of the speaker, with a 10-watt drive level, remains under 10% all the way down to 20 Hz, and is only 6% at 30 Hz. Heretofore, we have measured this order of bass distortion only with the most expensive acoustic-suspension speaker systems, or with other types such as horn-loaded speakers which are still costlier.

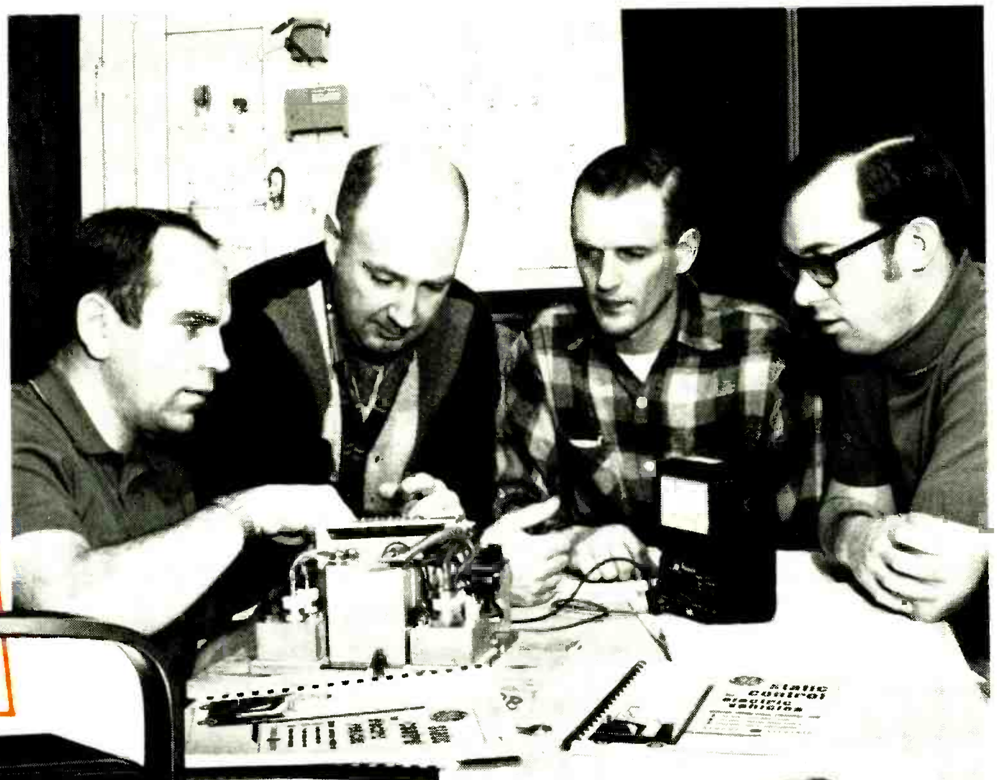
The tone-burst response of the speaker, in keeping with its smoothness (a requirement for good over-all transient response) is very good. The examples shown are typical of its behavior throughout its range.

In designing this speaker, the manufacturer had the goal of producing a speaker comparable in performance to the best acoustic-suspension types previously available, at a substantially lower price. We listened to the speaker by itself, and in A-B comparisons with some considerably more expensive types, and we feel that the company has essentially achieved its aims. It has a silky smooth, balanced sound with well-dispersed highs, and lows which can really be felt, rather than merely heard. We can't recall having heard another speaker in its price class that can match it (though obviously we haven't heard them all, nor have we compared it side-by-side with more than a few), and would consider that it ranks in sound quality with most speakers at twice its price. By all means listen to the speaker if you are contemplating purchase of any compact speaker system in the $100 to $250 price class.

The *Advent* speaker system is priced at $112. ▲



THE Goof-Proof VOM



SIMPSON 260-5P

J. P. Prufer, Director of the General Electric SCR Service Schools, shown with one of the recent student groups.

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These automatic turntables from BSR McDonald (Model 550A, left) and Perpetuum-Ebner (Model PE-2040, right) typify units tested. Representative models from three other manufacturers included in report (Dual, Garrard, Miracord) appear on cover.

EW Lab Tests NEW Automatic Turntables

By JULIAN D. HIRSCH / Hirsch-Houck Laboratories

Results of laboratory measurements on 17 units, from five manufacturers, meriting hi-fi use. Relatively minor performance differences were found; higher prices reflected more convenience features and small refinements.

IN spite of the widespread availability of stereo-FM broadcasts and pre-recorded reel or cassette tape programs, the phonograph record continues to be a favorite source of good music in the home. Reflecting the popularity of records is the constantly expanding automatic-turntable market, with literally dozens of models to choose from over a wide range of prices.

The name "automatic turntable" at one time was applied to record changers whose performance and features compared favorably with the separate arm-and-turntable combinations which were popular among critical audio enthusiasts. It was rightly believed that cheap mass-produced record changers, with unbalanced tonearms tracking at forces of six grams or more, would destroy one's records in short order. Cartridges were available, even in pre-stereo days, that could track at less than 3 grams, but many record changers had trip mechanisms that imparted a considerable side thrust to the arm and required even greater forces for proper automatic operation. In terms of the basic operating parameters of speed accuracy and constancy, rumble, and tonearm tracking errors, the ordinary record changer left much to be desired.

In the so-called "automatic turntable," these deficiencies were reduced or eliminated in a straightforward manner. Better balance of all rotating parts, especially the motor and revolving platter, drastically reduced rumble. Heavier turntables minimize rapid speed fluctuations, known by their audible effects as "wow" and "flutter." In most models, the arm is balanced by an adjustable counterweight, often isolated from the arm proper by a resilient material to damp the low-frequency arm resonance. Tracking force is applied by a spring, generally with a calibrated scale reading directly in grams. Tracking error is minimized by longer arms and, in many types, the cartridge position can be adjusted for minimum tracking error with cartridges of different dimensions.

Most modern automatic turntables, regardless of price, embody practically all of these design characteristics. In fact, one would be hard put to find any ordinary "record changer" in current catalogues. We prefer to look at an automatic turntable as a record player, capable of manual or single-play operation, but with the ability to play a number of records automatically. For some people, no doubt, the reverse order of emphasis would apply—an automatic record changer which can be conveniently used to play records singly with manual arm positioning.

Two other features, once found only on the most expensive units, are now offered on virtually every automatic turntable. Anti-skating correction, which compensates for the side thrust on the cartridge due to friction with the record surface, is now included in all but the least expensive players. Cueing controls, which raise or lower arm without the operator actually handling it, are now found over the whole price range.

Faced with so many makes and models of automatic turntables, whose prices span a range of about 4 to 1, the consumer cannot be blamed for his confusion. Many manufacturers offer a broad line of turntables, often without a clear indication of the differences among them. Then, at any given price level, there may be several competing products. How does one make an intelligent choice?

Tests Performed

We have approached the problem by testing and evaluating some 17 automatic turntables, from five manufacturers. This group includes most of the turntables meriting serious consideration for high-fidelity use. Our laboratory measurements were made under as nearly identical conditions as possible. The same test records and instruments were used for all models tested. Whenever possible, the same cartridge was used. We chose a *Shure* V15 Type II, as representative of the best performance currently available from phono cartridges. Although this cartridge cannot be operated at forces greater than 1.5 grams, we felt that a top-quality automatic turntable should be able to function properly at that force. Two of the lowest priced models tested (the *Garrard* 40B and SL55B) required slightly more tracking force, so a good-quality medium-force cartridge (the *Grado* FTE) was used with them, operating at 2 to 2.5 grams. The three *BSR McDonald* units were supplied as complete playing systems, with *Shure* Type M44 cartridges installed, and were tested in that form at the recommended force of 2 to 3 grams.

Our tests were limited to the basic performance parameters of the turntables. We did not judge their durability, reliability, or ease of servicing. However, all the manufacturers are reputable, and we have no reservations about the quality of any of the units we tested. Our comments on the subjective

DUAL AUTOMATIC TURNTABLES

THE Dual line includes three automatic turntables, which, despite considerable difference in price, have very similar basic performance. All are three-speed players, with a vernier adjustment of ±3% about each speed (our measurements showed it to be nearer ±2%). The vernier is mechanical, sliding the idler wheel along the tapered sections of the motor shaft.

Although their changing mechanisms appear to be identical, the three models have few other parts in common. Their arms, motors, and platters are different, as well as design details.

The lowest priced model is the 1212. In contrast to the chrome and glitter of many audio components, it is finished in flat black. The automatic spindle both supports and drops the records. In manual play, a short spindle is inserted, which revolves freely with the record to reduce center-hole wear. Manual operation is very simple—merely lifting the arm from its rest starts the motor. The finger lift is satisfactory, although we found it a little slippery to grasp at times.

The arm is a light aluminum extrusion with an "A" shaped cross-section. The adjustable counterweight is isolated from the arm by a compliant material to damp the resonance. The tracking-force dial is calibrated from 0 to 5½ grams at ½-gram intervals. Anti-skating is built in, coupled with the tracking force adjustment. The cueing lever works smoothly, with damped lowering of the pickup.

The cartridge slide is slotted to permit longitudinal adjustment of cartridge position for lowest-tracking error. A plastic jig is supplied with the unit for this purpose. We found the installation of a cartridge in the Dual units to be a relatively inconvenient procedure, since there is not a tapped hole to receive the screw. All Dual changers mute the cartridge output during the change cycle.

The platter of the 1212 is a heavy, two-piece drawn unit and is idler-driven by a four-pole induction motor.

The 1209 is a somewhat huskier and more attractively finished version of the 1212. Its arm is a tube of circular cross-section. Its elastically decoupled counterweight, instead of sliding along the arm, rotates for adjustment, with click stops at 0.01-gram intervals. The tracking force dial is similar to that of the 1212, but there is a separate anti-skating dial on the motorboard, calibrated from 0 to 5½ grams in red (for conical styli) and from 0 to 3½ grams in black (for elliptical styli). The motor of the 1209 is similar to that of the 1212, but is slightly larger and in our tests was less affected by line-voltage variations. It drives a heavy cast platter.

The model 1219 is the top unit of the line. Its arm (one of the longest of any automatic turntable), is a slim aluminum tube with a circular cross-section. It has the same click-stop counterweight as the 1209. The 1219 arm is supported by a true gimbal structure, using four identical pivots. It is claimed that this results in the very low (and unmeasurable, by us) friction of 0.007 gram vertically and 0.015 gram horizontally.

A unique feature of the 1219 is its adjustable arm height. In order to obtain the correct 15-degree vertical stylus tracking angle, it is necessary for the arm to be parallel to the record. When playing a stack of records, an arm cannot be parallel to more than one disc. In the 1219, a lever at the base of arm lowers it for manual (single) play so that it is parallel to a single record on the turntable. For automatic (multiple-play) operation, the lever raises the arm so that it is parallel to the middle of a full 6-record stack. When so positioned, the vertical error will be less than 1.5 degrees at the first or last record, which is negligible.

To reduce the chance of improper operation, if the arm is in the single-play position with the changer spindle in place, records will not drop and the arm will not leave its rest. In the multiple-play position, the cueing lever does not function.

The 1219 is powered by a husky synchronous induction motor, which drives a 7-pound cast platter. The cueing control action is damped in both directions, eliminating bounce or overshoot when lifting the pickup as well as providing a slow, gentle descent.

Vertical arm friction was obviously very low on all the Dual units. The tracking force of the 1212 and 1209 increased by 0.20 to 0.25 gram over a record stack, while the 1219 showed a change of only 0.05 gram—the smallest of any of the group of turntables tested.

The 1212 and 1209 had similar wow and flutter measurements, but the 1219 was measurably superior. To our surprise, there was little difference between the 1212 and 1219 in rumble level. All rumble figures were quite low.

The anti-skating compensation of the 1212 was not sufficient for the elliptical stylus in our test cartridge, although previous experience with this unit indicates that the compensation is approximately correct for a 0.7-mil conical stylus. The 1209 and 1219 both required about 1 gram more anti-skating than the recommended setting.

characteristics, such as ease of cartridge installation, tonearm finger-lift "feel," and general operating ease reflect a purely personal reaction.

The following test sequence was performed on all units (some of the initial setup was omitted with the ready-to-play *BSR* models). Each unit was unpacked and installed on the base supplied by its manufacturer. This proved to be a simple procedure in all cases. The cartridge was installed in the prescribed manner, and the arm balanced according to the manufacturer's instructions. A subjective appraisal of vertical arm friction was made, by noting how freely the arm "floated" in a balanced condition, and during the measurement of tracking force.

The actual downward force at the stylus was measured at indicated settings of the force adjustment from 1 to 5 grams, using a balance gage accurate to 0.05 gram. To determine how much the force increased from the first to the last record of a stack, we set the force to 1.00 gram (wherever possible) at the turntable height, and re-measured it with the stylus raised about ½" to simulate the height of a stack of records. For all subsequent tests, the force was set to between 1 and 1.5 grams (with the *Shure* V15 Type II) or 2 to 3 grams (with the *Grado* FTE or *Shure* M44).

Using a special protractor, the angular tracking error was measured at distances of 2 to 6 in from the record center. The anti-skating correction was evaluated with a record having 30 cm/s burst of 1000-Hz tones. With insufficient compensation, there was visible waveform distortion (using an oscilloscope) on the cartridge output corresponding to the outer groove wall channel. Excessive compensation caused distortion on the opposite channel output. When the anti-skating adjustment was optimized, both channels had identical waveforms. The setting of the anti-skating dial or indicator required for optimum correction was noted. This test can also be made easily and accurately, without use of instruments, by means of the STEREO REVIEW SR12 test record.

Turntable operating speeds were checked with a stroboscope disc, while a record was being played. Line voltage was varied from 95 to 135 volts and any effect on speed was noted. The stroboscope disc had two additional sets of dots corresponding to speed changes of ±2%, which were used to check those turntables having variable speeds.

Wow and flutter (r.m.s.) were measured at each operating speed with a special test record and a *Donner* 2800 wow and flutter meter. Rumble (unweighted) was measured at 33⅓ r/min, using a special record developed by *Acoustic Research*. The RIAA low-frequency equalization characteristic was used for this measurement. The rumble is expressed in decibels below a reference level of 1.4 cm/s at 100 Hz, which is the NAB standard. We made a measurement on the output of a single channel and on the paralleled output of both channels. The first figure includes both vertical and lateral components of rumble (V+L), and the second is essentially the lateral (L) rumble. If the two numbers are essentially equal, one can infer that the rumble is all lateral; the relative proportions of the vertical and lateral components can be estimated by the difference between the two figures. The audible significance of the two rumble components is that the vertical component can be eliminated by switching to mono in the amplifier, as when playing mono records, while the lateral component will always be present.

The *CBS Labs* STR100 test record was used to make a sweep from 200 Hz down to 10 Hz to reveal any resonances in that region. In almost every case, no resonance was found, indicating that the main arm/cartridge resonance was below 10 Hz, or very well damped, or both.

The distance from the arm horizontal pivot to the turntable was measured, as an indication of arm length. The turntable platter was removed and weighed. Each turntable was used briefly, both in automatic and manual modes, to verify proper operation of its dropping, indexing, and cueing mechanisms.

It must be understood that the numerical test data which

SUMMARY OF TEST RESULTS

Mfgr. & Model	Speeds (r/min)	Accuracy	Line-Volt Effect	Turntable Dia. (in)	Turntable Wgt. (lbs)	33 r/min Wow (%)	33 r/min Flutter (%)	Rumble (V+L) (—dB)	Rumble (L) (—dB)	Max. Rec. Stack	Arm Length (in)	Arm Balance	Adj. Cart. Position	Max. Tracking Error (deg/in)	Max. Tracking Force Error (g)	Price ($) (less cart. & base)
BSR-McDonald																
400	16,33,45,78	Slightly fast	none	10⅞	2	0.20	0.07	24	30	6	6½	no	no	0.67	N.A.	50
500A	16,33,45,78	Slightly fast	none	10⅞	2	0.20	0.05	29	33	6	6½	no	no	0.40	N.A.	60
600	16,33,45,78	Slightly fast	none	10⅞	3¼	0.11	0.04	31	35	6	6½	yes	no	0.80	0.85	75
Dual																
1212	33,45,78	Adjustable	1%	10⅜	3¼	0.10	0.03	38	40	6	7¼	yes	yes	0.40	0.20	90
1209	33,45,78	Adjustable	none	10½	4	0.10	0.035	35	43	6	7¼	yes	yes	0.80	0.10	130
1219	33,45,78	Adjustable	none	12	7	0.06	0.03	39	40	6	8	yes	yes	0.40	0.25	175
Garrard																
40B	33,45,78	Exact	2%	10⅜	1¾	0.20	0.06	35	38	8	6¾	no	no	1.0	N.A.	45
SL55B	33,45,78	Exact	none	10⅜	1¾	0.08	0.055	35	38	8	6¾	no	no	1.0	N.A.	60
SL65B	33,45,78	Exact	none	10¼	2	0.15	0.04	27	30	8	7	yes	no	1.0	0.25	80
SL72B	33,45,78	Exact	none	10½	1¾	0.07	0.035	38	43	8	7½	yes	no	0.40	0.30	90
SL95B	33,45,78	Exact	none	11⅜	3	0.07	0.03	39	43	6	7½	yes	no	0.80	0.15	130
Miracord																
620	16,33,45,78	Slightly fast	none	10¼	3	0.12	0.04	35	37	10	7⅛	yes	yes	0.50	0.10	110
630	16,33,45,78	Exact	none	10⅜	5	0.08	0.035	38	40	10	7⅛	yes	yes	0.60	0.15	130
750	16,33,45,78	Slightly fast	Very slight	12	5½	0.03	0.035	38	39	10	7¼	yes	yes	0.80	0.18	150
50H	16,33,45,78	Exact	none	12	5½	0.10	0.04	37	39	10	7¼	yes	yes	0.50	0.05	170
Perpetuum-Ebner																
2038	33,45,78	Adjustable	Very slight	10½	4¼	0.08	0.05	32	37	8	7⅜	yes	yes	0.70	0.05	115
2040	33,45,78	Adjustable	Very slight	11⅜	7(est.)	0.08	0.04	39	42	8	7⅜	yes	yes	0.67	0.15	145

NOTES: Arm length = turntable center to arm horizontal pivot; Tracking error = between 2.5" and 6" radius, in degrees/inch; N.A. = not applicable; Tracking-force error = between 1.00 and 3.00 grams.

we obtained cannot, in general, be compared with similar data obtained by manufacturers or other testing agencies. Test records, cartridges, and instrument characteristics can have a profound effect on measurements of turntable characteristics. This is especially true in the case of rumble measurements, where many of the turntables we tested have rumble levels very close to the residual rumble of our test record. Differences of one or two dB in our rumble figures cannot be considered as significant, since a subjective judgment must be made of a meter reading which is fluctuating by several dB.

However, for purposes of comparison among the models we tested, our test data is valid, and we believe it to be unique in providing the consumer with a meaningful survey of the automatic turntable market.

General Comments

Reviewing the mass of data resulting from our tests, we were impressed by the relatively minor differences among most of the turntables we evaluated. In general, of course, the more expensive units tended to have better performance

PERPETUUM-EBNER AUTOMATIC TURNTABLES

THE **PE** Models 2038 and 2040 appear to be essentially similar to the former Models 2018 and 2020. The units have some interesting and unique features. Perhaps the most noteworthy is the adjustable vertical cartridge angle. A small knob on the end of the cartridge slide tilts the entire cartridge so that it can be made parallel to any record being played, whether it be a single disc or any of a stack of from 1 to 8 records high being played automatically.

Both **PE** automatic turntables use the same motor and drive system. It is a 4-pole induction motor, providing a ±2% vernier adjustment about each of its nominal speeds. The adjustment is mechanical, by sliding the idler wheel along a tapered section of the motor shaft. The 2038 has a heavy cast platter; the 2040 has an even heavier platter. We were unable to remove it for weighing, but estimate its weight at about 7 pounds.

The arms are identical; they have a circular cross-section, with a resiliently mounted counterweight that rotates for balance adjustment. A small knob on the side of the pivot structure adjusts tracking force 0 to 6 grams, with calibration at ½-gram intervals. The anti-skating control of the 2040 is on the motorboard, and is calibrated arbitrarily from 0 to 10. A table in the instruction manual gives the recommended settings for different stylus dimensions and force settings. On the 2038, the anti-skating dial is concentric with the stylus force dial, and is calibrated over the same range of 0 to 6 grams.

The **PE** arm had extremely low pivot friction, resulting in an unambiguous balance condition. The error of the stylus force dial was exceptionally low, less that 0.15 gram at any setting. The change in force over a record stack was 0.20 to 0.25 gram. The maximum tracking error was 0.7 deg/in at a 3-in radius. The anti-skating adjustment of the 2038 had to be set 2 grams higher than the tracking force for optimum compensation. The 2040 did not have sufficient compensation available, even when tracking at 1.5 grams with the dial set to its maximum of 10.

The cueing action of the units was very gentle, and damped in both directions. We noticed a slight tendency for the cartridge to drift outward during the drop, under the influence of the anti-skating force. These turntables have a unique single-lever operating control (in addition to the speed-selector knob and its concentric vernier control). The removable manual spindle rotates with the records for low center-hole wear.

If there is no record on the turntable, the arm cannot leave the rest, so that accidental stylus damage from operating the player without a record on the platter is impossible.

The mechanism of the turntables is one of the most "automatic" we have encountered. We used it extensively in our tests and found it to be truly fool-proof. Underneath, the mechanism seems to be rather more complex than most automatic turntables, but not unusually so.

In their basic performance, both **PE** units were excellent. Wow, flutter, and rumble were low for both units. The heavier model 2040 was even better with respect to rumble.

BSR McDONALD AUTOMATIC TURNTABLES

THE three **BSR McDonald** turntables were supplied to us as complete record players, with cartridges installed, mounted on a plastic base, and with a plastic dust cover. All three models appear to be identical in mechanical design and changing mechanism, and use the same four-pole induction motor, which drives the platter through an idler wheel. Interchangeable automatic and single-play spindles are provided. The turntables feature a unique automatic arm lock which releases when the unit goes into operation, and clamps the arm when it shuts off.

The anti-skating dial is calibrated at 2, 4, and 6 grams. The cueing lever is undamped in either direction, so that smooth control requires a gradual movement of the lever. The finger-lift is well designed and easy to use.

The differences among the three units are in their arms and turntable platters, as well as in the cartridges supplied with them. (the basic turntables can also be purchased without base or cartridge). The 400 and 500A use the same drawn turntable, formed in two concentric sections, and a Shure M44-7 cartridge. The arm of the 400 is not fully balanced, and has a fixed counterweight rigidly attached to the arm. There is no stylus-force scale, so that a separate gage is required if another cartridge is installed. With the anti-skating set as recommended, correction was optimum. At 6½ in, this was the shortest arm of the group of turntables tested. It is an aluminum tube of circular cross-section.

The 500A is identical to the 400, except for an improved arm. Adjustable counterweights permit the arm to be balanced with cartridges of different weights. The weights are rigidly screwed to the arm. The calibrated tracking force dial has click stops at ⅓-gram intervals from 0 to 6 grams. When we balanced the arm, we observed some vertical pivot friction, which showed up as a substantial error in tracking force. With the dial set to 2, the actual force was 2.60 grams, and anti-skating was optimum at the recommended setting of 4.

The Model 600 is identical to the 500A, except that the turntable platter is a heavier two-piece casting, and the cartridge is an elliptical-stylus Shure M44E. Muting has been added to this unit to short the cartridge outputs during the change cycle. With the tracking force set at 2 grams, the actual force was 1.90 grams, and the anti-skating setting of 4 was optimum.

The relatively short arms of the **BSR** players had satisfactorily low tracking errors, with the largest readings falling between 0.4 and 0.8 deg/in, at radii of 2.5 to 3 in. The variations are not significant. The low-frequency sweep record revealed small resonances (of about 1 to 2 dB) at about 140 and 170 Hz, with the major arm resonance, also of 1 or 2 dB, at about 13 Hz. The tracking force on all three units increased about 0.3 gram at the end of the record stack, compared to the force on the first record.

The heavier platter of the 600 produced a substantial reduction in wow, flutter, and rumble. The wow and flutter were about half as much as in the others, and the rumble was lower.

but even this was not always consistent within any one manufacturer's line. It was apparent that much of the difference among turntables was in the realm of convenience features and small refinements, which might not always justify the price differential to some users.

Every one of the automatic turntables in this group was capable of true high-fidelity performance. This impresses us as a noteworthy situation, in view of the 4 to 1 price ratio within the group. This is not to imply that all were equally good, of course. Some of the lower priced units were marginal in respect to wow (0.2%). We listened critically to these turntables with piano, and other revealing recordings, and concluded that even 0.2% wow was not necessarily offensive—in fact, it could usually only be detected by critical listening. In some of these same units, rumble was typically 5 to 10 dB worse (lower −dB figures) than in most of the medium and high-priced models, but was not obtrusive unless a high listening level was combined with considerable bass boost. Flutter was negligible on all units, being well under 0.1% on all and generally not more than 0.05%.

Probably the major limitation (from the listener's standpoint) of the lowest priced turntables was their inability to operate with tracking forces less than 2 or 3 grams. This seemed to be a weakness of arm pivot design, since we ob-

MIRACORD AUTOMATIC TURNTABLES

THE **Miracord** 620 and 630 are essentially similar, differing only in finish and turntable platter construction. The turntable of the 620 is of drawn construction, while the 630 has a heavier cast platter. Both are driven by a 4-pole induction motor.

The turntables use a single-point center record support, with a removable automatic play spindle. The interchangeable single-play spindle rotates freely in its mount, minimizing center-hole wear of records. The units require that the automatic-play spindle be removed before taking records off the turntable.

The arm of the 620/630 is tubular, with a circular cross-section. The adjustable counterweight is resiliently mounted. The stylus force dial is concentric with the horizontal pivot, exceptionally easy to read and set, and is calibrated from 0 to 6 grams at ¼-gram intervals. The calibration proved to be very accurate, within 0.10 gram at all settings on the 620, and with errors up to 0.3 gram at higher settings on the 630. At a 1-gram setting, the stylus force increased by 0.2 gram over a ½-in record stack on the 620 and by 0.25 gram on the 630.

Around the arm base is a rotating ring which sets the anti-skating force, on a scale reading from 0 to 6 grams. We found the optimum setting, with the elliptical-stylus cartridge, to be about 2 to 2.5 grams greater than the stylus force setting.

The removable plastic cartridge mounting slide has an integral finger lift, which we found exceptionally easy to use. The cartridge position can be adjusted longitudinally for minimum tracking angle error. In the 620, the stylus is aligned with two white dots on the edge of the slide during installation. In the 630, turning a screw on the end of the slide moves the cartridge until the stylus is aligned with a retractable post on the motorboard. When the installation is complete, a brush fits over the post and removes dust from the stylus every time the arm returns to its rest.

The 620 and 630 had low tracking errors over the entire record. Arm friction was low, which probably accounted for the notable accuracy of the stylus-force indication.

Single-play operation is very simple, since merely lifting the arm from its rest starts the motor, and it returns to rest automatically after playing the record. The cueing lever (on all **Miracord** models) is damped in both directions, providing exceptionally smooth control of the phono pickup during cueing operation.

On the 620, we measured low wow and flutter. The 630, because of its heavier turntable, had even less wow and flutter. Rumble was very low for the 620, and was 3 dB lower for the 630.

The two deluxe models of the company's line have many points of similarity, and differ in their details from the 620 and 630. The models 50H and 750 are identical except for their motors and minor finish and trim details. Both use large, heavy cast platters The motor of the 50H is an outside-rotor, constant-speed hysteresis-synchronous type, while the 750 uses a 4-pole induction motor similar to that used in the 620 and 630.

The 50H and 750 use a slightly longer arm than most of the other models. It has a square cross-section, and uses the same adjustable cartridge slide (with its very good finger lift) and retractable stylus positioning guide as the 630. The arm has a resiliently mounted rectangular counterweight, whose position is adjusted by a knob on its side (the 620 and 630 have a threaded weight which is rotated for adjustment). The stylus-force dial, in line with the vertical pivot axis, is calibrated at ¼-gram intervals from 0 to 6½ grams. Anti-skating is controlled by a knob on the motorboard, calibrated from 0 to 6. No distinction is made between the different settings required for conical and elliptical styli.

The arms of the 50H and 750 have very low friction, and are among the most unambiguous and accurate in balancing and stylus-force adjustments. When it is balanced so that a small index mark on the arm is aligned with the "0" calibration of the stylus force dial, the dial calibration is sufficiently accurate so that no external gage is required. The 50H was accurate to within 0.05 gram from 1 to 5 grams, while the 750 was accurate within 0.15 gram from 1 gram to more than 4 grams. The change in force over a record stack was less than average, about 0.13 to 0.15 gram.

Both the 50H and 750 use the same basic push-button-control system as the other **Miracord** models. Their mechanisms are identical. On both units, the optimum anti-skating setting was about 3 grams higher than the tracking force setting.

Wow and flutter were low for the 50H and even lower for the 750. The rumble level of both units was virtually identical, and very low.

served vertical pivot friction of 0.5 gram or more on some arms. The finest cartridges (which cost as much as or more than the turntables in question) cannot be used in these arms, but fortunately there are a number of very satisfactory cartridges at moderate prices that can.

We were interested to find that there was little correlation between arm length (which ranged from 6½" to 8") and tracking error. However, tracking error was not excessive in any of the models tested, with typical maximum values of 0.4 to 0.8 degree per inch of radius (the criterion for relating tracking error to the distortion it produces). The largest errors (about 1 deg/in) were found in several of the less expensive units, which have no provision for adjusting the cartridge position for minimum tracking error. However, the distortion resulting from even this much error is insignificant compared to other distortions in the recording and playback process.

When calibrated stylus force scales were incorporated in the turntable design, they were usually quite accurate once the arm was properly balanced. However, many arms cannot be balanced visually with sufficient precision to assure accurate tracking-force settings, especially at low values. An unbalance generally introduces a fixed error, which may be several tenths of a gram. This is insignificant at tracking forces of several grams, but cannot be overlooked at 1 to 1.5 grams. We found that tracking force error was less than 0.25 gram in the 1- to 2-gram range with most of the turntables which were otherwise suitable for use at such forces. Fortunately, in each case the error was on the high side, so that one could depend (*Continued on page* 64)

GARRARD AUTOMATIC TURNTABLES

WE tested five **Garrard** automatic turntables, which clearly indicates the choice of design and performance features offered. All the players have three speeds and use a common cartridge slide. Installation of a cartridge is exceptionally easy, but there is no provision for adjusting the cartridge position for minimum tracking error. The finger lift, which is identical in all of the record players, is short and straight and not too easy to grasp firmly since it lacks a hooked end.

The three lowest priced units (40B, SL55B, and SL65B) have generally similar appearance and control configurations. At 78 r/min only 10-in records may be played automatically. The 12-in size can be played manually. Moving the operating lever to "Manual" starts the turntable rotating, and the arm is picked up and placed on the record manually.

The 40B, SL55B, and SL65B have a removable automatic spindle that supports the record stack through its center. A swing-away overarm holds the records level and, by dropping down when the last record has been played, signals the unit to shut off. For single-play operation, the overarm is moved to a "park" position in the rear, and a short spindle replaces the automatic spindle.

All three turntables have a cueing lever, with a damped descent but undamped elevation of the arm. The arm of the 40B is a tubular design with circular cross-section and a fixed rubber counterweight. In general, it operates in an unbalanced condition. Downward stylus force is applied by a spring, adjusted in nine uncalibrated steps. There is no anti-skating compensation on the 40B. Cartridges of varying weights may be accommodated by adding weights (supplied) to the cartridge slide when installing a light cartridge.

The 40B has a drawn platter which is idler-driven by a four-pole induction motor. There is no muting during the change cycle on this and on the SL55B.

We tested the 40B with the **Grado** FTE cartridge, tracking at 2.5 grams. The tracking force could be varied in steps of approximately 1 to 1.5 grams, from a negative value to more than 6 grams. A separate stylus force gage must be used to make this adjustment. The change in force from beginning to end of a record stack was greater than 0.5 gram.

The tracking error was low over practically the entire record surface, reaching a maximum of 1 deg/in at a 6-in radius. The low-frequency sweep showed slight resonant dips at 130 and 160 Hz, and a 1-dB rise at the 14-Hz resonance.

Wow and flutter were reasonably low for a low-priced turntable such as this. The rumble was surprisingly low.

The SL55B has the same turntable platter as the 40B, but uses a "Synchro-Lab" motor that operates at synchronous speed and is not affected by line-voltage changes. The arm is identical to that of the 40B, but has an anti-skating adjustment calibrated from 0 to 5 to correspond to the tracking force.

In our tests, the tracking error was quite similar to that of the 40B, except that the maximum value of 1 deg/in was reached at a 2.5-in radius. The arm friction, as with the 40B, was relatively high, so that a test force of 2.1 grams was used (the closest we could come to the 2.5-gram figure used with the 40B). The same small resonances were found, as well as a 1 to 2 dB rise at 14 to 15 Hz. The anti-skating control had little effect.

The improved motor of the SL55B, in addition to providing exact and constant speed, produced substantially lower wow and flutter than the induction motor of the 40B. The rumble was exactly the same as on the 40B.

The next model tested was the SL65B. In general appearance and control operation it resembles the 40B and SL55B. However, its turntable uses a slightly heavier drawn platter, driven by a "Synchro-Lab" motor. The arm of the SL65B is slightly longer than that of the lower priced models, has an adjustable resiliently mounted counterweight, a stylus force scale calibrated from 0 to 5 grams in ¼-gram intervals, and an anti-skating dial with corresponding calibrations.

The arm friction was considerably lower in the SL65B so that we were able to use the **Shure** V15 Type II cartridge operating at 1 to 1.5 grams. The actual tracking force was 0.15 to 0.50 gram greater than the scale reading, and increased by 0.45 gram from beginning to end of a stack of records. The anti-skating compensation required settings about 1.5 grams higher than the tracking force for optimum results.

Tracking error was moderate, with the maximum of 0.8 to 1.0 deg/in occurring at radii of 2.5 to 3 in. No resonance was found during the sweep test. The cartridge outputs are shorted for muting during the change cycle on this and the more expensive **Garrard** models.

The wow and flutter of the SL65B were very low although the rumble was higher than that of any of the other **Garrard** turntables. The figures are satisfactory for a moderate-priced turntable, and are not audible in ordinary listening unless considerable bass boost is used.

The next unit tested was the SL72B. In its physical design and operating controls, it is quite different from the lower priced models, and is almost identical to the top-of-the-line model SL95B.

An upright lever operates the cueing function, with damping on the descent of the pickup. The pickup outputs are shorted during the change cycle (as they are also on the SL95B).

The record support and drop system of the SL72B (and SL95B) differs from that of the other **Garrard** models. In automatic play, the stack is supported at the center and on one edge, at a slight angle to the horizontal. In single-play operation the spindle is free to rotate with the record, minimizing center-hole wear. The turntable platter is of single-piece drawn construction, idler-driven by a "Synchro-Lab" motor.

The arm is tubular, with a hexagonal cross-section. A resiliently mounted counterweight is used for balance, and the stylus force scale is calibrated from 0 to 5 grams in 1-gram intervals. Anti-skating compensation is applied by a lever which is tilted up as the arm moves toward the center of the record. A sliding weight on the lever sets the anti-skating force. There are two scales, calibrated 0 to 5 grams for conical styli and 0 to 3 grams for elliptical styli.

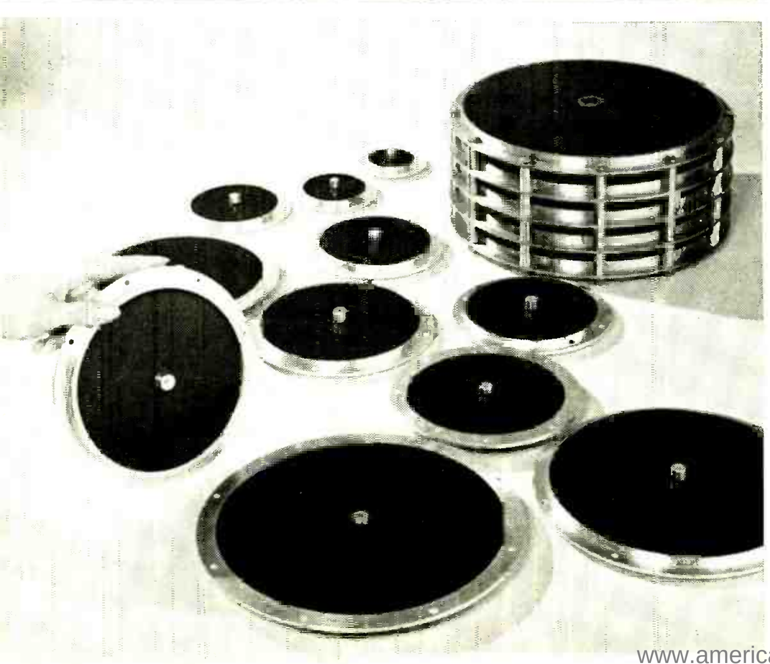
The tracking error of the SL72B was very low over the entire record surface, and essentially zero at the inner portions of a record. The increase in tracking force over a record stack was 0.4 gram from a 1-gram starting point. The anti-skating setting for optimum performance was 1.5 grams greater than the tracking-force setting.

Wow and flutter were low and rumble was very low.

The SL95B is the company's top automatic turntable. The arm, although the same length as that of the SL72B, is a rectangular cross-section "U"-shaped aluminum extrusion, filled with Afrormosia wood, which is not only visually attractive but is claimed to provide additional damping of arm resonances. The stylus force scale is calibrated 0 to 5 grams at 1-gram intervals, with click stops every ¼ gram. The anti-skating device is similar to that of the SL72B, and like it had to be set 1.5 grams higher than recommended for best results.

The SL95B turntable is a heavy cast platter with the same record-handling mechanism as is used in the SL72B.

The tracking error was low over most of the record surface, reaching its maximum at a 6-in radius. The change in force from beginning to end of a stack was 0.2 gram. The arm friction was very low, so that it floated freely in a balanced condition. Wow and flutter were low and rumble was very low.



Recent Developments in Electronics

Digital Data Transmitter for Police Cars. (Top left) A system that can handle 100 data transmissions in the same time it takes for one voice message is being tested by the San Francisco Police Department. Twelve routine codes can be digitally transmitted and received by mobile units and license-plate checks can also be made. Shown in the photo is a police officer sending a message simply by dialing the correct numbers on a control panel and then activating the transmit button. The message is sent over the regular radio frequency to a computer which displays it on a dispatch console for action. An acknowledged signal appears on an illuminated dashboard display in the car. In addition to reducing congestion on police radio channels, the digital system also provides greater efficiency in the assignment and control of patrol cars. The system has been developed by Sylvania Electric Products. The company claims that the system can be expanded to include a car-locator feature that can be employed to automatically keep track of the exact location of every patrol vehicle that has the equipment installed.

CRT Display Terminals for Airline Reservations. (Center) More and more airlines are starting to use high-speed cathode-ray tube display terminals for passenger reservations and flight information. One of the latest that we have heard about is this installation of over 50 such display terminals at the Honolulu reservation office of Hawaiian Airlines. Information is depicted on television-like screens within several seconds after requests are initiated via the terminal keyboards. The reservations network utilizes a central data base located in Dallas, Texas, where the required flight and reservation information is stored. Information on flight schedules, fares, seat availability, and other data for all the airline's flights can be displayed. The terminals have been installed by Sanders Associates, Inc.

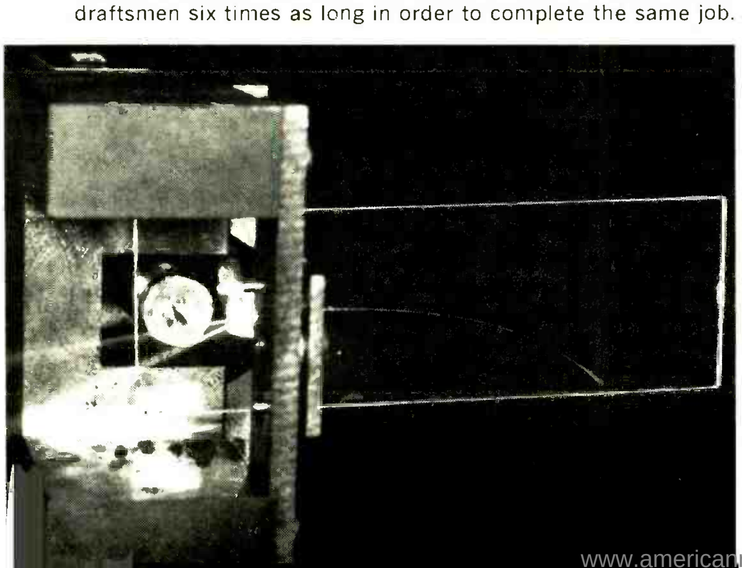
High-Voltage Feedthrough Capacitors. (Below left) The unusual looking components shown in the photograph are high-power, high-frequency, non-radiating feedthrough capacitors. The flat disc construction of the new capacitors results in extremely low inductance and very high self-resonant frequency. What is more, the special flange and core design not only facilitates mounting and dismounting in circuits, but enables any number of capacitors to be assembled in parallel. The components are said to be highly stable because of an unusual combination of metals and plastics used in their construction. The dielectric is a type of epoxy plastic with the metal electrodes forming an integral part of the dielectric structure. Capacitance values of 500 pF and 1000 pF at voltages ranging from 5000 V to 25,000 V are available as standard items while 2000-pF units have also been made. The new capacitors, made by Polyflon Corp., are designed for use in high-power broadcast and communications transmitters, radars, and ground-support transmitters.

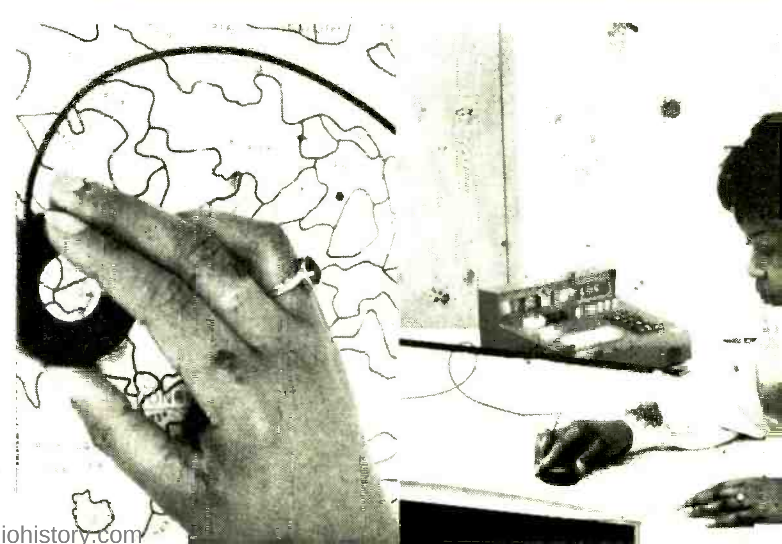
Bank Computers Generate Graphic Displays. (Top right) This is the master control room that overlooks three main conference rooms of a new Management Communications Center at the First National Bank of Chicago. Here an operator controls sound, lighting, communications, and displays which are generated for management groups by the bank's computers. Extensive use is also made of closed-circuit TV in the new system. Control circuits for displays are solid-state, with tone-control encoders and decoders like those in push-button phones.

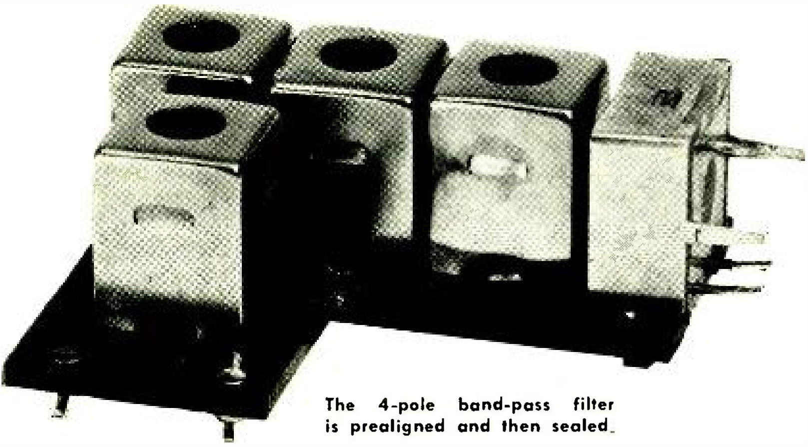
Electronic Scale for Jet Cargo. (Center) A heavy baggage cargo container is propelled onto the floating platform of a transporter which will carry it to a jet plane for loading. The transporter platform is part of a new solid-state electronic weighing system which gives digital readout of cargo weights, and aids faster turnaround of bigger aircraft. Digital information can be used with computers, accumulators, card-punch units, or for other automated systems. Readout is in kilograms with a range from 0 to 2268 kg (0 to 5000 lbs). Weighing system was developed by Semtrol Electronics (Western Gear Corp.).

Waveguide for Laser Beam. (Below left) The laser beam shown entering the glass plate is being bent downward by a newly developed laser waveguide or lightguide. This is a thin glass or crystal strip—about 100 times thinner than a human hair—deposited as a film on a glass plate. The width of the film is about ten times its thickness, so that an entire laser circuit could fit on a plate the size of a nickel. Such a circuit, relatively unaffected by heat, noise, or vibration, will enable scientists to manipulate laser light as though it were a current in an electronic circuit. The lightguides have been developed at Bell Telephone Laboratories as part of a continuing research program investigating use of lasers for communications.

Electronic Map Reader. (Below right) The U.S. Forest Service at Berkeley, Calif. is using a new electronic instrument to record coordinates from maps, charts, and photos and feed the information into a computer. The instrument, the Datagrid Digitizer developed by Bendix, employs a free-moving cursor which the operator simply moves over the map to be "read." Information is stored on magnetic tape so that it can be analyzed or reproduced as needed. With the reader, an unskilled operator can, in a period of three months, record the size and location of all water rights in one of the six National Forest System's western regions. Previously, it took two experienced draftsmen six times as long in order to complete the same job.







The 4-pole band-pass filter is prealigned and then sealed.

High-Quality AM SECTION in New Hi-Fi Receiver

By KLAUS J. PETER / Project Engineer, H. H. Scott, Inc.

Design of tuner section that narrows quality gap between AM and FM. A 4-pole filter, FET front-end, and IC i.f. strip are employed.

MOST manufacturers of audio equipment have tended to neglect AM almost completely. However, there are many programs on AM that are not available on FM. What is more, many AM stations are transmitting high-quality signals with fidelity that is comparable to FM broadcasts.

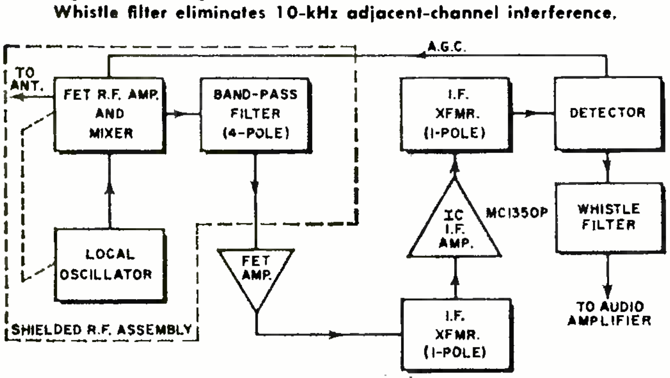
A rapidly growing mass market and increasing demand for AM/FM tuners and receivers resulted in hi-fi manufacturers adding AM sections to their existing FM equipment. The performance of these "added on" AM sections were, in most cases, no match for the FM sections.

This unsatisfactory situation has been changed by a new line of *H.H. Scott* receivers (Models 382-C, 386, and 3900). The AM sections of these new AM/FM receivers were designed around state-of-the-art circuitry to give superior performance.

FET Front-End

Let us look at a block diagram of the AM tuner section and see where circuit improvements have been made (Fig. 1). The receivers use a ferrite loop antenna which helps to reduce electrostatic interference. This type of antenna is designed to select the magnetic components of the radiated field and thus eliminate most types of man-made noise (as from neon lights, machinery, etc.). For the ferrite coil antenna to be most effective, it must have a high *Q* and therefore should not be loaded by the first r.f. stage. The design achieves this with a fully neutralized FET stage that serves as a combined amplifier and mixer, that is, a mixer with gain. This presents an extremely high input impedance to the antenna at the operating frequencies. A conventional, bipolar transistor stage or even an un-neutralized FET amplifier would result in a lower loaded *Q* of the ferrite antenna with a corresponding decrease in performance. A further advantage of this type of antenna lies in its directional properties. Since the ferrite antenna can be rotated without moving the receiver, it can be helpful in selecting weak stations, reducing strong stations, and minimizing local interference.

Fig 1. Block diagram of the new AM tuner section of receiver. Whistle filter eliminates 10-kHz adjacent-channel interference.



In order to keep unwanted magnetic fields from reaching the ferrite loop antenna, the power transformer has a low flux density (10,000 gauss maximum at 60 Hz) plus a copper strap to minimize the radiated field. If a strong alternating magnetic field were allowed to reach the antenna, which could happen if the power cord is placed close to the ferrite element, the incoming r.f. signals may be modulated by the 60-Hz line frequency. This will only happen if the field is strong enough to drive the ferrite loop into its non-linear or saturated regions during alternate peaks. Fortunately, this condition can be easily rectified by moving the power cord away from the antenna or, in rare cases, changing the location of the receiver.

The main advantage of an FET r.f. amplifier-mixer lies in its excellent noise characteristics and superior overload capability. The FCC requires a station to produce a typical signal strength of 5 to 10 mV/meter in a primary service area and 0.5 mV/meter in a secondary service area during the daytime. The FCC also specifies that only 1% of the population in a given area can be in a location resulting in a signal strength of 1 V/meter. The large a.g.c. range of which these receivers are capable allows the reception of signals ranging in signal strength from 200 μV/meter to 2 V/meter with equal volume.

The a.g.c. voltage derived from the detector is applied to the gate of the FET to maintain its ideal square-law characteristics during all types of signal conditions. (See December, 1965 issue of ELECTRONICS WORLD, "Field-Effect Transistors for FM Front-Ends," by Daniel R. von Recklinghausen, Chief Research Engineer, *H.H. Scott, Inc.*) A minimum number of spurious signals and cross-modulation products give rise to cleaner sound with minimum interference between stations. Bipolar transistor r.f. stages are inherently easier to overload and cross-modulation as well as spurious-response characteristics can cause strong stations to appear at several points on the dial.

The 4-Pole Filter

Following the mixer, but still inside the shielded r.f. assembly, is a band-pass filter constructed of four inductively coupled, individually tuned *LC* circuits. This is referred to as a "4-pole filter."

Since there may be dozens of AM signals present at the receiving antenna at any one time, the selectivity of the tuner will determine how well one station can be selected while all others are rejected. The r.f. amplifier-mixer stage, if it is tuned, will do a certain amount of preselection, but the bandwidth resulting from one or even two tuned stages is far too wide to separate two stations close together.

The over-all selectivity is therefore determined mainly by the band-pass characteristics of the i.f. amplifier. The primary function of the i.f. band-pass filter, then, is to reject all unwanted signals while accepting the selected one without attenuating its sidebands, hence affecting its fidelity. These two requirements can only be met by means of careful filter design.

Even though the FCC provides a maximum frequency separation of 40 kHz between local AM stations, signal conditions at night often change and more closely spaced distant signals may be picked up. There are still over twice as many AM stations as FM stations in the U.S. with roughly the same number of channels assigned to them.

If two AM stations situated 20-kHz apart modulate their carriers with 8-kHz sine waves, their frequency spectra after the mixer (but before the filter) will look like Fig. 2. Assume the receiver is tuned to the lower of the two frequencies. Since the two adjacent sidebands are separated by only 4 kHz, the band-pass filter must have very steep skirts to attenuate the unwanted sidebands while accepting the desired ones. The ideal filter would have vertical slopes while the top remains perfectly flat; unfortunately such ideal filters exist only on paper.

The curves of band-pass filter designs shown in Fig. 3 were computer-generated for several numbers of tuned sections or poles. The measured response of the i.f. strip was so close to the predicted curve of the 6-pole filter that it is not shown separately on the graph. The over-all response of the receiver, including r.f. section, showed a slight improvement in selectivity over the 6-pole filter curve. (Refer to inner curve in Fig. 3.)

The circuit of the 4-pole filter is shown in Fig. 4. It consists of four distinct *LC* networks, the coils of which are inductively coupled. This network is aligned once and then sealed. The input coil of the filter is tapped to provide a neutralizing output which is connected to the FET gate through a 2.2-pF capacitor.

After the 4-pole filter, there are two additional tuned transformers resulting in a total of six tuned *LC* networks. As expected, the over-all i.f. band-pass characteristics follow closely the calculated curve of a 6-pole *LC* filter, as shown in Fig. 3.

Immediately following the 4-pole filter is another FET in a grounded-source configuration, achieving isolation and gain in one simple step. The primary of an i.f. transformer acts as the drain load for the FET. The secondary of the transformer feeds a new high-gain IC.

IC I.F. Strip

A number of years ago, we introduced the first consumer receiver to use an IC i.f. strip in its FM section. An improvement in performance as well as simplification of the i.f. amplifier circuitry resulted. This design technique has now been applied to AM with excellent results.

The IC itself, a high-gain low-noise type (*Motorola* MC-1350P), contains 16 *n-p-n* transistors. Half of these transistors are used directly for i.f. amplification, two are part of an a.g.c. circuit, while the remaining six are used to set d.c. operating points of all stages. At the output of the IC is the last tuned *LC* section of the i.f. amplifier. The secondary of this transformer provides the i.f. output for the detector circuitry.

The monolithic IC makes available a large amount of gain in one tiny package so that fewer stages are necessary to achieve the over-all amplification required. Consequently, the number of points at which a filter can be inserted in the circuit have diminished, and a small number of "lumped" or multiple-pole filters have replaced a larger number of single-pole filters.

All these innovations and refinements have helped to elevate AM performance from the "also-ran" position it has occupied in most receivers. Due to inherent differences between AM and FM, as well as the availability of stereo FM, the latter will always have a slight edge, but the gap has narrowed with this new receiver design. ▲

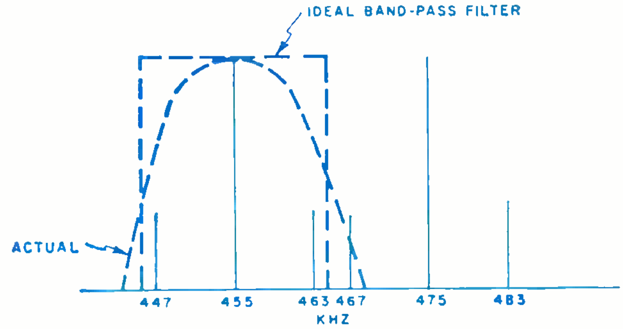


Fig. 2. Frequency spectra of two AM signals after mixing.

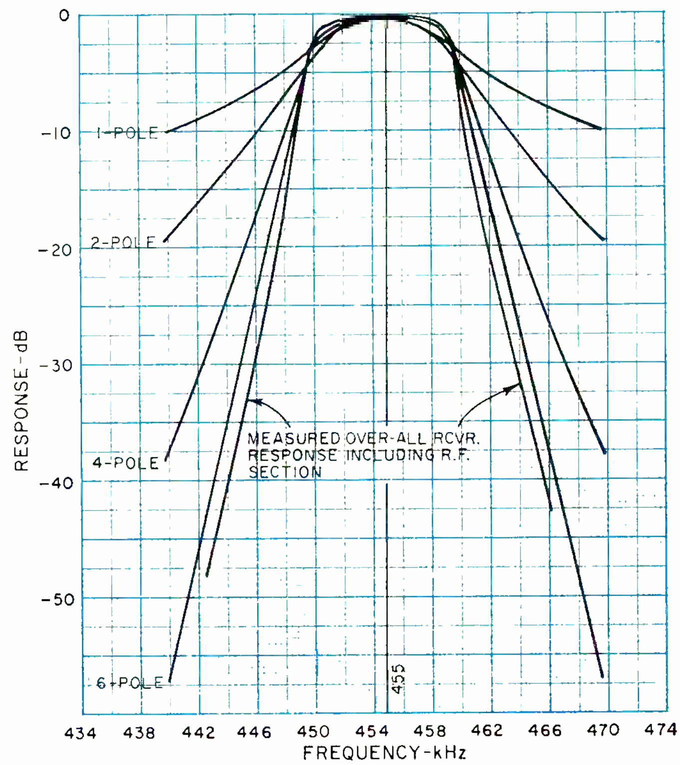


Fig. 3. Computer-generated response curves of various filters. The i.f. response curve of the receiver is so close to the 6-pole curve that it is not shown here. The measured over-all response, including r.f. section is 30-dB down at about ±9 kHz.

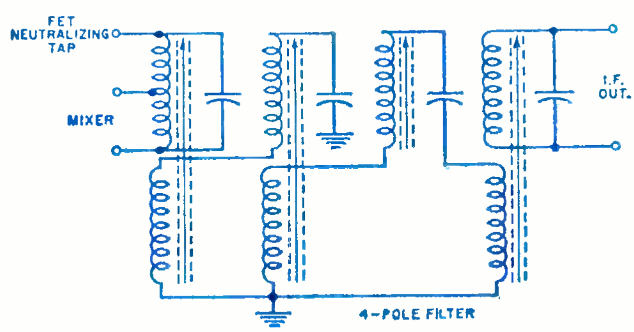
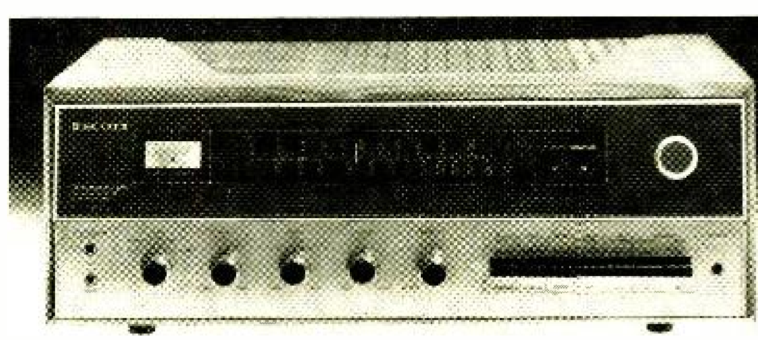
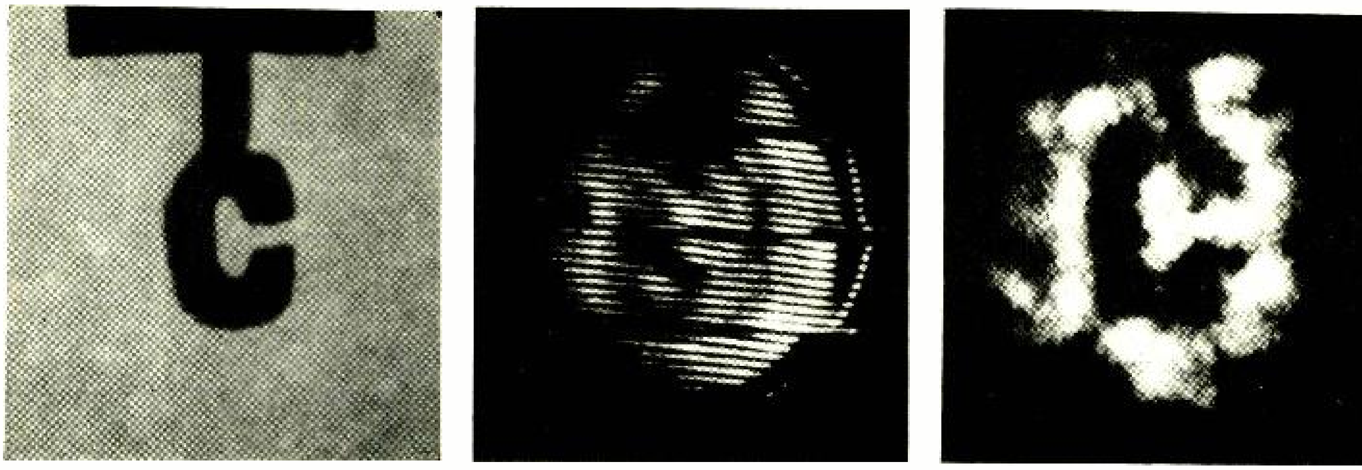


Fig. 4. Circuit of band-pass i.f. filter used in AM section.

One of the receivers with new AM section is Model 386.





Sample of sonic holography using an ultrasonic camera showing (left) object, (center) corresponding hologram, and (right) reconstructed image.

SONIC HOLOGRAPHY

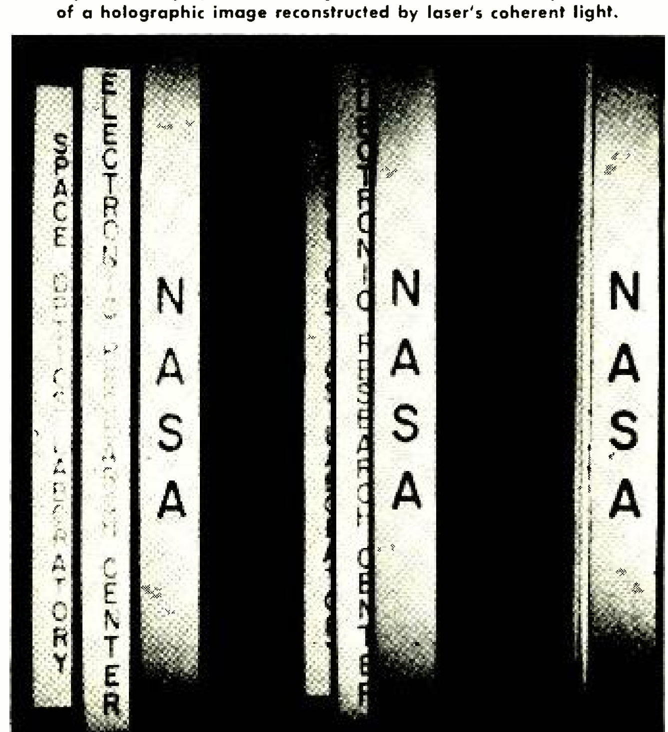
By FRED W. HOLDER

Sound waves, like laser beams, can produce holograms. Since sound waves penetrate, sonic holograms give inside 3-D views of solid objects. This "see-inside" ability of sonic holography suggests many new applications.

IN 1947, Dennis Gabor, a British scientist, nudged the state-of-the-art of optical technology when he conceived the idea of holography. His new concept was good, but the practical application of holography had to wait until an adequate source of single-frequency, coherent light was available. This problem was solved in 1960 with the development of the laser, but three more years passed before the laser was applied to holography by Emmett Leith in 1963. With this breakthrough, a workable system emerged from the laboratory wherein a three-dimensional image of an object can be reconstructed by illuminating a hologram with the coherent light from a laser (Fig. 1).

A hologram is a photographic recording of the interference pattern formed in a plane by combining the light waves emanating from an object or scene with the light waves from a reference source (see Fig. 2). The resulting photographic image, or hologram, is a nonsensical combination of lines, swirls, and dots that have little or no resemblance to the object image. When the hologram is illuminated with light from a laser, it becomes a "window" through which a viewer may see the object in vivid, three-dimensional realism and in full depth. The viewer need only move his head to see a different view of the object or to see behind an object in the foreground of a scene. You should keep in mind, however, that there are really two images created during the reconstruction process; a true image which appears where the object used to be and a conjugate image which appears on the other side of the hologram. These images appear in different planes so that they cannot be viewed simultaneously.

Fig. 1. Photographs illustrating the three-dimensional qualities of a holographic image reconstructed by laser's coherent light.



Because the hologram is the recorded interference pattern of two waves, it may be generated by several types of waves. This article discusses sonic (or acoustical) holography, which uses sound waves to construct the hologram. Reconstruction of the three-dimensional image from a hologram is the same, irrespective of the method used to construct the hologram originally.

The advantage of using sound to construct a hologram is evident from its ability to penetrate solid objects that normally block light rays. As a result, the reconstructed sonic image recorded on the hologram gives a three-dimensional "view inside" the object. It doesn't take a wild imagination to predict the far-reaching potential applications of sonic holography in such fields as medical diagnosis, non-destructive testing, underwater viewing, and exploration of the earth. When perfected, such devices will allow us to look into windowless buildings, see submarines as clearly as if they were on the surface, seek out oil deposits deep underground, look into the human body in search of the source of ailments, and detect faults in castings.

Constructing Sonic Holograms

Several methods have been developed to generate these sonic holograms. In general, they fall into one of four categories: (1) water surface levitation, (2) mechanical scanning, (3) electronic scanning, and (4) optical scanning. Each of these methods is discussed briefly to give you a general idea of what's happening in the acoustical laboratory. The simplest method to implement and to understand is water surface levitation; it is discussed first.

Water Surface Levitation

The water surface levitation method of constructing sonic holograms works on the principle that a submerged ultrasonic source will cause the surface of the water to rise until surface tension and gravity overcome the sonic energy. If two of these ultrasonic sources are submerged in water and directed so that their sonic beams intercept at the surface, a stationary ripple pattern will form on the surface of the water. The ripple pattern represents the interference pattern of the two beams. When an object is placed in one of the ultrasonic beams, the ripple pattern is modified to form a sonic hologram of the object.

The surface of the water can be photographed to obtain a photographic hologram for reconstruction by normal methods or the image can be reconstructed in "real time" by illuminating the surface of the water with a beam of coherent laser light. For real-time reconstruction, Fig. 3, the laser illumination is directed onto the surface of the water. Both the true image of the object and the conjugate image appear along the optical line of light. These images are formed in different planes so that only one image can be viewed at a time.

Because the wavelengths of the sound used to generate the hologram and the light used to reconstruct the object image differ greatly, longitudinal distortion is introduced. The amount of distortion is proportional to the ratio of the two wavelengths used. If, for example, the wavelength of the wave used to construct the hologram is twice that of the light used for reconstruction of the image, the object will appear to be twice as far away as it actually is. In the case of sonic holography, this ratio is quite large. (For example, in one experiment, 7-MHz sound having a wavelength of 0.0002 meter was used to construct the hologram. Reconstruction was made with laser light having a wavelength of 0.00000063 meter. The result was a ratio of approximately 317:1.) The presence of such distortion causes the image to appear much smaller than the actual object so that a telescope is needed to view the reconstructed image.

Dr. A. F. Metherell, Research Scientist at *McDonnell-Douglas* Advanced Research Laboratories in Huntington Beach, California developed a method of overcoming the need to view the object through a telescope. According to

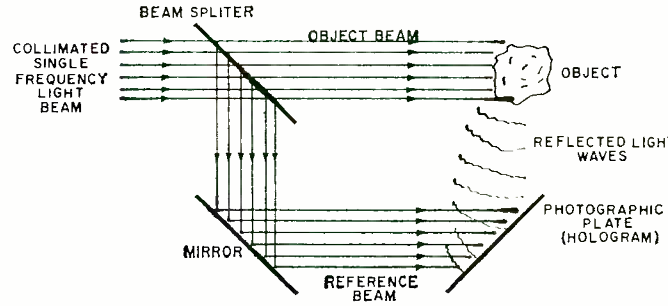


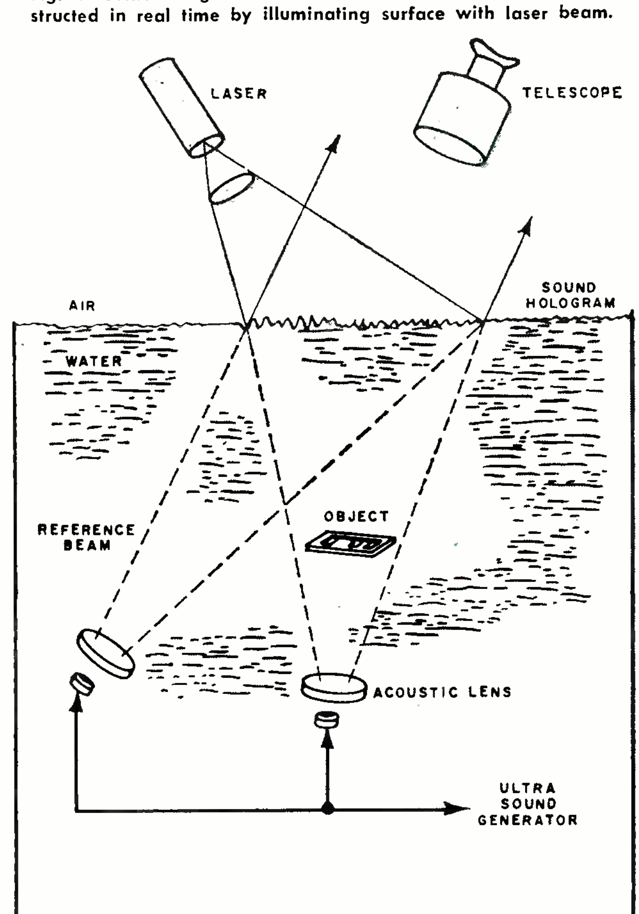
Fig. 2. Hologram on photographic plate represents interference pattern of the light reflected from object and reference beam.

Dr. Metherell, this may be accomplished by inserting an acoustical lens between the object and the surface of the water in such a way that the three-dimensional image formed by the lens is projected onto the surface. The reference beam remains unchanged and the ripple-pattern hologram formed on the surface of the water becomes a focused hologram. When reconstructed, the image appears on the surface.

The water surface levitation method of constructing a hologram has two major disadvantages: (1) the surface of the water is very sensitive to vibrations, and (2) the two beams of sonic energy have to be very carefully balanced to prevent surface streaming. Both of these problems cause break up of the ripple pattern or distort it to some extent.

An improved modification of the water-surface method, in which the water surface is covered with a thin membrane, has been used successfully by Byron B. Brenden at the Pacific Northwest Laboratory of Battelle Memorial Institute. A layer of oil a few millimeters thick is placed on top of the membrane so that the ripple pattern of the hologram forms on the oil surface. Using this method, a motion-picture film was produced of the real-time acoustical holographic image of a fish. A frequency of 9 MHz was used to construct the

Fig. 3. Sonic hologram formed on surface of water is reconstructed in real time by illuminating surface with laser beam.



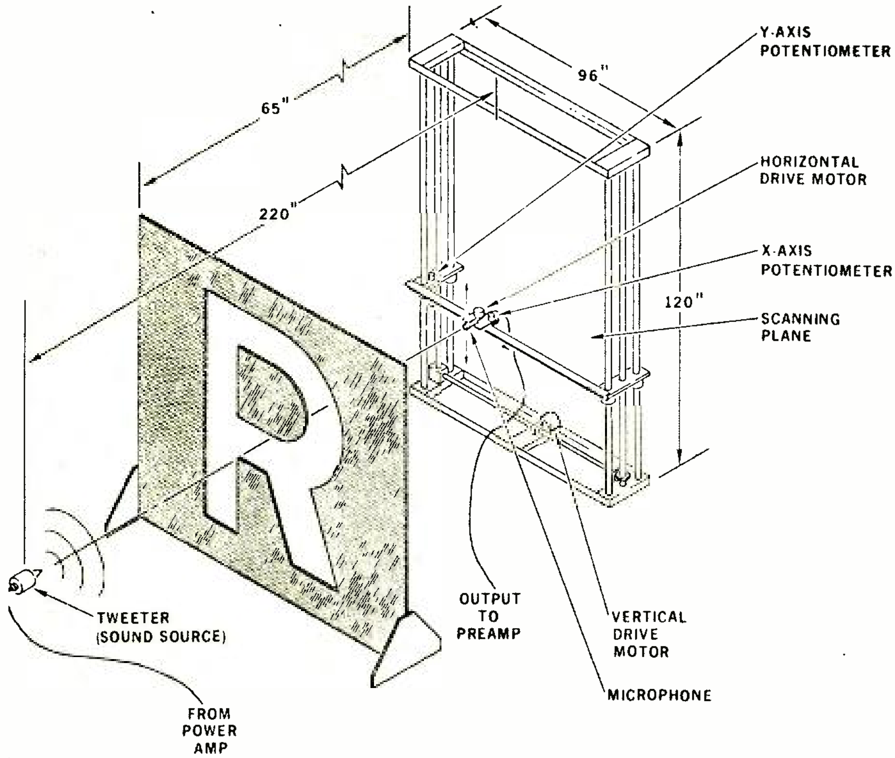


Fig. 4. Mechanical scanning method used by McDonnell-Douglas Advanced Research Laboratories to generate holograms in the air. Holograms are produced at frequencies up to 25 kHz by mechanically raster scanning microphone over a plane.

hologram. The resulting motion picture clearly shows the skeleton of the fish and its denser internal organs.

The water surface levitation method is limited to applications in which the subject or object can be submerged in a tank of water. It will likely find applications in medical diagnosis and non-destructive testing. To seek out submarines and other submerged objects or to explore the earth's crust, science must turn to other methods of generating the holograms.

Mechanical Scanning

Although limited to applications where the object is stationary, mechanical scanning of a submerged plane eliminates the problems of water surface stability present in the water-surface method. A hydrophone is mechanically raster-scanned across a plane below the surface where the two sound beams combine. The signal picked up by the hydrophone is used to control the intensity of a tiny lamp, attached to the scanning mechanism, which exposes a photosensitive plate or to control the intensity of the electron beam in a cathode-ray tube (CRT) while the beam is raster-scanned in synchronism with the hydrophone. By time-exposure photography, a hologram may be generated from the face of the CRT.

When the CRT method is used to expose the photographic plate, the ultrasonic reference source may be electronically simulated. This is done by electronically combining, in a mixer circuit, the sonic image waves arriving at the hydrophones with the reference signal from the ultrasonic generator.

Mechanical scanning is not limited to underwater use. It may be applied to the generation of holograms in air at frequencies up to 25 kHz. *McDonnell-Douglas* is using such a method to investigate the properties of acoustical holography (see Fig. 4). They have found, for instance, that the results are the same whether the sound source or sound receiver is scanned. The long wavelengths of air frequencies do not promise any practical applications at present.

Mechanical scanning is limited because of the time required to complete one scan cycle and because the hologram is actually a composite sampling of many different sonic waves. It appears that practical, real-time scanning will require the high-speed techniques available through electronic scanning.

Electronic Scanning

Electronic scanning has been accomplished by the *Bendix* Research Laboratories, Southfield, Michigan, using an ultrasonic camera for acoustic detection and a TV monitor to display the hologram (see Fig. 5). A sample of the results of this type of scanning, using the ultrasonic camera, is shown in the lead photograph. The ultrasonic camera is a Sokolov tube which was invented in 1938 and is basically a modified TV camera in which the faceplate of the camera tube has been replaced by a thin resonant piezoelectric (quartz) crystal plate. The crystal plate is designed to resonate at the sound frequency being used. When sound waves strike the crystal's surface, it vibrates locally to generate a piezoelectric voltage proportional to the strength of the sound wave at that point. The secondary emission from the faceplate, as the electron beams scans through its cycle, is modulated by this piezoelectric voltage.

The modulated secondary emission signal is combined with the ultrasonic reference signal to generate the interference signal necessary to holography. The frequency of the reference signal used in this application was shifted slightly from that of the sonic source to simulate a true physical plane-wave reference beam of variable inclination.

Proposed System

A method of electronic scanning, which uses a square array of hydrophones to pick up the sonic image, is shown in Fig. 6. Such a system, using a square array of 100 by 100 elements (or 10,000 separate elements) to detect the sonic image, was proposed by H. R. Farrah, E. Marom, and R. K. Mueller of *Bendix* Research Laboratories. (*Bendix* is currently at work developing an array which will have 20 elements by 20 elements and will be used in an experimental system.)

In the proposed system, high-frequency sound waves (kHz range) would be pulsed in the direction of the object to be viewed. The "bounce" (or return) signal would be detected by the hydrophone array, which is electronically gated and scanned by the receiver. By making the receiver active for only a short period of time, in the microsecond range, it is possible to establish an accurate ranging system through the range-gating method. Using this method, the receiver accepts return signals only when an object is at the range set into the system. However, some of the holographic benefits are lost in a range-gated system such as this because the reconstructed image will only be seen in two dimensions.

The sonic image signal is combined with the reference signal in the receiver to generate the holographic video signal. The hologram is then displayed on the face of the special tube. By illuminating the tube face with a laser beam, the hologram is converted to an object image. The image can be picked up by a TV camera, through suitable optics, and displayed in real time on a TV monitor. Because of the relatively short time (about 10 milliseconds) that the image will be reconstructed for each transmitted pulse, it will be necessary to use some form of optic memory device to aid the operator. A photocathode-phosphor screen diode could be used to perform this function.

CBS Laboratories, Stamford, Connecticut is working on what appears to be a similar electronic scanning system. A new tube *CBS* has under development in its laboratory will be used to display the hologram image. This tube, called the Lumatron, should be ready for practical application in about a year. *CBS* researchers have studied several arrangements of about 500 hydrophones milled on a sheet of barium titanate. Each hydrophone would be about one millimeter square. It is possible to mill up to 250,000 hydrophones on a single sheet of barium titanate, but this is not practicable because an amplifier must be located behind each hydrophone. Most of the *CBS* configurations are based on a single line of hydrophones about two feet long.

The *CBS* system would not scan like a PPI radar because it would pick up the interference pattern of the returned signal and display it on the Lumatron. By illuminating the face of the Lumatron (which serves as a light valve) with a laser, an image would be constructed in the horizontal dimension, which exactly resembles the display normally seen on a PPI radar.

Optical Scanning

High-speed electronic scanning techniques may become one of the primary methods used to generate sonic holograms in the practical systems of the future. At this time, however, we must not discount other techniques under development, such as the optical scanning method which has been devised by A. Korpel.

In the Korpel optical scanning method, Fig. 7, the sound beam is directed into a block of plastic so that it strikes the front surface at an angle. The object to be recorded as a hologram is inserted in the sound path inside the plastic block. The high-frequency sound waves striking the surface cause a ripple to move up the front surface of the block; the ripple oscillates at the sound frequency. A laser beam scanned over the surface of the block is reflected by the ripple. The variations in reflected light are converted to a modulated voltage signal by means of a knife edge and a photodetector. The resulting modulated voltage signal is then mixed with the reference signal and displayed on a TV monitor as a hologram.

Future

As new hardware is developed to implement the techniques described here, sonic holography will become a useful tool to "see" inside of solid objects. For example, it will show not only the bones and denser structures of the human body, but also the soft tissue and organs as well. Eventually, diagnostic machines will be available, using sonic holography, that far exceed the capability of the best x-ray machines available today. Through sonic holography, three-dimensional images of the internal structure of inanimate objects will provide the means of locating faults and flaws to improve the reliability of the finished product. The oil industry is looking to sonic holography as a tool to help find the 85 percent of the world's oil supply which is located in oil sands and cannot be detected by regular seismic methods. Scientists believe that these sources of oil can be located by sonic holography because it will be able to differentiate among the various earth strata. Such exploration will probably be done at very low frequencies, ranging from 10 to 100 Hz, and will probably use mechanical scanning techniques because the objects to be viewed are essentially immobile.

There are many hardware and technological problems standing between the current state-of-the-art of sonic holography and its practical application. Nevertheless, this "infant" science has come a long way since its beginnings in the mid 1960's. But as new hardware is developed and one by one the technological problems are solved, the art of sonic holography moves forward. ▲

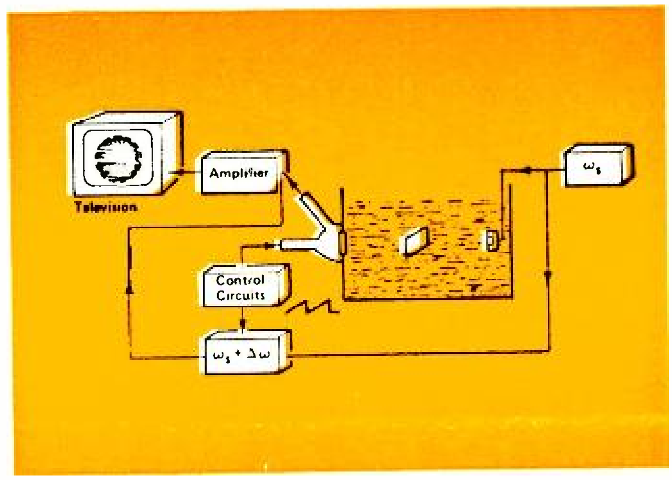


Fig. 5. Electronic scanning method used by Bendix Research Laboratories to generate sonic holograms. An ultrasonic camera, basically a modified TV camera (Sokolov tube), is used for acoustic detection and a TV monitor to display hologram.

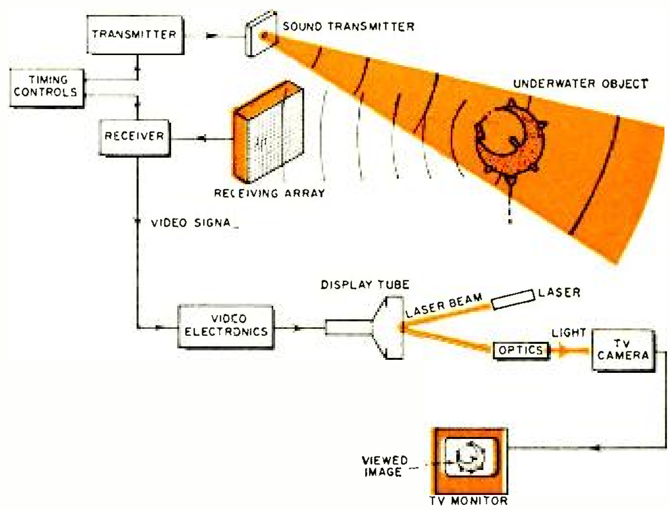
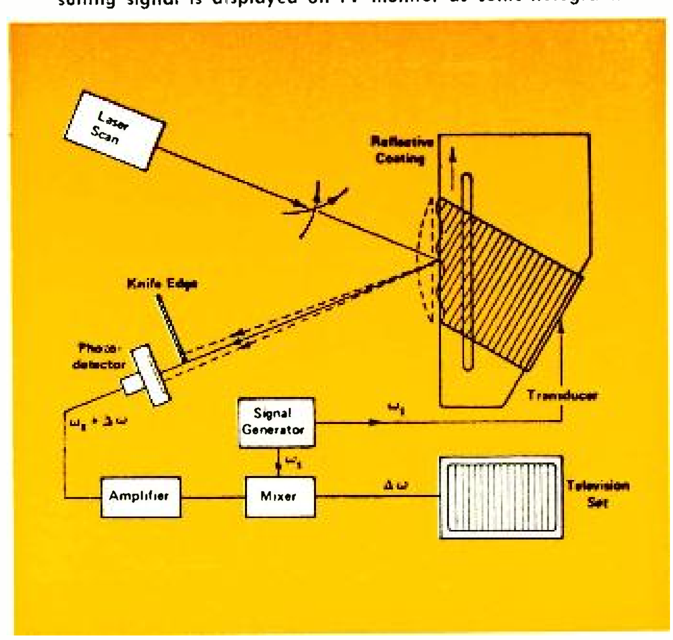


Fig. 6. Another electronic scanning method proposed by Bendix Research Laboratories. Square array of hydrophones is used to pick up sonic image and then combined with the reference signal in the receiver to generate the holographic video signal. The hologram is displayed on a special tube.

Fig. 7. Korpel optical scanning method. Light rays reflected from surface ripple present on face of plastic block containing object to be recorded is mixed with reference signal. Resulting signal is displayed on TV monitor as sonic hologram.



SCR Controls for Small Motors

By LAWRENCE FLEMING/Innes Instruments

Highly efficient, switching-type controls for adjusting the speed of series- and shunt-type universal motors.

THE nice thing about SCR motor controls is that they are highly efficient because they operate in the switching mode. The trouble with them, from the experimenter's point of view (also the engineer's), is that their designs have a tendency to get complicated. For top performance in critical industrial and military applications, the circuit design becomes complex, willy-nilly. But for modest performance with small motors, such as in a sewing machine, the circuit may be very simple indeed.

In the old days, someone found out that you could control the speed of one of the small PM hobby-type motors very nicely by connecting it in the cathode circuit of a thyratron tube and putting a variable positive d.c. bias on the grid. Nowadays, the same sort of thing is done with a power transistor. Fig. 1A shows this type of arrangement. The transistor can be practically any type that will stand the voltage and current. The problem is efficiency. If the motor is running loaded and slowly, there may be, say, 2 volts across it; and the other 10 volts of the 12-volt supply is across the transistor. If the motor is drawing half an ampere, the transistor has to dissipate 5 watts.

The back-e.m.f. of a PM motor is proportional to its speed. If this back-e.m.f. should become higher than the emitter voltage of the transistor—set by the pot at, say, 4 volts—the transistor will become back-biased and stop conducting. It won't start conducting again until the back-e.m.f. of the motor drops below about 4 volts, which it will, since the motor has had its current cut off, and is going to slow down. Simple transistor controls of this type are inexpensive, smooth-working, and effective, provided only that you take care of the heat dissipated in the transistor.

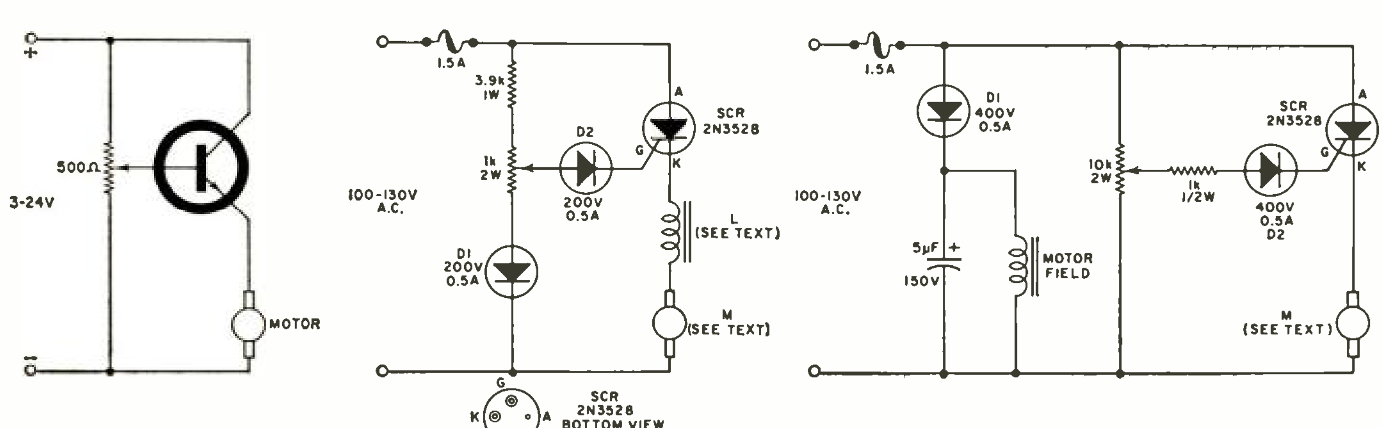
Fig. 1B is the complete circuit of an SCR control for a small series motor. Since the SCR operates in the switching mode, heat is no problem. In ordinary intermittent use, with a motor of the sewing-machine type, it will run stone cold. It will work on almost any small appliance or portable tool run by a series or "universal" motor. Maximum power is about 80 percent of the power you get when the motor is directly across the power line. This circuit is used on a commercial coil-winding machine, with a series motor rated 1/15 hp at 5000 r/min, 117 volts a.c.

The circuit in Fig. 1B is a version of one found in the application notes of several semiconductor manufacturers, and is often called the *Singer* circuit. There is a trick in its operation (but not in its use). Since it is a half-wave circuit, there is no current at all through the motor during the negative half-cycles; essentially, it is disconnected. Since there is no current through the series field during these negative half-cycles, there appears to be nothing capable of generating a back-e.m.f. There would seem, then, to be nothing capable of furnishing the required regulating action, such as was found in connection with the simple transistor control of Fig. 1A. There is, however, The gimmick is that there is some residual magnetism left in the iron of the motor field during the "off" half-cycles, and this is enough to let the motor generate a sort of d.c. tachometer voltage. If this should be, say, 5 volts and the potentiometer is set to give a gate voltage above this, the motor will pick up speed when the next half-cycle comes around. If the pot is set too low, the motor will coast until its "tachometer" voltage drops lower.

Actually, of course, the pot voltage is not d.c. but a.c., and the SCR fires at that point in the positive half-cycle when the pot output rises above the "tachometer" voltage.

The diode, *D2*, is important in all SCR applications. The SCR gate will not stand a reverse voltage of more than 4 or 5 volts. The purpose of *D2* is to keep the gate from getting *any* reverse voltage, and so guard against blowing out the SCR. The particular SCR called for in Fig. 1B, the 2N3528, has an average forward gate-current requirement of 8 milliamperes for firing, which is more *(Continued on page 83)*

Fig. 1. Some of the circuits used to control the speed of small motors. (A) Inexpensive elementary transistor control circuit for hobby-type PM motors, (B) simple half-wave SCR control circuit for small series motors, and (C) half-wave control circuit for PM and shunt motors.

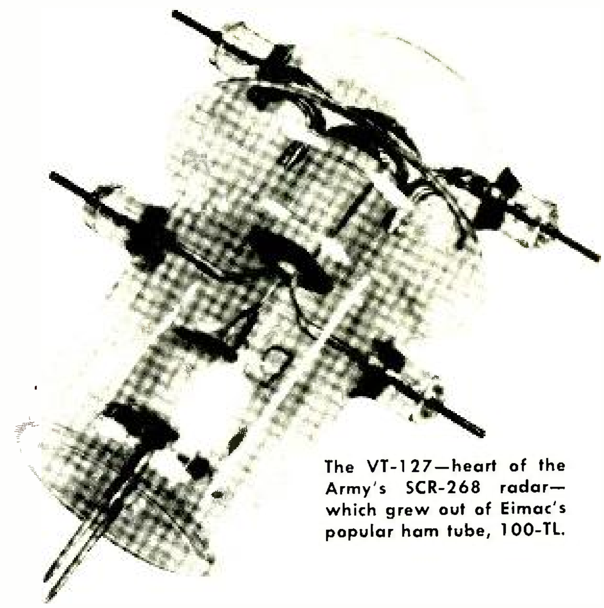


(A) (B) (C)

THE TUBE
Behind the Army's
SCR-268 RADAR

By HAROLD A. ZAHL

The story behind the Eimac 100-TL, the heart of the Army's 1936-vintage radar—from one who was there.



The VT-127—heart of the Army's SCR-268 radar—which grew out of Eimac's popular ham tube, 100-TL.

BEHIND every World War II radar, there is a story of an electron tube, almost invariably the development of a new type—be it for higher power, higher frequency, greater tuning agility, lighter weight—or possibly, even a new design principle and invention. These parameters were starting points for innovations—be they for ground, sea, or airborne detection, and/or fire-control systems. For each of these new tubes, now mellowed with time, there were stories of adventure and excitement—and history was being made.

The Army's workhorse, the SCR-268, was no exception. Following years of preliminary research, the development of this set was officially launched in February, 1936, when the Chief of Coast Artillery provided the Signal Corps with a set of "military characteristics" describing the desired aircraft detector. In succession, T-1 and T-2 models were fabricated and tested, as under "Boss" Colton (later Major General) Fort Monmouth engineers moved on to the T-3 model, of which some 3100 sets would ultimately be distributed to combat units throughout the world.

Maximum Power/Maximum Range

With radar out of the incubator stage, and with war clouds gathering, our objective at Monmouth was to achieve, in the least possible time, the highest frequency possible with easily available tubes and maximum power, to give maximum ranges on aircraft. Towards this end, Monmouth engineer Jack Slattery investigated all types of available tubes and experimented with various circuits, seeking the best combination in the least possible time. Above 200 MHz, he found the going getting harder and harder with the tube technologies of that day—so he settled on 205 MHz, leaving the higher frequencies for another day, when the VT-158 would open up the 600-MHz band and, even later, when the British-invented multi-cavity resonant magnetron would usher in the era of microwaves.

Besides transmitters, radars also needed highly sensitive receivers, power supplies, pulsing techniques, time-measuring devices (down to microseconds), antennas, and all sorts of electronic circuitry required to probe space for that mini-pulse winging its way back from a target many miles away.

To integrate all these bits and pieces into one system, Paul Watson and his military associates, Col. Colton and Major Corput, picked Jack Slattery as the Systems Engineer for the production model of the SCR-268. One of his first acts was to pass along transmitter development to a young genius named Melvin Baller, whose new transmitter model looked as though Salvador Dali were his collaborator.

Frequent visitors to the Fort Hancock Laboratory, Sandy Hook, New Jersey, were two enterprising young electron tube engineers from San Bruno, California. These men, Bill Eitel and Jack McCullough, had built up a small business making quality tubes for the ham market. A key to their success was the use of tantalum for anodes, a material which could be brought up to white-heat during pump-out. When sealed off, these tubes would seem to run forever, the plate at red-heat—gas problems, negligible (paradoxically, they did have some gas problems when the plates ran at lower temperatures—lower tube life). One of their most popular tubes was a triode which seemed to possess considerable merit for the pulse operation planned by the Signal Corps—an operation with a power input which would drive the plates to incandescence.

With this West Coast affiliation, then followed one of the most unusual sagas in electron-tube R&D history; one aspect of which was the low development cost to the government. As Melvin Baller worked on his multi-tube transmitter; following the pattern set earlier by Jack Slattery, either Bill Eitel or Jack McCullough would show up at Sandy Hook, pockets bulging with variations of their 100-TL. As the visitors watched, these new tubes would be tested immediately, generally with the plates and grids of adjacent tubes being connected through half-wave transmission-line tuned circuits. With this type of circuit, one could avoid putting the tube capacitances in parallel—thus allowing for the generation of high peak-power slightly over 200 MHz. As Baller made tests with each new batch of tubes, the visitor from San Bruno (either Jack or Bill) would take careful notes. Then, on the next visit, the substance of these notes would be translated into samples. During this quite informal procurement arrangement, I seem to recall that the Army was charged an off-the-shelf price of about $13.00 for each of the tubes delivered. With round-trip fare from California about $400, this obviously was not a high-paying venture for *Eimac*. . . . but a good gamble.

Design Finalized

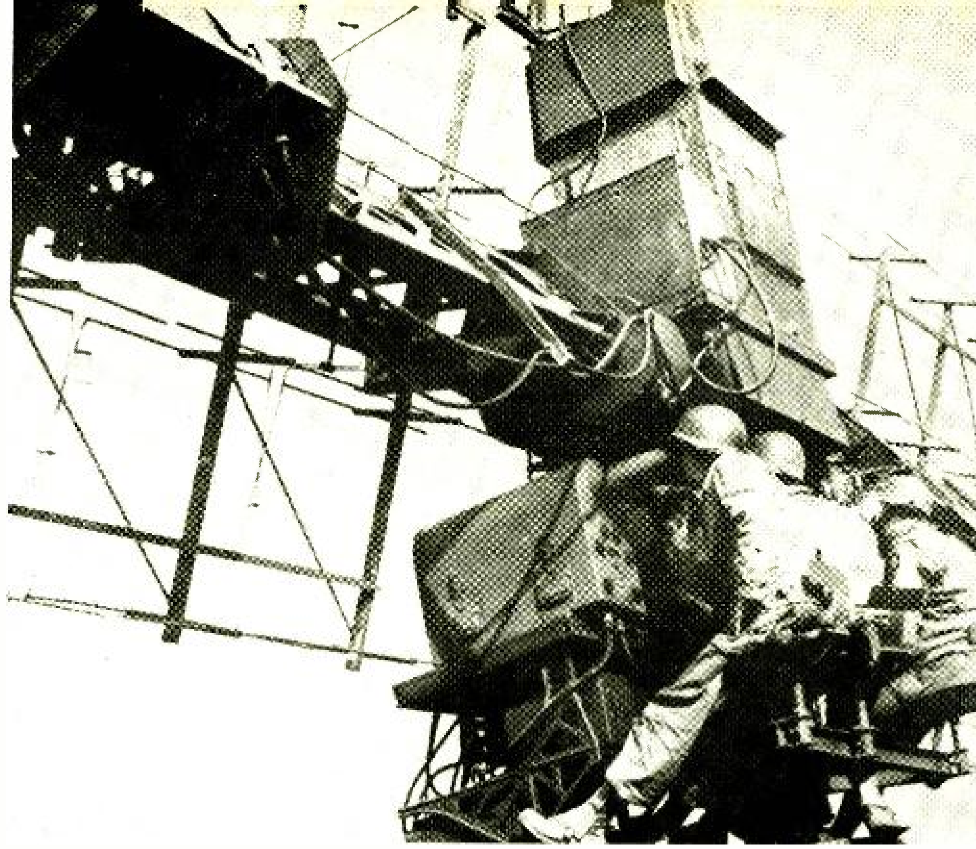
Since Baller and Slattery were having a lot of fun, this search for perfection might have gone indefinitely—or at least until the fiscal collapse of *Eimac*. Suddenly, however, this blissful electronic adventure came to an end at the instigation of Lt. Col. Roger B. Colton, then Lab Director.

"Baller," he said one day, "this is Friday afternoon. At 8:00 a.m. this coming Monday morning, whether you know it or not, your R&D on this transmitter job will be finished. Your latest model will be turned over to our Spec and Drafting people to make production drawings. You have all weekend to finalize your thinking!"

"But, Colonel," I seem to remember Baller protesting, "can't I have just one more whole week?"

Legend has it that Col. Colton looked at his watch and said, "You have 64 hours starting *right now*. Play like you are single, skip church, skip sleep, eat on the go—and if you have a dog, ask your neighbor to feed him; I mean Monday at 8:00 a.m. Get going."

With this pronunciamento, the SCR-268-T-3 was given a scheduled birthday—64 hours away, and the final labors had started. Simultaneously, the latest model of the *Eimac* 100-TL became the Army's VT-127 (with a million or so tubes like them with this designation to follow), as the set was groomed for war.



While the original 8-tube ring circuit gave fair ranges, field use of the first production lot indicated the desirability of a much greater range—which in electron-tube language meant increased power. The quick-fix was to double the number of tubes—and soon, a 16-tube transmitter was on the air and in the field. We had to gamble a bit on performance, for the emergency was very great.

Technical Problems

With a major war imminent, it was quite natural that research, development, and production would merge into a single activity. To accomplish this, as the *Western Electric* production line started turning out sets, we kept a representative number for testing purposes, so that changes could be made if and as necessary—for we had moved rather rapidly from innovation status to assembly line. I seem to recall that at one time we had about 20 SCR-268's running intermittently at Sandy Hook to observe both weaknesses and strengths—all to make the thousands of sets to come better.

During this early testing period, we would project the beam at a large gas tank on Coney Island, observing the height and constancy of the echo from the target some 20 miles away. For other tests on the transmitter alone, power was fed into a rather unique load designed and built locally. The load was a wired rosette of many incandescent light bulbs of the household variety. These bulbs were de-based and the loose wires thereby exposed soldered into a small two-conductor ring—some 10-15 light bulbs, which when connected to the output of the transmitter, would glow like a Christmas wreath—the amount of illumination being a measure of how well the transmitter was working.

But, besides the technical problems, we had one which was non-technical. Since these light bulbs were made for 60-Hz operation, and not for a few hundred MHz, their life was very short. Army regulations required that the Laboratory requisition these bulbs as common stock items through the Quartermaster Corps—which we did, for a while. But as gross after gross were burned out in the Sandy Hook radar area, people within certain Army requisition areas started growing suspicious and thought that somewhere in our local military environment, someone was engaging in a lucrative private business—selling Government purchased light bulbs.

Radar still being too secret to talk much about, a ruling suddenly descended upon us that light bulbs for the Sandy Hook operation had been rationed. But to the engineers and scientists, busily engaged in trying to help in the refinement of radar and demonstrate its wartime practicability, this posed no serious problem—for it was the scientific brain pitted against a supply clerk trying to do his job and enforce regulations. The decision was made to stop using light bulbs.

From Sandy Hook, a series of procurement requisitions started coming out reading: "Urgent, required immediately, 10 gross, luminous resistors—type *Mazda* (or equal) 50 watts."

These our local procurement people could purchase from any electric shop, with deliveries made by GI-truck pick-up. We reasoned that while the Quartermaster Corps rightfully should buy all the Army's light bulbs, it was equally correct that the procurement of resistors, luminous or non-luminous, was well within the purview of the electronics-oriented Signal Corps.

But there were other problems. War being a 24-hour-a-day, 7-day-a-week affair, the number of tubes needed for the SCR-268 became astronomical, a situation made worse by a little thing called "grid-emission." With gradual contamination, the grids of these tubes would start emitting electrons in competition with the filaments. This, of course, would throw the circuit out of balance. The only solution at the time was to replace the tubes—perhaps after every 50 hours of operation, sometimes less. Simple arithmetic shows, assuming an average of 1000 sets operating around the clock, that to keep 16 sockets filled would require 250,000 tubes for each month of the war—and it looked like a long war during those dreary days of early 1942.

Eimac engineers worked feverishly to increase tube life and thus lower consumption rate. Finally they made a small breakthrough, but an expensive one. It was found that if the grids were made of pure platinum wire, contamination if any, was deferred. Operating life appeared to jump an order of magnitude. Accordingly, this change was made in the assembly line. For a time it looked as though all platinum jewelry might have to be turned in to make platinum wire by the mile for the desperately needed VT-127 and other tubes.

The Roof Falls In

But after a brief period of seeming success, the roof fell in on the platinum grid. The bomb was dropped by none other than General of the Armies Douglas MacArthur. A

The SCR-268 radar operating near Nettuno, Italy. This is a combat situation. Up to 3100 sets were made and used widely in virtually all war theaters—including the Pacific.

curt priority message came winging its way across the Pacific reading somewhat as follows: "I am sending back two C-54's loaded with useless vacuum tubes, all having grid-filament short circuits. Do something, I repeat, do something."—signed, MacArthur.

When this message arrived at the Camp Evans office of Col. R. V. D. Corput, it suggested to him that perhaps something should be done.

"Zahl," Rex said as I panted into his office, "you are temporarily relieved of whatever you may be doing. You are now in procurement and production" . . . and he showed me the MacArthur message.

"As you know," he continued, "we sensed such a message was coming and I have already started action. Here are letter-authorizations from our four Procurement Agencies giving you full power-of-attorney to make changes on the spot in any of our $40,000,000 contracts for tubes on the West Coast. You know the platinum wire story. I want you to leave for California this afternoon accompanied by a lawyer from the Monmouth Procurement Agency."

After a few "yes, Sirs" and a brisk salute, within hours we were priority passengers on a DC-3 enroute to San Francisco. Yes, I knew what the problem was. Platinum grids stopped grid emission, but pure platinum was a very soft metal. With careful handling during shipment, once in their sockets, the tubes worked beautifully—and gave long life. But in the Pacific Theater, lacking docks, frequently the unloading process from cargo ships meant pushing waterproofed boxes overboard near the beach, and the boxes then drawn or pushed to land. The shock of a 30-40 foot fall, even into water, was enough to cause the soft platinum grids to bend a bit and make electrical contact with the nearby filament, making the tube useless.

Our first stop on the West Coast was at the San Bruno plant of *Eimac*, as this company held the bulk of the contracts about which we were concerned. It turned out that Bill Eitel and Jack McCullough had already received the word about the MacArthur message and we had, of course, wired our arrival. They were waiting—and ready.

Losing no time, we went downstairs to the shipping department and, in a friendly gesture, Bill threw a cardboard box at me. I missed the catch and the box fell hard on the cement floor. I knew there were tubes in the box.

"No harm done," Bill and Jack grinned. "The VT-127's in that box have new grids. We found that if we mixed platinum with 4% tungsten, electronically it was just as good—but for strength, it was much, much better."

The box was then opened, the tubes tested—all perfect.

"Let me show you something else now," Jack smiled, "and this one will interest you particularly. It's the way we now package the tube you invented—the VT-158," and he opened a package.

This tube, of very complicated design, was really four triodes within one glass envelope and, in addition, resonant grid and plate circuits in the same envelope—peak power 250,000 watts at 600 MHz—and very expensive. There in the box it was suspended with metallic springs so that shocks to the box would be dissipated in the springs, and not passed on to the sensitive parts of the structure.

Then for 30 minutes, we playfully tossed tube-containing boxes around like footballs, even kicking some of them. Hopefully, we were simulating any treatment a GI in a combat area could inflict, without a sledge-hammer. Later inspection of the brutally treated tubes showed no damage—the problems were solved by the 96% platinum 4% tungsten grid wire and, for several of the larger tubes, the use of coil-spring suspensions in packaging for shipment.

The "X-Grid"

But Bill and Jack had even more to show me—and it was a "company secret."

"Harold," Jack said, "what we have shown you represents only what we call an interim solution to the problem. The real solution would be to get rid of the expensive platinum alloy entirely—and we think the boys in the lab are just about ready to do that very thing. We call it our 'X-Grid.' It is a strong wire, and try as we may, we just can't make it emit electrons. It won't bend under shock, and there should be no grid-emission—might make 1000-hour tubes, maybe much better. Of course, it's a lot cheaper than platinum. With a few more tests, I think we'll be ready to put it on part of our assembly line."

I grinned happily—and knew better than to ask what elements were in their new secret alloy. The discovery had come so rapidly that the *Eimac* patent office also had a little homework to do.

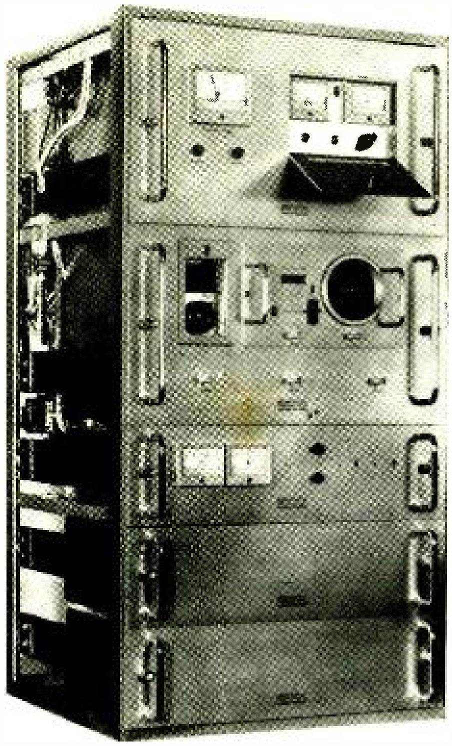
Months passed. We heard no more from General MacArthur, and there were no more re-shipments of faulty tubes from the combat areas. In the meantime, however, Procurement personnel routinely kept orders for the VT-127 going at the high rate they were used to during the period when the tube life was very short. So the buying continued and the storage people kept piling up boxes filled with VT-127's—even as requests from the field for new tubes fell off to a mere trickle. Yes, inter-department communications were very slow, and there were no million-dollar computers to call attention to this over-purchasing.

The system just didn't seem able to comprehend that the 50-hour tubes had suddenly been replaced by tubes having an order of magnitude, or more, life. But procurement rolled on and on.

But now some sadness.

My responsibility within the electron-tube environment involved mostly R&D, but this also included nurturing the first production runs of tubes for which the specifications were yet incomplete, and for which the techniques for routine mass-production had not yet been worked out. For these "pilot runs" I had many field engineers reporting directly to me as they made their inspections in various plants. Dollar volume for tubes of this type, at one point in the war, was about $200,000,000.

With this responsibility, it behooved me to also keep in touch with the over-all picture of the mass-production tube world. As part of this, about once a month I would send Max Markell down to Washington (*Continued on page* 59)



The Cesium-Beam Atomic Clock

By V. PHILIBERT

Highly accurate time standard now being used where precise time measurements are required. Accuracy is one microsecond per day or one second in 3000 years.

Fig. 1. A cesium-beam atomic clock, the Oscillatom, described in this article. Clocks of this type will play important role in future space and jet travel.

TIME measurement, like so many other techniques, has evolved at an incredible speed in recent years, upsetting traditional concepts regarding precision, stability, deterioration, and even the uses of time-keepers.

Time today is no longer what it was twenty years ago and observatory clocks have only their name in common with those in existence before World War II.

The use of quartz oscillators, followed by atomic resonators, has increased the precision of time measurement to such a degree that the mind can no longer fully grasp it. Sports timing, where time is recorded in hundredths and thousandths of a second, is the limit of what the average man can imagine, and the practical utility of infinitely more accurate equipment is difficult to conceive. The ignorance of most people regarding the constantly increasing needs of science and industry is perfectly understandable since this subject is not included in courses traditionally taught in schools and universities. Also, the subject demands a great deal of study and research.

Modern science and technology require a degree of accuracy situated at the extreme limits of possibility. In fields as varied as aviation, navigation, astronomy, radar, and communications, accuracies within one part in 10^8 to 10^9 have become mandatory. To meet these requirements, there has been a profound upheaval in time-keeping and time measurement. In the last twenty years we have witnessed a change from traditional timing methods to completely different ones, having recourse to particularly stable phenomena, such as the internal resonances of matter. The spectacular improvement in time measurement obtained by these revolutionary methods has enabled science and technology to make impressive strides forward. Certain fundamental definitions have also had to be challenged as a result. The time standard, for instance, based for centuries on the earth's rotation around its axis (second = 86,400th part of the average mean solar day) has been found inadequate.

Recent measurements carried out by atomic clocks demonstrate that this rotation is less regular than the stability of these clocks.

Time Standard Redefined

In 1956 a new definition was prepared basing the time standard on a tropical year (one second = 1/31556925.9747 of the tropical year for 1900 January 0 to 12 hours of ephemerous time.

Finally, in 1967, the thirteenth General Conference of Weights and Measures estimated that the atomic cesium-beam frequency standard had been extensively tested and was sufficiently accurate to serve as a time base. The second was then defined as follows: "The second amounts to 9,192,631,770 Hz of the radiation corresponding to the transition between the two hyperfine levels of the fundamental state of the cesium-133 atom."

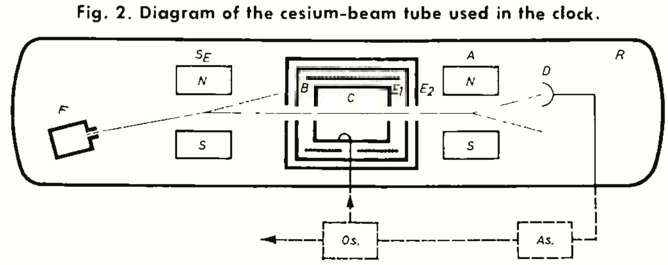
Like all other types of clocks (except for statistical chronometers), the cesium-beam atomic clock is based on the application of a periodic phenomenon; the use of atomic or molecular oscillators that nature has conveniently provided. The vibration of the quartz crystals is stabilized by that of an atomic transition. As the latter is unaffected by pressure, temperature, deterioration, and shock, it is clear the atomic clock is insensitive to the chief factors that affect the rate of other types of clock. It surpasses all existing timekeepers (quartz clocks, molecular clocks, nuclear clocks) for exactitude, reproducibility, and stability.

Atomic Clocks

The Oscillatom (Fig. 1), an atomic clock built by the Oscilloquartz Department of *Ebauches, S.A.*, Neuchâtel, Switzerland, and developed in cooperation with the Swiss Laboratory of Horological Research, guarantees a relative margin of error below 10^{-6} second per day or one second in 3000 years (an accuracy of 1 part in 10^{11})

A simplified description of the Oscillatom follows: A small furnace, *F* (Fig. 2), produces a beam that consists of cesium atoms of which slightly more than half are in the lower-energy level and the rest in the higher-energy level. The cesium atoms, behaving like small magnets, produce a magnetic torque. When the cesium atom enters the heterogeneous magnetic field produced by the state selector, *SE*, each of

Fig. 2. Diagram of the cesium-beam tube used in the clock.



the atoms will undergo a deflection dependent on its energy state. The system is so designed that after passing between the pole pieces of the state selector, the cesium atoms in the higher of the two hyperfine levels pass through the resonator cavity, *C*, while the cesium atoms in the lower hyperfine level form a divergent beam which does not pass through the resonant cavity. Inside the cavity, an oscillating field is produced by means of the external oscillator, causing some of the atoms in the higher level to fall to the lower level, emitting an electromagnetic wave.

As the quartz oscillator *Os* is less stable in frequency than the cesium-beam atomic standard, it is necessary to provide a device for changing the quartz oscillator frequency so that the frequency of the excitation signal is always exactly the same as the transition frequency. Under these conditions the optimum stimulated emission is produced.

Some of the atoms in the cesium beam leaving the resonator cavity *C* have undergone a transition while others have not.

A magnet *A*, called an analyzer, and similar to the state selector, enables these atoms to be sorted according to their quantum state. The magnet disperses the atoms which have not undergone a transition and directs those that have to an atom detector, *D*. The detector consists of an ionizer, a mass spectrometer, and an electron-multiplier tube.

The ionizer is formed by a tungsten wire heated to about 1832° F and a plate to which a negative potential has been applied. When the cesium atoms come in contact with the heated tungsten strip they lose a surface electron and leave the tungsten strip in the form of positive ions. The ions thus produced are accelerated by the negative plate and, when the ion current is at its maximum, resonance occurs. The ionizing surface of the tungsten ionizer must be spotless and to avoid the production of ions from the impurities in the ion current a mass spectrometer is used to separate the cesium ions from the others.

The mass spectrometer makes it possible to gather the cesium ions on the input dynode of the electron-multiplier tube. Electrons are liberated by the dynode when it is bombarded by positive cesium ions. The secondary electron multiplier must have a sufficient number of stages to supply a usable output current. A frequency-controlling device, *As*, enables the frequency of the quartz oscillator *Os* to be constantly regulated so that the signal collected at the output of the detector is always at its maximum.

A general diagram of the Oscillatom system is shown in Fig. 3. It is characterized by two control loops. The first synchronization loop (on top in the diagram) serves to synchronize the frequency of the excitation quartz generator *G*1 at a value corresponding to the maximum resonance. The atomic frequency standard is made up of the cesium-

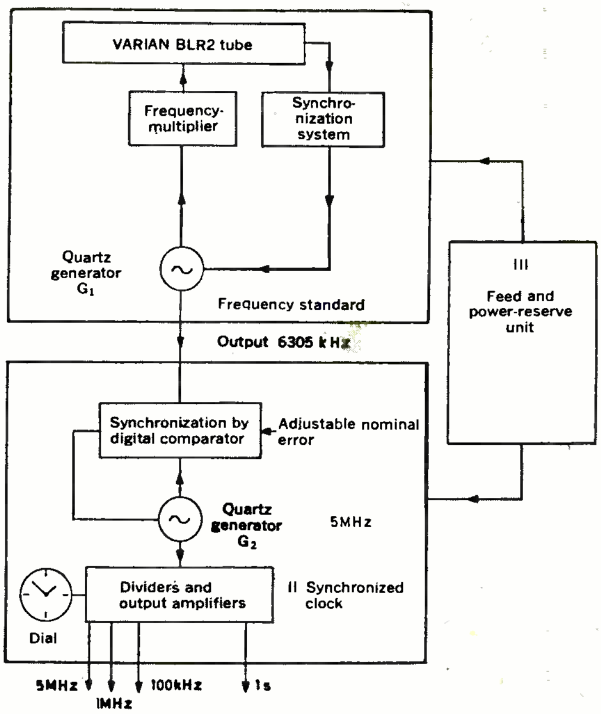


Fig. 3. Block diagram of the cesium-beam atomic clock.

beam tube, the quartz generator (*G*1), the synchronization system (first loop), and the frequency multiplier. It supplies an extremely stable frequency of 6305 kHz. The Oscillatom is not only an atomic frequency standard but also an absolute time standard (atomic time) in which several time scales can be established (universal time, atomic time, etc.). A synchronized clock (bottom of diagram, Fig. 3) has been added to the atomic frequency standard to meet these requirements.

The quartz generator, *G*2, is controlled by means of a digital comparator which has excellent short-term stability and gives the time plus a series of standard frequencies (5 MHz, 1 MHz, 100 kHz, etc.) rigorously synchronized with the atomic standard.

Comparing Time Standards

As mentioned previously, modern science and technology demand accurate timing where variations do not exceed one-millionth of a second per day or less. However, there is at present no transmission system (*Continued on page* 67)

GLOSSARY OF TERMS

Tropical year: the time required for the sun to increase its mean longitude by 360° in relation to the true equinox.

Ephemerous time: is the standard of time based on the tropical year at 1900 which is used in the legal definition by the Comité Permanent des Poids et Mesures.

Transition between two hyperfine levels: according to the theory of quantum mechanics an atom can only exist in certain determined energy states. It undergoes a transition when passing from one state to another. The cesium-beam atomic clock makes use of the frequency of electromagnetic waves corresponding to a well-chosen transition of the cesium-133 atom.

Molecular clock: made up of a molecular frequency standard producing an electromagnetic oscillation of very stable frequency coming from a beam of the rotation spectrum, the vibration or inversion of a particular molecule (ammonia molecule), and a counting device.

Nuclear clock: made up of a radioactive source where the mean interval of time between two successive disintegrations provides the time base.

Exactitude: degree to which the oscillator frequency is the same as that of a standard accepted as such, or the degree to which an oscillator frequency corresponds to an accepted definition of frequency.

Reproducibility: degree to which an oscillator reproduces the frequency of another model of the same type.

Stability: degree to which an oscillator produces the same frequency over a certain lapse of time once the clock is started.

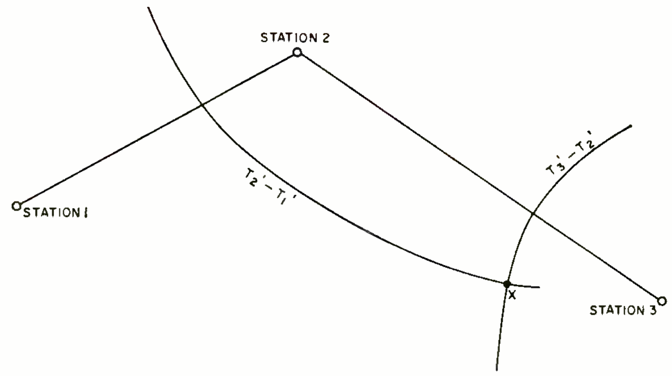


Fig. 5. Geometrical method of determining location of vehicle. T_2'-T_1' and T_3'-T_2' represent hyperbolas that describe all possible locations of vehicle between stations 1 and 2 and 2 and 3, respectively. The actual location of vehicle is at intersection of the two hyperbolas, indicated by the "X".

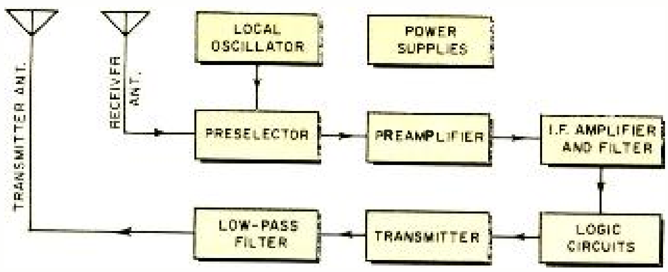


Fig. 6. Block diagram of the transponder used in vehicle.

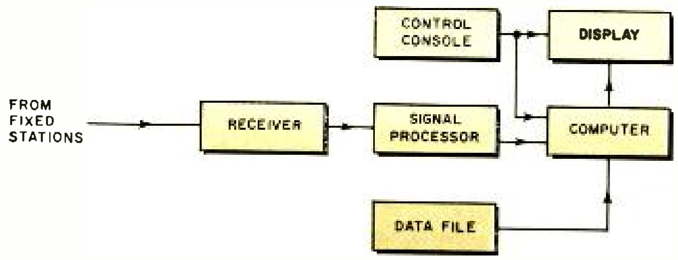


Fig. 7. Block diagram of the basic functions performed at the central control station when receiving relayed signals.

with the most recent vehicle location for each vehicle in the system. When a dispatcher receives a request for help, he simply enters the street address into the computer which then selects the nearest available vehicle. The location and vehicle number are displayed and the dispatcher can then call that particular patrol car by voice radio.

The AVM Equipment

In order to make the AVM system economically practical, the cost of the transponder in the vehicle must be minimized and this means the equipment must be simple. The block diagram of the transponder is shown in Fig. 6. It consists of an L-band receiver and transmitter operating between 900 and 1500 MHz. Although two separate antennas are shown, a single antenna can be used with a suitable duplexer. The receiver front-end is a passive preselector with a crystal mixer and a solid-state local oscillator. A 60-MHz preamplifier, i.f. amplifier, and filter drive the video detector which, in turn, feeds the logic circuits. When the two synchronizing pulses are detected, clock pulses are gated to a counter which is preset to the time-slot number of the particular vehicle. When this time slot is reached, the transmitter is enabled. The status code is either generated by manual switches or, in the case of a taxi, by the meter flag, and, together with the location pulse, modulates the L-band transmitter.

To prevent the transponder from being triggered by other transponders, the timing clock continues to run and inhibits the sync detector until after the last timing slot. The r.f. and i.f. portions of the transponder will be similar to those currently used in aircraft transponders and the logic portion will consist of IC's, mounted on printed-circuit cards. *Hazeltine* hopes to be able to manufacture these transponders, in quantity, for less than $1000 each.

Each of the fixed stations has an antenna with about 7.5 dB of gain and an omnidirectional radiation pattern and a receiver which is essentially the same as that used in the transponder. The only difference will be that the bandwidth of the receiver is somewhat broader. In some installations it will be practical to use a microwave link from the fixed station to the central control station and this will be a standard, commercially available, microwave link. Where coax cable is used, it will be the same as closed-circuit TV or CATV cable. In metropolitan areas, such as New York, the coax cable is expected to be leased from the *Bell System*.

The transmitter at the central control stations is basically the same as that used in each transponder, except that more power may be required. The basic functions at the central control stations are shown in Fig. 7. At the receiver, the relayed signals are detected and amplified sufficiently for the signal processor. This unit contains the logic circuits controlled by timing signals derived from the synchronizing pulses. Processor logic determines the vehicle number according to the time slot in which the reply is received, measures the time differences, subtracts the fixed time delays, and converts the result into a binary number which is supplied directly to the computer.

The computer then performs the calculations required to locate the vehicle and draws on the data file to convert the coordinate information into the correct street address. Most general-purpose computers can be programmed to accomplish this. The address is then shown on the display. The types of displays will depend on the requirements of the particular AVM system. One kind of display may be a print-out of the vehicle number, street address, and status. Another type of display may be a large map of the area with arrays of small lamps behind it.

For police purposes, both types of displays will be used in combination, while for a taxi fleet only the print-out may be required. The dispatcher may want to see all the vehicles that are available at a given time or else he may simply enter an address into a computer and request the available vehicle that is closest to that address. When an emergency condition is reported, the computer will automatically display and print out the location and identity of the vehicle, together with an audible and visual alarm.

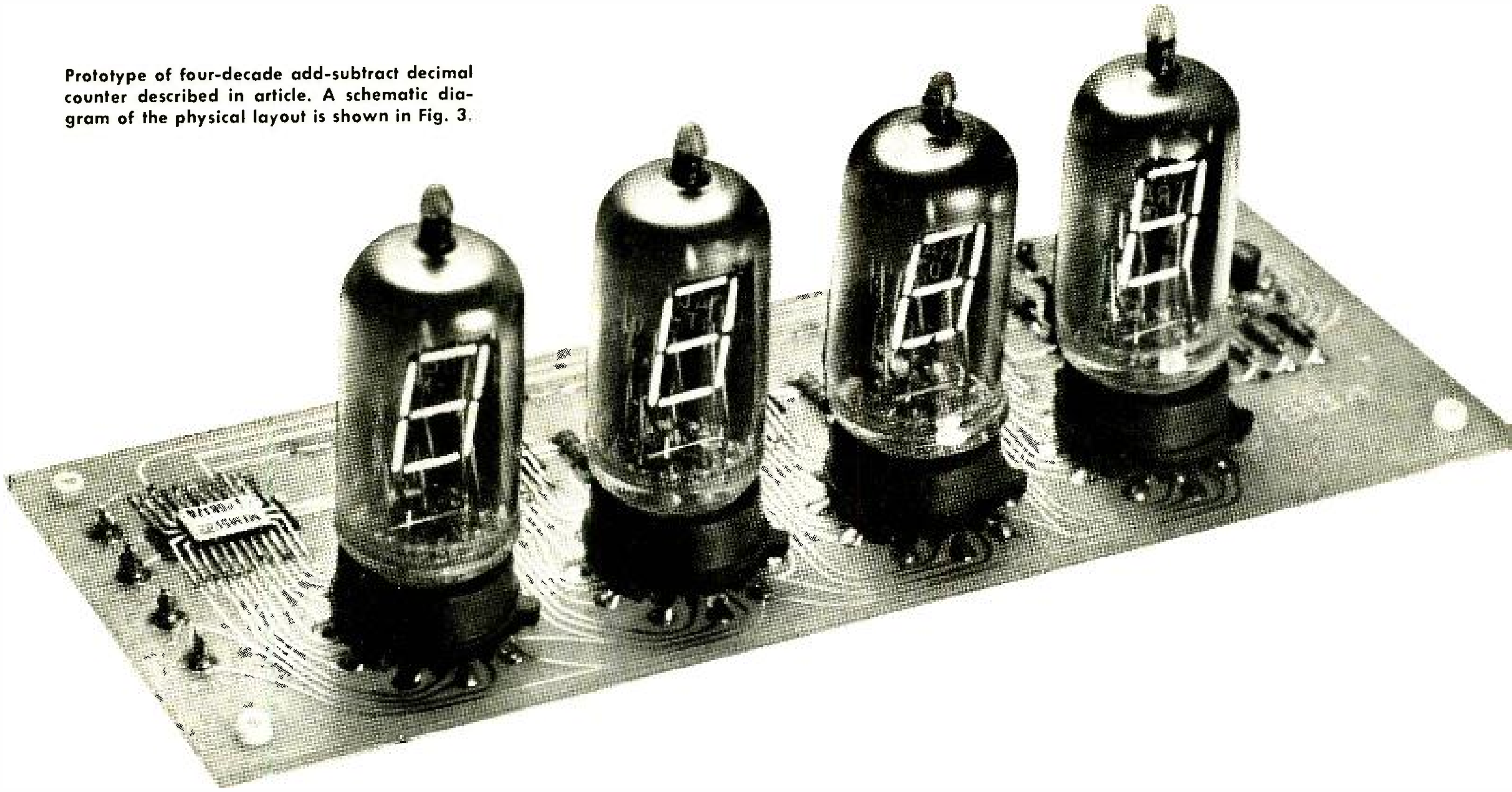
The New York City Police Department has a semi-automatic dispatching system, the "Sprint" system, which already uses a computer to monitor police activity in every area of the city. By adding the information obtained in the AVM system, the existing computer can provide an automatic, instantaneous location, identification, and status display.

Field Test Results

In field tests conducted in New York during January, 1970, the central control station and one base station were located at the Essex House on Central Park South, with two other base stations located in New York's Upper East Side. An arbitrary coordinate system was superimposed over the test area and 278 test locations, one at each intersection and one at each mid-block location were established. The transponder-equipped vehicle was interrogated and its replies were evaluated at each test point. When the computed locations were compared with the actual locations, it was found that in 77% of the tests the computed location was within 175 feet of the actual location and in 95% of the tests was within 300 feet.

Considering the nature of the test area, shown in lead photo, these results are remarkable. At a demonstration held for city officials and other interested parties, a police officer directed the test vehicle through the tangled traffic and reported the actual street location of (*Continued on page* 52)

Prototype of four-decade add-subtract decimal counter described in article. A schematic diagram of the physical layout is shown in Fig. 3.



Add-Subtract MOS IC Decimal Counter

By DONALD E. LANCASTER

Use this 0-9999 decimal counter to construct many practical digital instruments. RTL-compatible MOS IC alone performs all functions of counting, storing, decoding, and driving the fluorescent readouts.

A NEW MOS integrated circuit has been introduced which will single-handedly add-subtract decimal count, store a count, decode that count, and drive a fluorescent 7- or 9-bar segmented readout. Besides these features, the same IC may be set to zero or any other count at any time, may be internally gated "on" and "off," and can have its display blanked or unblanked without disturbing the counting or storage actions.

Maximum count rate is 500 kHz and the system is actually cheaper than many competitive counting schemes, particularly when the add-subtract feature is important. One IC and one readout per decade are all the parts required.

Four of these IC's (Type MEM 1056 from *General Instruments Semiconductor*) have been combined with four vacuum fluorescent readouts and some logic translators to produce the 0-9999 add-subtract decimal-counter assembly described here. The assembly has RTL (Resistor-Transistor-Logic), TTL, or DTL (Diode-Transistor-Logic) compatible logic inputs and is easily converted into a calculator, digital voltmeter, digital panel meter, frequency counter, electronic stopwatch, digital servo, or positional control. A number of low-cost RTL module kits are available which can be used to convert the basic assembly into many practical digital instruments.

Features

The counter assembly has five inputs, called In (Clock), Reset, Gate, Blank, and Add-Subtract. The Count input advances or retards assembly one count per input pulse. The Reset input instantly returns the assembly to count 0000. The Gate input conditions the assembly to either accept or ignore input count pulses. You can make a simple frequency counter by connecting a 1-second square wave to the Gate input and working out a Reset scheme. The Blank input either lights or extinguishes the display without affecting the counting or storage section. Finally, the Add-Subtract input "tells" the counter assembly whether the next series of input pulses will be added or subtracted to the tally already in the assembly. In the interests of simplicity, several other features have been omitted from the prototype. As we'll shortly see, these are easily added at the expense of PC board jumpers and extra translator transistors.

Maximum assembly counting speed is 500 kHz with a four-place accurate (0.01%) answer taking a maximum of 20 milliseconds. Input data must, of course, also be equally precise

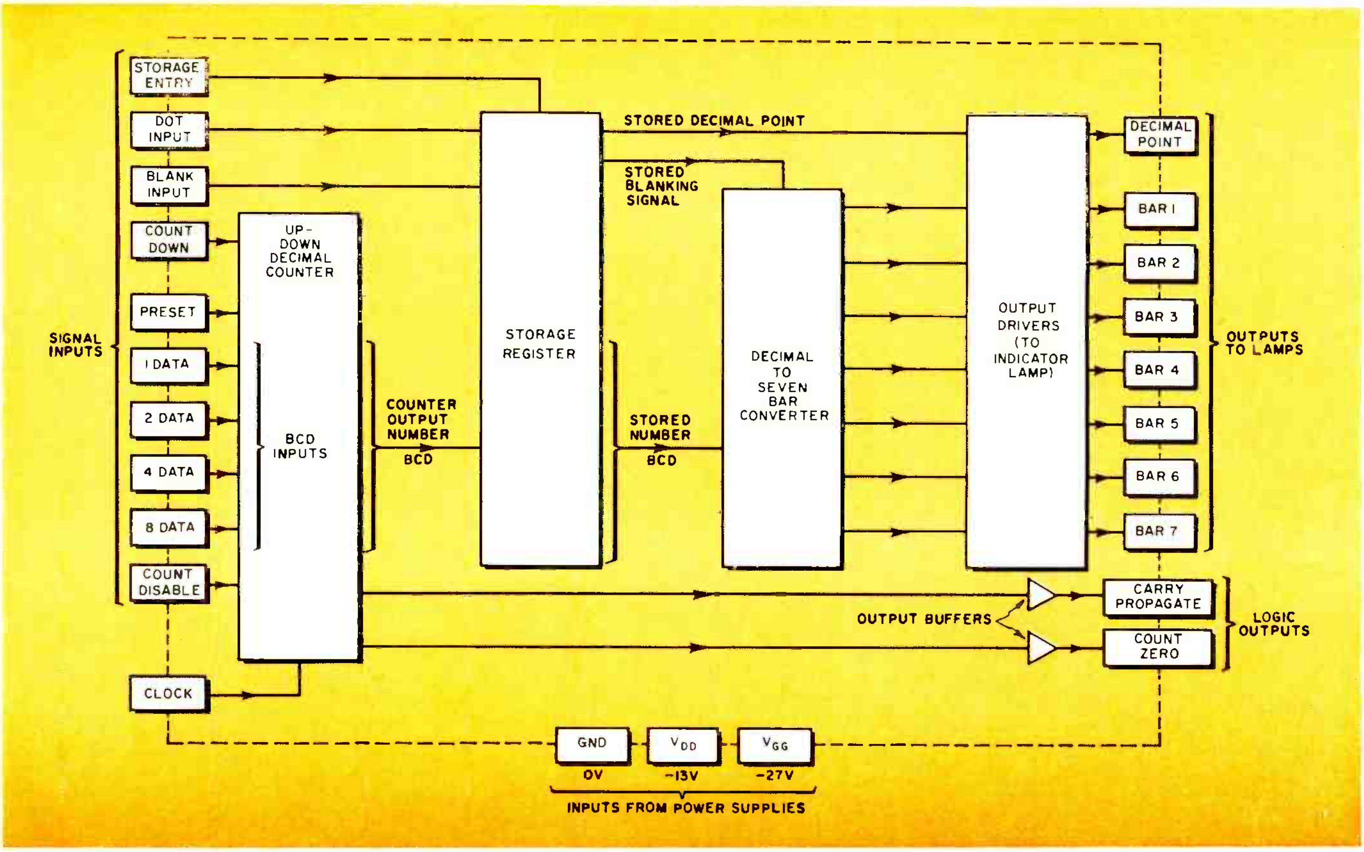
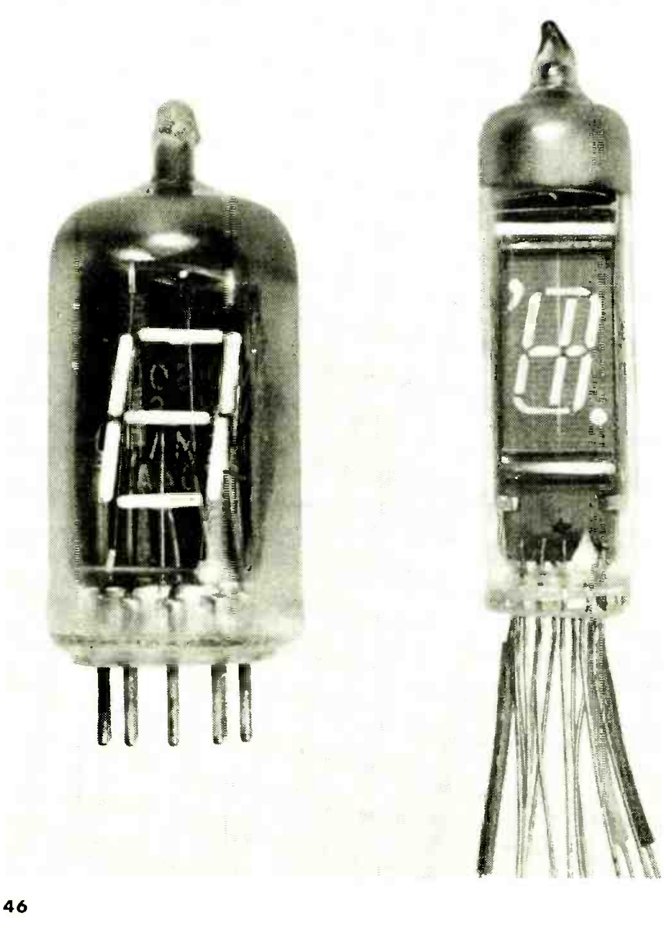


Fig. 1. Block diagram of the MEM1056 MOS integrated circuit used to construct the add-subtract decimal counter. The integrated circuit performs all of the functions represented in the four large blocks of diagram.

Fig. 2. The Tung-Sol DT1704A (left) and Itron DG12C (right) vacuum fluorescent readouts used with the MEM1056 MOS IC.



to achieve this accuracy. Extra stages are easily tacked on the end for more accuracy.

Advantages and Disadvantages

There are many presently popular approaches to decimal counting, decoding, and readout. Irrespective of a manufacturer's claims, no one counting system is "ideal" nor is any one system suitable for all possible counter and display applications. In the case of this system, there are both advantages and disadvantages to its use.

Its greatest advantages are its simplicity and the add-subtract feature. Only two or three parts—an IC, a readout, and possibly a socket are needed per decade. Assembly on a single-sided, multiple-decade PC board with only 13 holes and two jumpers per stage is possible, especially if a slightly wider-than-normal numeral spacing is acceptable.

The Add-Subtract feature is offered on very few competing systems, and then only at considerably higher cost and complexity. On the other hand, the subtract operation is rarely used in digital instruments and is accomplished in a different (parallel) manner in calculators and computers; it is unessential for practically everything but predetermining counters, positional controls, and very simple arithmetic operations.

The display is a pleasing green and is visible over a wide angle. It does not have exceptional brightness and a totally dark area behind the display is recommended, along with a filter. The "boxiness" of the characters is probably objectionable to a "Nixie"-oriented instrument market. A more legitimate objection is the off-center "1" and awkward "4" presented by the display, and the resultant "holes" in a numeric sequence. This may be overcome by using a nine-bar display and an external transistor or two. The output voltages and currents of the IC are only compatible with vacuum fluorescent readouts.

The greatest disadvantages are undoubtedly the rather "weird" supply voltages required: —27 volts, —13 volts, and a 1.6-volt, 45-90-mA filament voltage *referenced* to the −27 volts. Simple translators have been included in the assembly. Each of these consists of a *p-n-p* transistor and two resistors and allows the assembly to be driven from conventional 0- to +3-volt RTL or DTL logic signals.

Other disadvantages include the limited speed which is partially offset by today's low-cost decade scaler circuits. The slower speed does buy better noise performance, particularly in industrial environments. The IC, being a MOS type, can be damaged instantly by reversed supply power, extremely careless handling, or by very large line transients. Protection has been included both inside the IC and on the prototype assembly for normal static, installation, and handling.

The readout has several failure modes, and thus has a limited, but probably quite acceptable life. At least one readout manufacturer has "beefed up" its readouts considerably to make them more immune to vibration. Sockets are probably a worthwhile addition for heavy-use applications.

The readout is also electrostatic-sensitive, with the glow dancing around if you bring a finger near the display. A physical barrier (such as a color filter) and some anti-static spray takes care of this particular problem. A newer *Tung-Sol* readout is available that is smaller, more rugged, and not electrostatically sensitive.

One big objection experimenters and technicians will have is the steep pricing structure of both the IC and the readout. Only in very large quantities can the counter be built for less than $7 per decade. In small quantities (1-99) cost will run around $29 per decade ($24 per IC and $5 per readout). Commercially available competing decimal-counter kits presently range from $10 to $30 per decade in small quantities, depending upon the readout and the speed of operation; none of these is as simple or has the subtract feature.

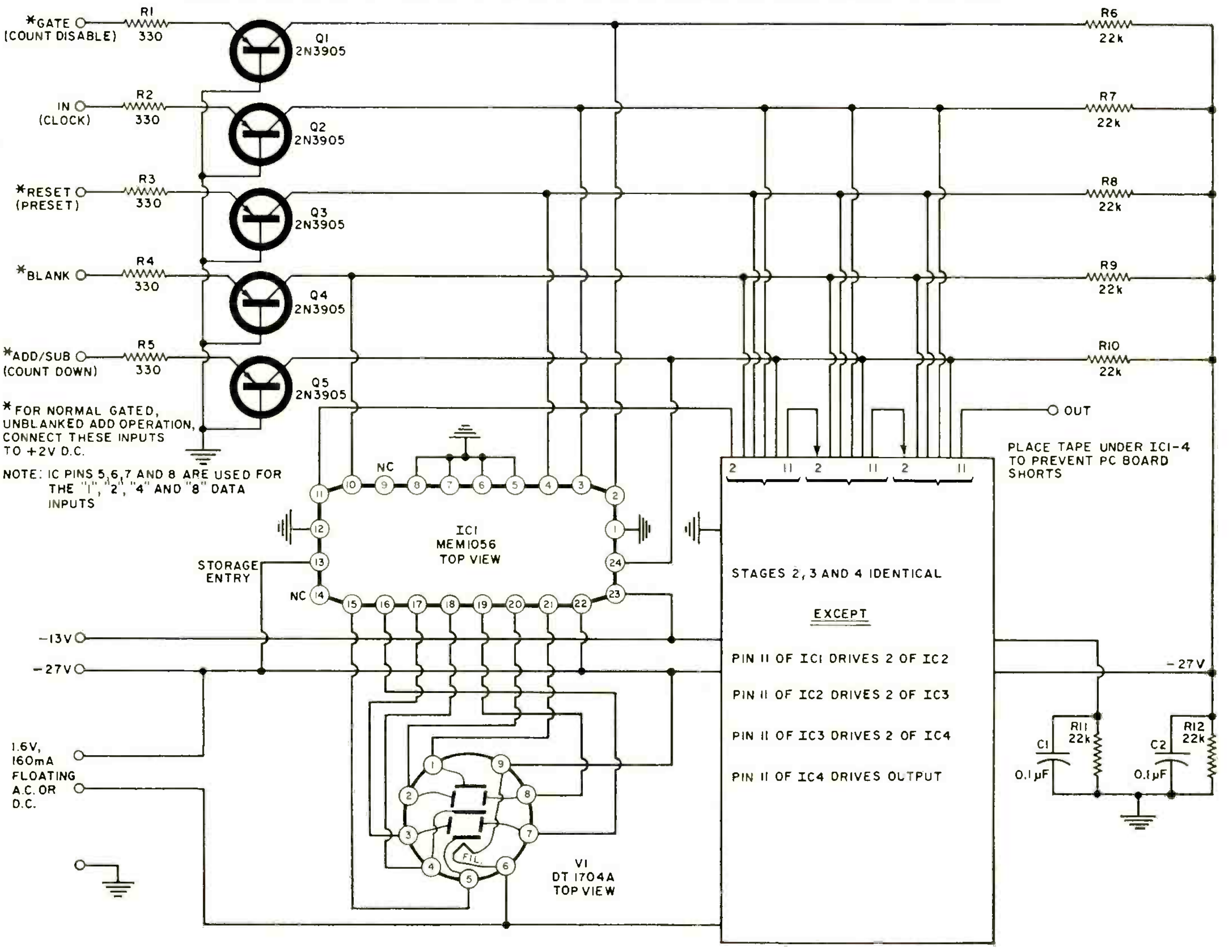
A block diagram of the MEM1056 is shown in Fig. 1. This is a MOS integrated circuit and comes in a 24-lead flat pack that operates off two negative supply voltages of −27 and −13 volts. The input logic swings from 0 volt ("0" or "No") to −27 volts ("1" or "Yes").

There are four main parts to the IC: the up/down decade counter, the storage register, the decimal-to-seven-bar logic converter, and the output drivers. The up/down decimal counter can accept either *series* (a sequential series of count pulses) or *parallel* (simultaneous appearance of count pulses) data.

To count serially, 0- to −27-volt pulses are applied to the Clock input. The clock is a "two-phase" type. The number in the counter changes as the Clock input goes from −27 to ground. Some first-decade conditioning is needed; the Clock input signal must have rise and fall times faster than 20 microseconds, and all mechanical contact or push-button inputs must be made "bounceless" to prevent contact noise from causing erratic operation.

The serial-input clock pulses are controlled by the Count Disable and the Count Down inputs. If the Count Disable input is at −27 volts (logic "1"), all input clock pulses will be ignored. If the Count Disable input is grounded (logic "0") input pulses are accepted. The Count Disable input is used to gate the counter for frequency or period measurement. The readout that is used remains lighted constantly

Fig. 3. Complete schematic of the four-decade counter assembly shown in the lead-in photograph. Complete wiring for one of the IC's and one of the DT1704A seven-segment fluorescent readouts is also included.



*MEM1056 MOS IC
General Instruments Corp.

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WILL COMPUTERS TAKE OVER?

If the hospital of the future can operate without nurses, who can be sure that he is indispensable?

By **John Frye**

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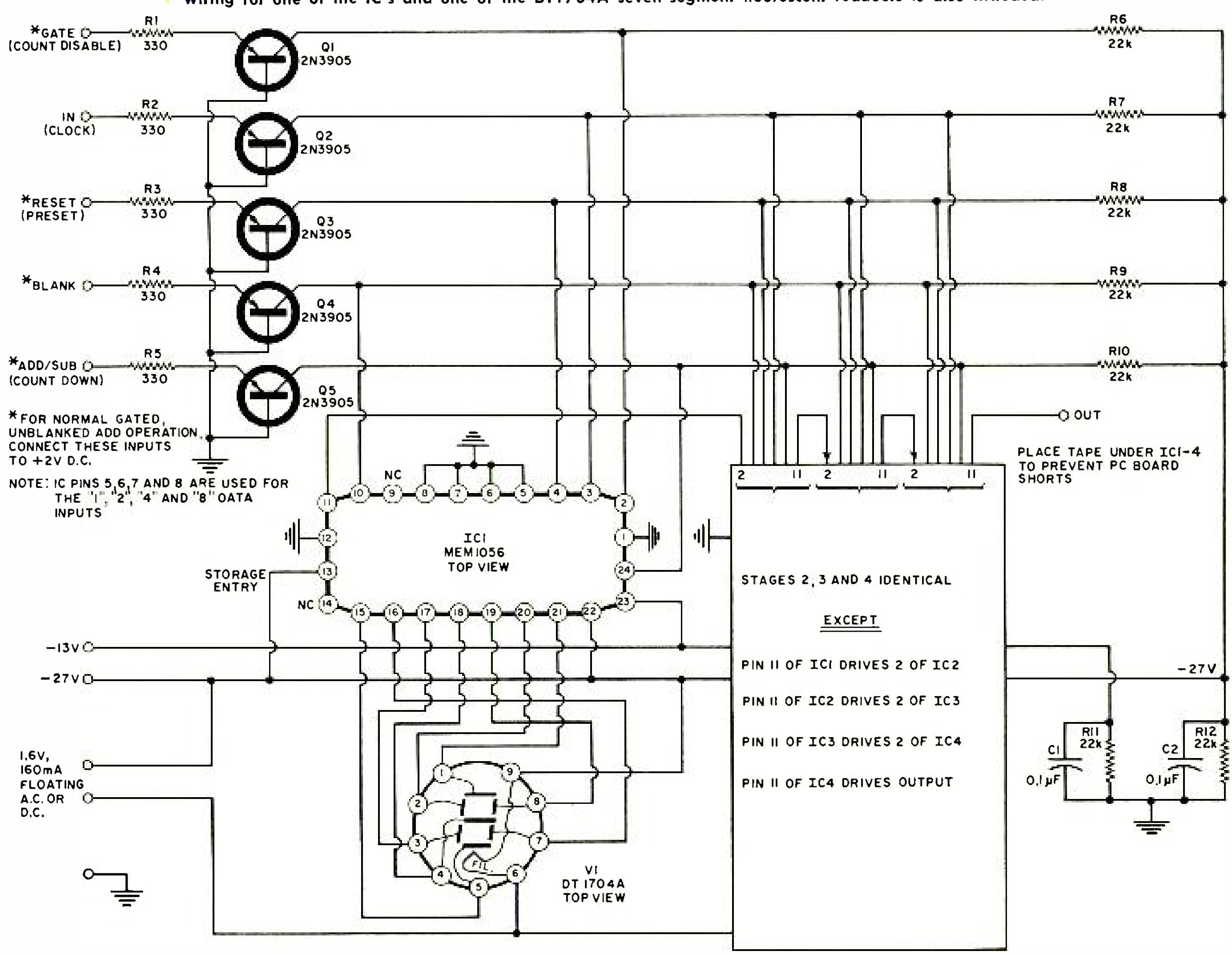


***MEM1056 MOS IC**
General Instruments Corp.
Semiconductor Products Group
600 W. John Street
Hicksville, New York

DT1704A and DT1705C 7-Bar Fluorescent Readouts
Tung-Sol Division
Wagner Electric Corporation
One Summer Avenue
Newark, New Jersey 07104

DG19 and DG12C 9-Bar Fluorescent Readouts
Itron Electronics Corp.
Ishimoto Trading Company
3118 W. Jefferson Blvd.
Los Angeles, Calif. 90018

#834 Drilled and Etched PC Board and Accessory Kit
Southwest Technical Products
Box 16297
San Antonio, Texas 78216

*Can be purchased at Terminal-Hudson Electronics,
236 W. 17th Street, New York, N.Y. 10011

Table 1. Sources where the components used in the Add-Subtract MOS Decimal Counter can be purchased.

irrespective of the condition of the Count Disable input.

The Count Down input determines whether the input clock pulses will be added or subtracted from the tally inside the IC; −27 volts ("1") on this input makes the IC subtract and grounding ("0") this input makes the IC add.

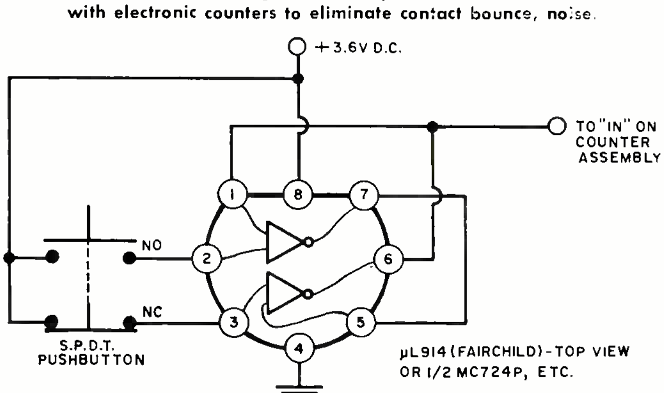
The Preset input forces the counter to the 0 count when −27 volts ("1") is applied, and does nothing when grounded. The "1," "2,'" "4," and "8" inputs may be used in combination with the Preset input to enter a number in parallel. These inputs are normally left grounded. To enter a "7," the Preset and only the "1," "2," and "4" inputs are lowered to −27 volts ("1"). The proper combination (a BCD word) is used for each required count. In this manner, a keyboard or a selector switch can enter counts without generating a separate series of pulses for each count. The readout will automatically produce an "F" indication if a false count (binary 10 through 15) is entered.

Input Protection

Most IC's are susceptible to damage by static electricity. The MEM1056 has built-in static protection and more is added on the prototype counter assembly. Nevertheless, all inputs to this IC (everything on the left in Fig. 1) must never be left floating or unconnected. All inputs should go either directly to ground, directly to −27 volts, to −27 volts through a 22k-ohm resistor, or to −27 volts through a resistor/transistor RTL-logic translator, depending upon whether control, permanent "1's," or permanent "0's" are desired.

Similarly, no input or power load must ever be allowed to go positive by more than +0.3 volt. Permanent damage will result instantly if positive voltage is applied.

Fig. 4. Schematic diagram of RTL push-button circuit used with electronic counters to eliminate contact bounce, noise.



Storage

The storage register "keeps" a number for the display. If the Storage Entry input is at −27 volts ("1"), the storage register follows the up/down counter and presents the number in the counter to the readout. If the Storage Entry input is grounded ("0"), the storage register maintains the old number for the display. Storage commands are used to display an old answer while the counter is working on a new count.

The Blank input may be used to turn the display "on" and "off"; −27 volts ("1") turns the display "on"; ground ("0") leaves it "off." Counting action continues even with the display "off."

The Converter and Driver blocks convert the stored number into the proper patterns on a 7- or 9-bar readout. The output swing is 0 (bar lighted) to −27 (bar out) volts with an available current of 1 mA. The Dot Input may be used for optional decimal-point storage.

Two logic outputs are provided, a Carry Propagate and a Count Zero. The Carry Propagate is connected directly to the Count Disable input of the next stage and all decades have their Clock inputs driven in parallel by the input counting signal. This is called a synchronous counter. The Carry Propagate automatically picks the right count for carrying or borrowing (a 9 when adding and a 0 when subtracting) and is inhibited by its own Count Disable input. Thus, gating applied to the first stage will automatically gate all succeeding stages.

The Count Zero output can be used to provide blanking of unused zeros in a display. This takes some external logic.

The Readouts

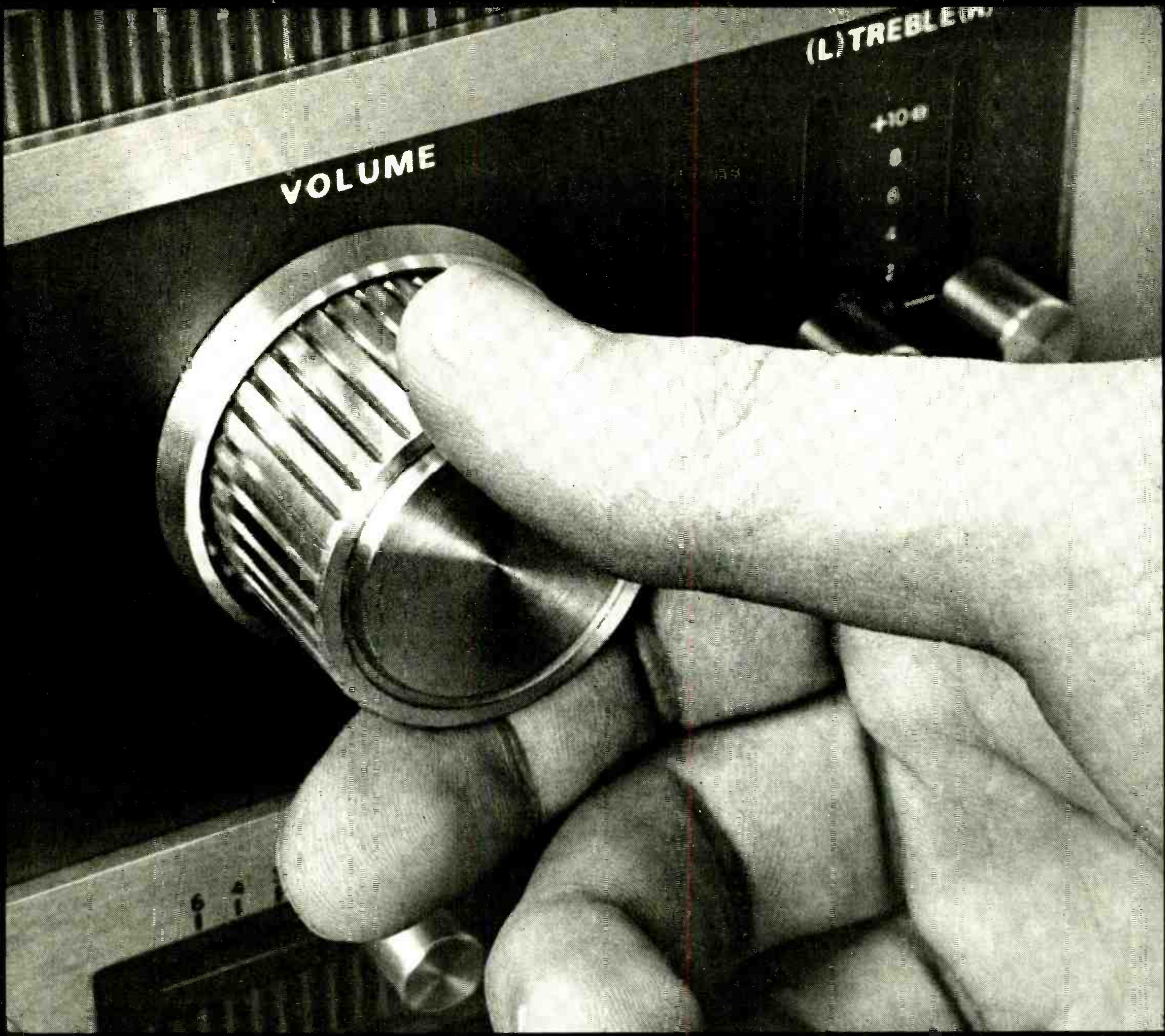
The MEM1056 will only drive a vacuum fluorescent readout. Suitable versions are the *Tung-Sol* DT1704A (0.6″ numeral, no decimal point) and DT1705C (0.6″ numeral, with decimal point) seven-bar types and the *Itron Electronics Corp.* DG19 (0.7″ numeral, with decimal point) and DG12C (0.5″ numeral, with decimal point) nine-bar types. The DT-1704A and the DG12C are shown in Fig. 2, left and right, respectively. All four readouts cost about the same (around $5 in small quantities to $2 or so in large volume). The *Itron* units have a more pleasing rounded character shape, and by adding external logic to the IC, the off-center "1" and awkward "4" may be eliminated. The logic takes two transistors and two diodes and is based on the fact that the top bar is out only on counts one and four.

Readout Operation

The operating principle of these readouts is similar to the old 6E5 and 6U5 tuning eyes and their more recent tuning-indicator offspring. The devices are basically a 27-volt vacuum tube with a filament, an optional grid (*Itron* units only), and 7 or 9 phosphor-covered, bar-shaped plates. The filament is a low-temperature one and is not normally visible. It is powered by 1.6 volts at 45-90 mA. The filament is referenced to −27 volts and thus one end of a floating supply is tied to this voltage.

If a plate segment is grounded, there is a +27-volt difference between plate and filament. Electrons are emitted, strike the plate and the phosphor, and that segment lights. If a plate is connected to −27 volts, there is no potential between plate and filament, and that segment remains out. By choosing the right combination of grounded and −27-volt plates, any numeral may be obtained. If the readout has a grid, it is normally connected to −7 volts, or around +20 volts with respect to the filament. In other applications, the grid provides an alternate way to blank the display.

The DT1704A is used in the add-subtract counting assembly. It has a 9-pin miniature base, (*Continued on page* 65)



VOLUME
(L)TREBLE

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"Sounds wild," Barney commented, "but I see how it could be possible for computers and automatic devices to replace the routine nursing. You've just eliminated back-rubs, feeding, turning, giving medications, charting, and bed-pan carrying. And if you're going to sleep all the time, there's not much point in wasting tender loving care on you."

"Precisely," Mac agreed. "That's the point Mr. Bennett was making. He explained how we arrived at this fictional state of medical care: 'Patients had demanded, the government had funded, and the patient had received patient-centered care of high quality—care that was both individualized and comprehensive.' He warns, 'If you become contented with the way things are—someone or something else *will* take your place!' "

"I realize he was talking to nurses," Barney said, "but there's undoubtedly a message for all of us there. For example, you said nothing about doctors, but you will note many of the things doctors now do were taken over by the computers in that projection of medical care. Whenever a technician of any kind falls into the habit of performing his work automatically and routinely, when he instinctively resists change, when he divorces his creative mind from his work as much as possible, when he stops thinking of his customers as people, and when they are not impressed with him as an individual human being, a computer is breathing hot on the back of his neck whether he realizes it or not."

"That brings to mind a story recently told me by my friend, Roy Hartkopf," Mac said. "The manager of the TV repair department of a big store had a service call from an elderly lady who said her set had quit. The only man available was a likable young chap who was not too experienced technically; so the manager sent him on the call but told him to bring the set in if it presented any problems he couldn't handle. The kid took a look at the set and replaced a horizontal output tube and then accepted the customer's invitation for a chat and a cup of tea. The elderly woman was so satisfied that she requested the same young man be sent the next time her set needed servicing.

"More than a year later the manager was going through the records and discovered the little old lady had had, in fifteen months, four service calls, four friendly chats, four cups of tea, and four horizontal output tubes; so the next time the set went bad the manager sent an experienced man who repaired the set properly. The manager was totally unprepared for the furious blast from the nice old lady. She complained that instead of sending the nice friendly young man they had sent this other incompetent person who just about pulled the

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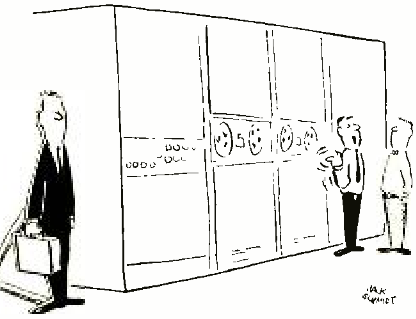
So, please, when you write us about your subscription, be sure to enclose the mailing label from the cover of the magazine—or else copy your name and address exactly as they appear on the mailing label. This will greatly reduce any chance of error, and we will be able to service your request much more quickly.

set to pieces and had then gone off without hardly talking to her. When the manager tried to explain, he merely convinced her he had a grudge against the nice young man who fixed her set so easily; and she warned that unless she always had the nice young man she would take her business elsewhere!"

"And I'll bet she got him!" Barney said with an appreciative chuckle. "A cold computer will have a tough time replacing that warm-hearted kid. More and more people these days are unconsciously hungry for person-to-person relationships. I believe the pendulum has swung about as far as it is going toward blind veneration for efficiency and impersonal dealing. We want to deal with other human beings and be treated as a human being. There's a growing suspicion of and resentment against computers and machines that goes deeper than just having to compete with them for jobs—although that's bad enough. We hate doing business with them. That news story a few months back about the man who shot the vending machine that cheated him struck a responsive chord in hearts all across the world; and you know the feeling of satisfaction it gives to read of a computer that goofs and writes a check for ten million dollars rather than one for ten dollars."

"True," Mac agreed. "The computer is threatening man's idea of *self,* and that's a basic threat he can't take lying down. It threatens to reduce him to a mere number and to codify all his accomplishments and failings into a few feeble tracings on a piece of tape.

"He must, though, learn to live with computers because they also promise to take over most of the drudgery of life. As I see it, the trick is to allow the computer to handle boring routine, to integrate details, and to maintain constant, untiring vigilance without allowing it to destroy the individual. The more flexible, imaginative, responsive, and warmly human a person is, the less likely he is to be replaced by a computer. But the more stereotyped, impersonal, routine-bound, and mechanical he is in his work and his relationships—in short, the more he *behaves* like a computer—the greater is the danger a computer will get his job." ▲



"I don't know how they afford it, but the computer company has a repairman here 24 hours a day."

Automatic Vehicle Monitoring

(*Continued from page 44*)

the vehicle by voice radio. Invariably, the AVM system was able to pinpoint the vehicle within a few hundred feet of its actual location.

The Future of AVM

When we think of the possibilities that the AVM offers a modern city, we can see many applications, for many different types of service. Probably the greatest potential of the AVM is a combination of police, fire, taxi, bus, and even truck monitoring in a single AVM system, because thousands of vehicles can be monitored by a single central control station and its fixed base stations. Referring back to the central control station block diagram of Fig. 7, it is possible to take the information from the signal processor and feed it, over ordinary telephone lines, to different computers, displays, and control consoles at different locations. The transponder signals which contain police car identification, for example, can be routed to the central police dispatching room. Those vehicles responding with the fire department identification code can go to that control center, taxis can report to the headquarters of a particular taxi fleet, buses can be identified and their location displayed at the bus company's headquarters, etc. The signal processor can be programmed so that any emergency reply, whether from a police car, taxi, bus, or truck, is displayed to the police dispatcher so that he can take appropriate action immediately.

AVM systems in adjacent areas can be synchronized so that alternate one-second intervals are used by each area. This permits vehicles to travel from one area to another without loss of monitoring features. Other methods can also be used to coordinate adjacent AVM systems.

When the cost, size, and weight of transponders have been sufficiently reduced as a result of mass production, it will be possible to monitor individual patrolmen, bank messengers, and others. Low-power transponders, carried by individuals can be part of separate, semi-mobile AVM systems, whenever a fixed location, possibly a van, is used to keep track of individual patrolmen or small detachments during some special event.

The AVM system described here has been demonstrated satisfactorily and the equipment is currently under design for early production. The basic principles, however, of a single transmitter, a number of fixed relay stations, and vehicle transponders replying during assigned time slots combined with the loran technique of locating vehicles, promise to find wide application in monitoring vehicles and, eventually, individuals. ▲

C.E.T. Test, Section #5

H & V Circuits

By DICK GLASS*

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

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

(Answers will appear next month.)
Answers to last month's quiz appear on page 82

1. **It is usually unwise to attempt to measure plate voltages on horizontal and vertical amplifier tubes because:**
   - (a) disrupting the signal will damage the tube
   - (b) the high d.c. voltage will possibly damage ordinary service meters
   - (c) ordinary service meters change the pulse waveshape, causing transformer damage
   - (d) the high a.c. voltage will possibly damage ordinary service meters

2. **Monitoring "B+" boost voltage with the yoke connected, then disconnected is:**
   - (a) a good method of determining a yoke short
   - (b) likely to damage a good yoke
   - (c) OK for vertical yoke windings, but a poor practice for horizontal windings
   - (d) likely to damage the output transformers

3. **In troubleshooting modern TV receivers you should not disable the horizontal output stage by:**
   - (a) disconnecting the plate cap
   - (b) disconnecting the control grid
   - (c) disconnecting the screen grid
   - (d) disconnecting the cathode

4. **A TV raster squeezed near the top would indicate:**
   - (a) output-section trouble
   - (b) oscillator-section trouble
   - (c) weak vertical sync
   - (d) open linearity capacitor

5. **After replacing an HV regulator tube in a color receiver:**
   - (a) replace horiz.-out tube too
   - (b) check the regulator current
   - (c) check high voltage
   - (d) set high voltage for best over-all focus

6. **Color-TV horizontal output tube current might be expected to be closest to:**
   - (a) 50 microamps
   - (b) 300 microamps
   - (c) 50 milliamps
   - (d) 300 milliamps

7. **Resistors in parallel with the vertical yoke windings are used mainly:**
   - (a) to compensate for yoke winding resistance increases caused by heat
   - (b) to improve linearity
   - (c) to protect yoke from sudden current surges
   - (d) to prevent ringing

8. **The practice of adding a capacitor from anode to cathode of the damper tube is:**
   - (a) a convenient method of correcting horizontal linearity or size problems
   - (b) a usual cause of x-radiation problems
   - (c) never necessary if the "B+" boost voltage is at specified level
   - (d) useful only in reducing width

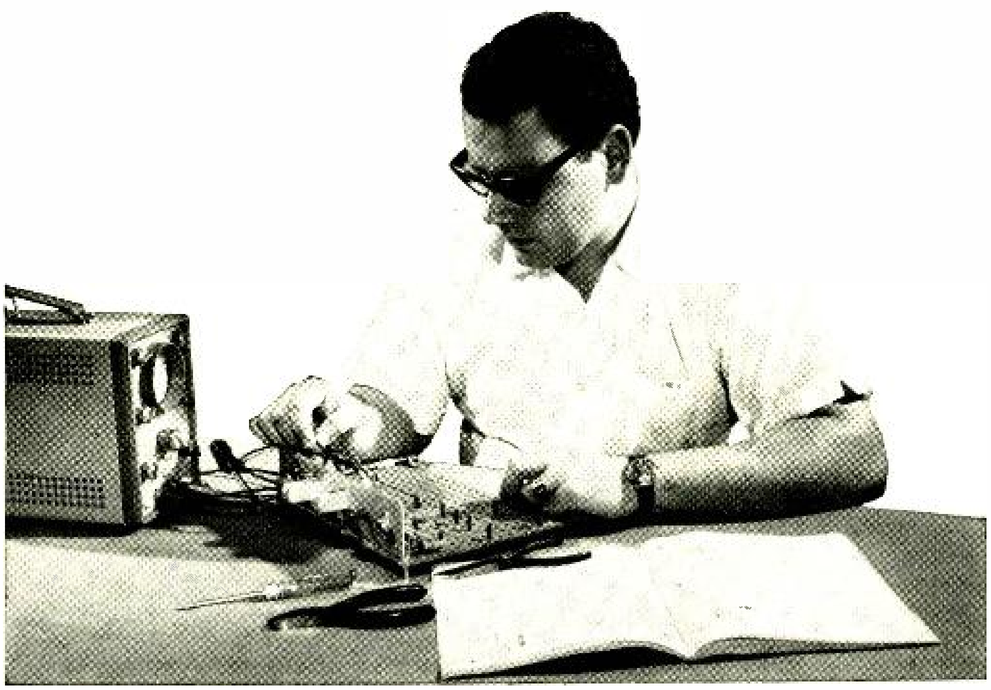
9. **In troubleshooting a vertical oscillator, the picture is rolling "up." This indicates:**
   - (a) vertical frequency is too high
   - (b) vertical frequency is too low
   - (c) nothing of use in troubleshooting
   - (d) open vertical integrator

10. **Horizontal a.f.c. phase diodes receive and compare two signals. Their output consists of:**
    - (a) a d.c. corrective voltage
    - (b) an a.c. corrective voltage
    - (c) a square-wave pulse in phase with the sync signal
    - (d) a square-wave pulse in phase with the feedback signal

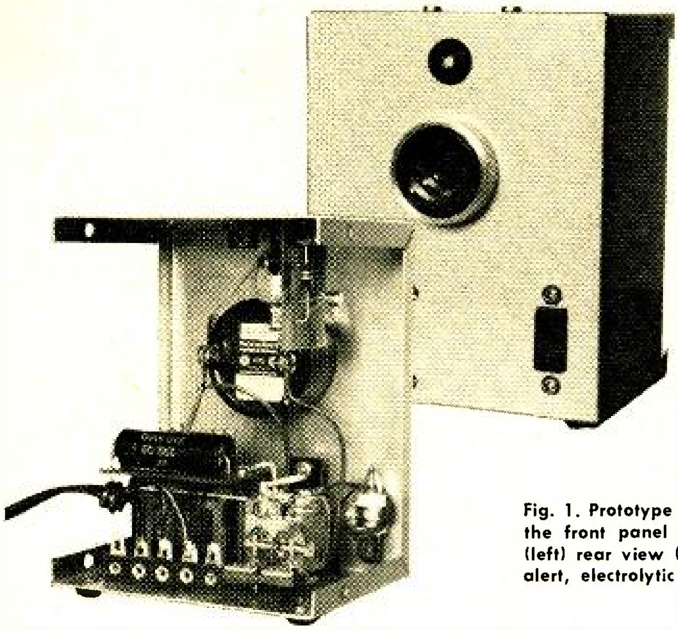
*Executive V.P., NEA, 12 South New Jersey St., Indianapolis, Ind. 46204, assisted by Lew Edwards, chairman of Test Make-up Subcomm.

10 Reasons why RCA Home Training is

your best investment for a rewarding career in electronics:



Performing transistor experiments on programmed breadboard — using oscilloscope.



Sensitive BURGLAR and FIRE ALARM

By FRANK H. TOOKER

Protect your home with this light-sensitive alarm that can be triggered even by the glare of a lighted match.

Fig. 1. Prototype of burglar and fire alarm discussed in article showing (right) the front panel with photocell, Sonalert, and 117-volt a.c. receptacle and (left) rear view (cover removed) with locations of SCS and resistor R1, Sonalert, electrolytic capacitor C3, relay, and the miniature mercury switch S1.

PROBABLY the two greatest dangers which threaten every home today are fire and theft; yet few homes have adequate warning systems. By placing the highly sensitive device described in this article in a room you want protected, the intruder who breaks into your home during the night and starts darting a flashlight around, is certain to be in for two things every burglar desperately wants to avoid: the wail of an alarm and a bright light turned on him.

The alarm can be triggered only by a *sudden* increase in room illumination, thus very slow changes in light level, such as the coming of daylight, do not affect it. In addition, the circuit is so sensitive that even the striking of an ordinary paper match, at a distance of six feet in front of the light cell in a darkened room, will trigger the setup, thus effectively doubling as a fire alarm.

Once triggered, the alarm can be turned off by operating a concealed reset switch. To avoid giving away its purpose as a burglar alarm, the prototype panel (Fig. 1, right) has been deliberately left unlettered.

How it Works

The fire and burglar alarm, shown schematically in Fig. 2, obtains its unique sensitivity by combining the sensitive turn-on characteristic of a silicon controlled switch, *Q*1, with the equally sensitive light-responsiveness of a photoconductive cell, *PC*1. In the dark, the resistance of the cell is in the high megohm range. Then when any direct or reflected light strikes the sensitive area of the cell, its resistance decreases, causing the junction of *PC*1 and resistor *R*1 to go to a more positive voltage level and the alarm to trigger.

When an increase in light level occurs quickly, a positive-going pulse is delivered to the cathode-gate of *Q*1 *via* capacitor *C*1, causing the SCS to turn on. Current flowing through the turned-on SCS activates both the *Mallory* Sonalert unit and relay, *RL*1, connected in parallel in *Q*1's anode circuit. With *RL*1 energized, 117 volts a.c. is applied through its normally open contacts to the receptacle, *SO*1, into which a table or floor lamp containing a 100-watt bulb may be plugged. If desired, this circuit may be used to alternately, or simultaneously, activate a remote alarm. Turning on of the lamp, when the unit has been triggered, is intended only to illuminate the intruder and isn't essential for the performance of the circuit.

Once triggered, even if the light source is removed, the SCS continues to conduct, the Sonalert continues to sound, and the relay remains energized until the circuit is manually reset.

To make it difficult for the intruder to turn off the alarm, the prototype unit contains no external reset switch. Turn-off can be accomplished only by an internally located small mercury switch, S1, electrically connected in the primary circuit of the power transformer and mounted so that it is necessary to turn the whole unit upside down to open the circuit. Even at that, reset does not occur until filter capacitor *C*3 becomes sufficiently discharged to drop the current through *Q*1 to a point below the SCS's minimum holding level. In the prototype, this occurs about five seconds after the Sonalert ceases to wail.

Once reset, if there is any light in the room, it is necessary to place the palm of the hand over the window of the photo-

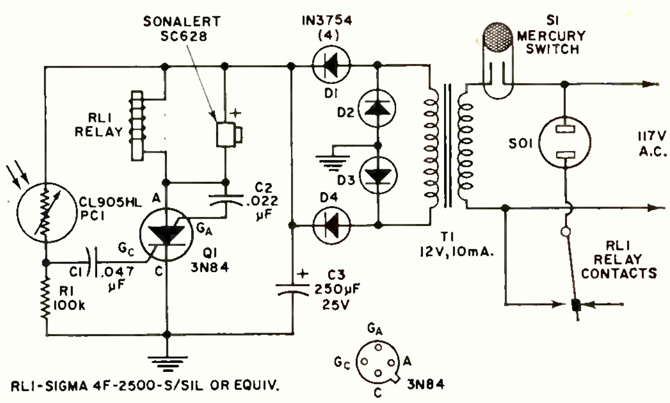
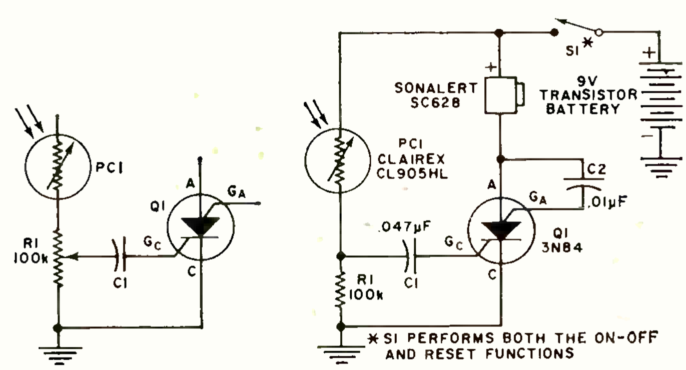


Fig. 2. Schematic of a.c.-powered burglar and fire alarm.

Fig. 3. Variations of sensitive burglar and fire alarm showing (A) resistor R1 replaced by 100k-ohm potentiometer and (B) battery-operated version of highly sensitive alarm.



(A) (B)

cell to darken it while turning the unit right side up. The hand is then *very slowly* removed from the window of the photocell. If room illumination is too bright, or if the hand is removed too quickly, the unit will retrigger.

Turning a light off in the room in which the unit is located does not activate the alarm, since a decrease in light level causes the voltage at the junction of *PC*1 and *R*1 to go in a negative direction and negative pulses will not trigger the SCS.

To maintain maximum sensitivity in the SCS, a capacitor, *C*2, rather than a resistor, is used in the *Q*1 anode-gate circuit to suppress response to line-voltage transients.

Construction

The unit is assembled in a 5″ × 4″ × 3″ aluminum chassis. Layout of the circuit isn't critical and if the SCS and the components immediately associated with it are kept reasonably separated from the a.c. line and the power supply, no difficulty should be encountered. The photocell is mounted in a small rubber grommet with its window flush with the grommet's front surface to provide it with the maximum angle of view of the particular room in which the unit is located.

If a small mercury switch isn't available, any other concealed method of opening the transformer primary will be just as effective and, if necessary, the reset switch may be omitted and the unit reset by unplugging its power-line cord for a minute or so.

If the setup proves to be too sensitive, *i.e.*, if it triggers at light levels too low for a particular location, sensitivity may be lowered by reducing the value of resistor *R*1, or by replacing *R*1 with a 100,000-ohm potentiometer (Fig. 3A) to permit any sensitivity setting from zero to maximum.

Battery-Operated Model

When 117 volts a.c. isn't available, the battery-operated version of this sensitive fire and burglar alarm (Fig. 3B) can be used. For example, while camping the unit can be used as an excellent lightning detector or thunderstorm warning device by aiming the photocell at the night sky. This circuit and its operation are fundamentally the same as the a.c.-operated version except that the power-supply components, the relay, and the receptacle, SO1, are omitted.

Although Fig. 3B shows a 9-volt transistor battery as the power source, any 9- to 15-volt d.c. supply can be used. The higher the voltage, the more sensitive the unit and the louder the wail of the Sonalert when the circuit is triggered. Current demand of this sensitive burglar and fire alarm is in the microampere range, except when the circuit has been triggered. ▲

SCR-268 Radar's Tube

(*Continued from page* 39)

"without portfolio" to see how the overall picture looked down there.. His trips generally cost the Government about $25, but most of the time he was able to point out minor errors which led to savings of a thousand or more times the cost of his trip.

But, back to the VT-127. We bought quite a few of them; how many million, I'm not sure anybody really remembers—or wants to. One day Max came back from Washington with a glowing report on how well the new grid in the VT-127 was making out. "Terrific," he said, "hardly any requisitions from the field—tubes must be running for ever. Lexington has over 500,000 in stock and production lots are still coming in by the thousands every week. Something has to be done or VT-127 storage space will have to be moved into Churchill Downs—under the grandstand perhaps. We have enough tubes to fight a 50-year war."

In Washington, people like Jack Slattery and Jim Keely also found that the VT-127's were in great surplus; and suddenly the Army grew harsh.

Overnight—all orders for this noble tube were abruptly canceled.

In Salt Lake City, where most of the tubes were being made, an order from *Eimac* went out terminating the jobs of well over 1000 people—24 hours' notice, with apologies.

Yes, the new grid had been just too successful.

In closing, here is a bit of advice for ham readers. If in years gone by you have purchased later versions of the VT-127 at post-war surplus sales—if they are still running, fine. But, when the filament burns out, check carefully. You may have a platinum grid which could yield an elegant, but low cost, jewelry gift for your best girl.

Yes, if electrons could laugh and read, surely they would get a chuckle out of the ups and downs, as the VT-127 quietly takes its place in the archives of military history, along with its many other de Forest cousins. ▲

ABOUT THE AUTHOR: Until his recent retirement, the author was director of Research at the Army's Fort Monmouth Laboratories, joining those laboratories in 1931, after receiving his Ph.D from the University of Iowa. While the author of some 100 technical articles and a physics textbook, in recent years some of his interest has shifted to writing about things which happened "behind the scenes" in electronic events of great historical importance. He is the author of a recent book, "Electrons Away," published by Vantage Press, New York.

SILICON CONTROLLED SWITCH MULTIVIBRATOR

By FRANK H. TOOKER

DEVICES which perform two functions in one are generally somewhat critical to get operating properly. Single-transistor multivibrators are in this category. However, the one shown in the diagram is the least critical of any the author has devised thus far. This setup uses a silicon controlled switch (SCS) in an arrangement which permits it to switch itself "on" and "off" at a repetition rate determined by the charge and discharge times of a capacitor, *C*1, in its cathode circuit.

The SCS is a *p-n-p-n* device similar to the silicon controlled rectifier (SCR), but with an extra lead brought out to provide an anode-gate (G_A) connection. The SCS is "off" (nonconducting) until its cathode gate (G_C) is made positive with respect to its cathode; at which time, it switches "on" and conducts heavily until (in the present application) its cathode gate is made negative with respect to its cathode. Making the cathode positive with respect to the cathode gate gives the same result, of course, and is usually the simpler method.

Because the SCS conducts heavily in its "on" state, sufficient resistance must be connected in series with its anode or its cathode to prevent burnout. The anode resistor, *R*4 in the diagram, accomplishes this easily for the 3N84. In fact, the silicon controlled switch operates far below its maximum rating in this circuit.

Each time the circuit is switched on, capacitor *C*1 is initially in a discharged condition. The voltage divider, consisting of resistors *R*1, *R*2, and *R*3, makes the cathode gate positive with respect to the cathode, and the SCS switches on. Current flowing through the device produces a voltage drop across cathode resistor *R*5, which charges cathode capacitor, *C*1. As *C*1 charges, the cathode becomes more and more positive, and cathode-gate bias gradually decreases. When the cathode becomes more positive than the cathode gate, a point is reached where the SCS can no longer keep conducting. At this point, it switches off.

With the SCS nonconducting, capacitor *C*1 discharges through resistor *R*5. As it does, a point is reached where the cathode gate becomes sufficiently positive with respect to the cathode to switch the SCS on again. With the SCS conducting, *C*1 charges and the cycle repeats.

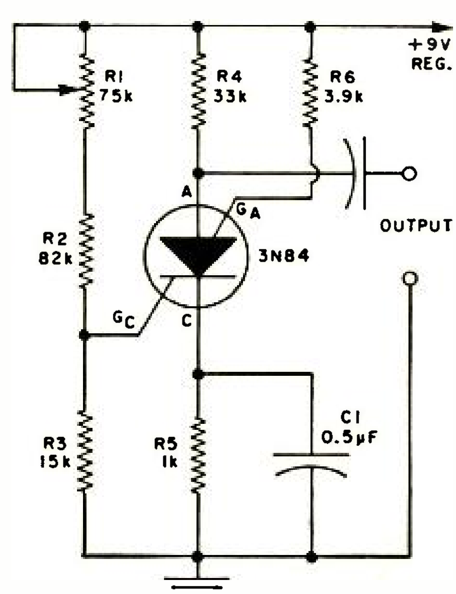
The change in potential across the cathode capacitor is a triangular waveform, but the SCS switches "on" and "off" abruptly. Consequently, the output signal voltage, obtained at the anode, is a rectangular waveform. Operating frequency of the SCS is limited, but the rise and fall times of the output signal are short compared with the repetition rate when operation is in the audio-frequency range.

With the component values given, the repetition rate is about 800 Hz. The output signal has an over-all swing of 7 volts and is rectangular except for some slight tilt of the horizontal position of the negative-going excursion of the waveform. The circuit has been operated satisfactorily at frequencies up to 20 kHz.

Before the circuit is first put into operation, set *R*1 at maximum resistance and connect a scope across the output terminals. Switch the power supply on. Then adjust *R*1 for the most symmetrical waveform. An occasional SCS may not start immediately, but if it is in good condition, will begin oscillating as *R*1 is advanced. Adjusting *R*1 changes the repetition rate to a certain extent. The circuit should be operated from a regulated power supply.

This single-semiconductor multivibrator isn't suited to variable-frequency operation since the most practical way to change the repetition rate is to change the value of capacitor *C*1. However, it is useful for many fixed-frequency applications. ▲

Schematic of SCS multivibrator.



Electronic Photoflash Meter

By WALTER W. SCHOPP

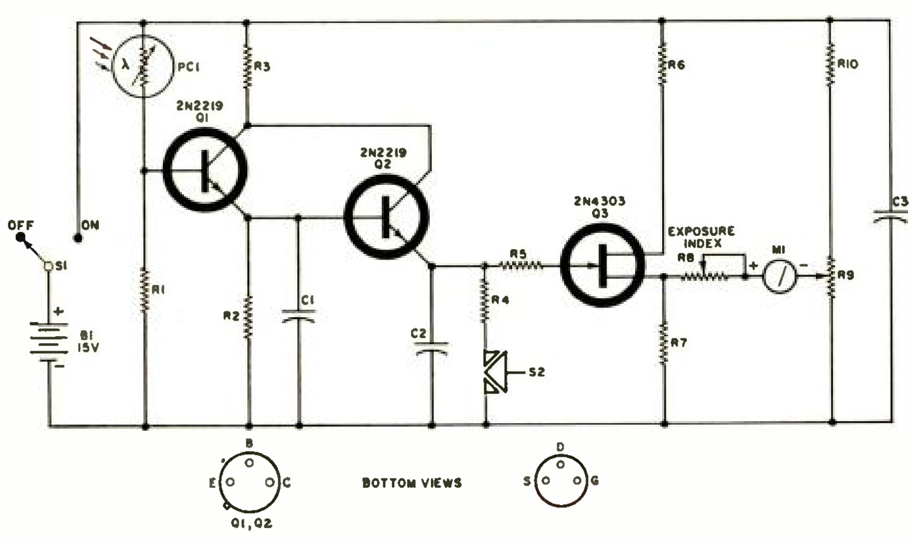
Construction of fast-reading light meter, with FET "memory" meter circuit, that guarantees perfect photoflash exposures.

Fig. 1. Front and rear views (with the cover removed) of electronic photoflash meter. Meter is calibrated in "f/stops."

MANY articles have been published about easy-to-build electronic photoflash units. When the "shutter-bug" finally builds one, he immediately obsoletes his "super-duper" cadmium-sulphide light meter that measures light in places so dark you can't even see the meter. The problem with using this type of exposure meter with an electronic photoflash unit is that the flash is produced and gone before the meter can leave the starting line; it is a victim of its own inertia. Using the flash unit with memorized settings presents other problems; it does not allow for any creative light placements or variations of lighting angles. Dark walls absorb much more light than brightly painted walls and many good pictures can be lost due to miscalculations of light settings. The only solution to the above problem is a light meter that reads the intensity of the short-duration flash and displays it on the meter long enough to read. Another desirable feature would be an adjustment to compensate for the various film speeds.

This type of compact flash-reading light meter (Fig. 1) solves most of the lighting problems produced by the electronic flash. Tucked into the "gadget bag," it will become an indispensable companion to your electronic flash unit. The meter is used by placing it in front of, or close to, the subject, with the light-sensing photocell facing toward the flash tube. A "dry run" is made by triggering the flash unit from the same location it will be in when the picture is taken. The light meter is then read and the camera settings made accordingly; the picture is then taken with the flash unit.

Fig. 2. Schematic diagram and parts list for light meter discussed in article. Trimmer resistor, R9, is used to zero meter and exposure index control, R8, to set meter reading for different ASA film-speed ratings. Reset switch, S2, is used to discharge capacitor C2 to prepare the meter for next flash reading.



R1—4700 ohm, 1/4 W res.
R2—10,000 ohm, 1/4 W res.
R3—47 ohm, 1/4 W res.
R4—1000 ohm, 1/4 W res.
R5—22 megohm, 1/4 W res.
R6—100 ohm, 1/4 W res.
R7, R10—27,000 ohm, 1/4 W res.
R8—25,000 ohm variable res.
R9—50,000 ohm trimmer (IRC Type 500 or equiv.)
C1—0.02 μF capacitor
C2—330 μF, 6 V tantalum capacitor
C3—100 μF, 20 V tantalum capacitor
S1—S.p.d.t. toggle sw.
S2—Push-button sw.
B1—15-V battery
PC1—Photocell (Clairex CL603)
M1—100 μA meter (Simpson 1212C or equiv.)
Q1, Q2—Silicon "n-p-n" transistor (2N2219)
Q3—Field-effect transistor (2N4303 or 2N4304)
Note: PC board that is used with meter M1 is available at $1.95, postpaid, from Neilsens, 934 Miranda Way, Livermore, Calif. 94550. Model PF-230.

How It Works

When the photocell *PC*1 (Fig. 2) is exposed to the brief light flash its resistance drops momentarily and a positive-going pulse is applied to the base of transistor *Q*1. This pulse is proportional to the intensity and duration of the flash and is amplified by transistors *Q*1 and *Q*2, and charges capacitor *C*2. This charge, which was produced by the light pulse, is then read by the field-effect-transistor voltmeter circuit. The low leakage characteristic of the FET enables the reading to be displayed on the meter for a long period of time after the flash has dissipated. The circuit is then prepared for the next light-flash reading by pushing the "Reset" button (S2) to discharge capacitor *C*2.

With the photocell blacked out, variable trimmer resistor *R*9 is used to zero the meter. The exposure index control *R*8 ("ASA") is used to adjust the circuit gain to correspond with various ASA film-speed ratings. Normal ambient light levels do not adversely affect the meter readings.

Construction

Construction is not critical. The complete light-meter circuit, excluding the panel-mounted components, can be mounted on the etched circuit board indicated in the parts list only if the same meter model, or a meter with the same spacing between the meter terminal studs, is used. This is because the circuit board is mounted to make electrical contact with the meter terminals to simplify construction. The circuit may also be constructed using a small piece of "perf board." The complete light meter is constructed in a chassis measuring 3½" × 2⅛" × 1⅝".

Calibration

When using an electronic flash unit in unfamiliar lighting situations, the main concern is setting the correct lens opening for the particular film being used. For quick and easy camera settings, the meter face is scaled directly in *f* stops while the exposure index knob is calibrated in ASA numbers corresponding to the various film speeds. The exposure index is calibrated first, using the full-scale meter reading, which is the *f*/22 stop point on the meter face, as a reference. After the exposure index is calibrated, the meter readings for the *f* stops are determined, using the ASA-6 position of the ASA exposure index knob. Using the ASA-6 position reduces the distances needed for calibration to reasonable figures as can be seen from the nomogram, which has been reproduced below as Fig. 3.

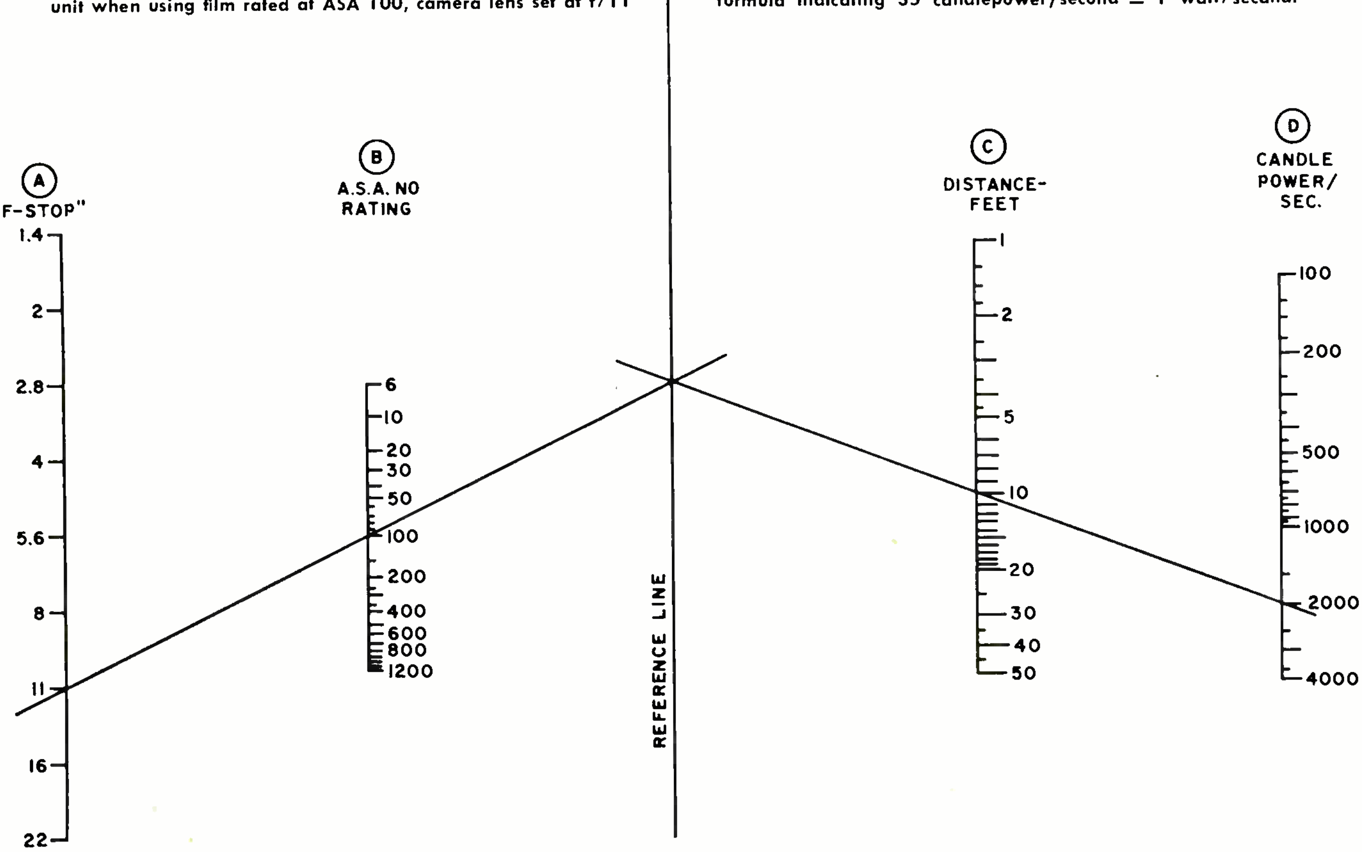
Turn the exposure-index knob to the maximum-resistance position. Refer to the nomogram, Fig. 3, and lay a straightedge from the *f*/22 point of column A to the ASA-6 point in column B. Mark the reference line where the straightedge intersects it. Next, lay the straightedge from the mark on the reference line to the candlepower/seconds rating of the flash unit being used for calibration in column D. The straightedge will intersect the distance line, column C, at the appropriate distance needed for calibration of the meter for *f*/22 at ASA 6.

Set the light meter this distance from the flash unit and push the "Reset" button to set the meter to zero. Trigger the flash unit and turn the exposure-index knob until a full-scale reading is obtained on the meter. Mark the knob-pointer position and label it ASA 6. Refer back to the nomogram and determine the distance needed to calibrate *f*/22 at ASA 10. Move the light meter back to this distance and reset by pushing the "Reset" button. Trigger the flash and adjust the exposure-index knob until full scale is obtained on the meter. Label this knob-pointer position ASA 10. Mark the rest of the ASA numbers, using the same procedure and the full-scale *f*/22 meter reading as the reference. Settings for special ASA numbers that are used more frequently can be determined from the nomogram and labeled as special points on the exposure index, if desired.

When the exposure-index knob is calibrated, set it on the ASA-6 position for the remainder of the calibration procedure. From the nomogram, determine the distance for ASA 6 at *f*/22 and set the light meter this distance from the flash tube. Since this is a repeat of the first setting, trigger the flash and regulate the exposure-index knob to obtain the full-scale meter reading. This point on the meter scale represents *f*/22. Refer to the nomogram and determine the distance for ASA 6 at *f*/16, and move the light meter back to this distance. Trigger the flash unit and record the meter reading obtained. Determine the distances for the remainder of the *f*/stops (*f*/11, *f*/8, *f*/5. 6, *f*/4, *f*/2.8, and *f*/2) and record the meter readings obtained from the flash at each of these *f*/stop distances so that each of the microamp meter scale readings can be replaced by the corresponding *f*/stop.

With the electronic photoflash meter in your "gadget bag," you are free to vary your lighting angles and techniques as much as you wish and still get a "perfect exposure" every time. ▲

Fig. 3. Namagram showing relationship between f/stop, ASA rating, distance, and candlepower/second. Example shows distance that the light meter should be from the electronic flash unit when using film rated at ASA 100, camera lens set at f/11 and an electronic flash unit rated at 2000 candlepower/second. If the only available figures for a particular photoflash unit are in watt/seconds, an approximation can be found by using the formula indicating 35 candlepower/second = 1 watt/second.



Automatic Turntables

(*Continued from page 27*)

on the indications of the stylus-force indicator even when using compliant cartridges. Nevertheless, we recommend using an accurate balance-type gage when setting up a record player for any force less than 2 grams.

Most automatic turntables have adjustable anti-skating compensation, with a calibrated scale corresponding to the range of tracking forces available. Since more compensation is needed with elliptical styli than with conical styli (typically about 50% more), several manufacturers provide separate scales for the two types of styli. Others use a single scale with a chart in the instruction manual indicating the recommended settings for different types of styli. Still others ignore the difference entirely. One of the tested turntables (*Dual* 1212) does not have separately adjustable anti-skating compensation. The *Dual* has an ingenious coupling of anti-skating with tracking force, with the compensation roughly optimized for conical styli.

It has been our experience that the recommended amount of anti-skating compensation is rarely, if ever, sufficient to produce equal tracking conditions on both channels. This was confirmed in the current test series, in which we found that the anti-skating settings had to be from 1 to 3 grams higher than the tracking force, for equal distortion on both channels. Since the audible effects of anti-skating compensation are slight, at best, this is a rather minor matter, but we feel that it makes good sense to get the greatest benefit from the manufacturer's design efforts.

We are presenting the results of our tests in two forms. Within each manufacturer's product line (see boxed copy), the differences in features and performance among the various models are described. Then, in each major price bracket, we comment on some of the differences among competing products. Note also that our test results are summarized in the table on page 25.

It should be evident from the boxed reports on the specific manufacturer's products and from the summary table, that none of the turntables tested is "tops" in every respect, and that none of them falls short of doing a satisfactory job of playing records. However, a few general observations can be made concerning the features to be found at different price levels.

At $50 or below (only the *BSR McDonald* 400 and the *Garrard* 40B fall in this category), the tonearms are unbalanced, the minimum tracking force is 2 to 3 grams (which eliminates the use of some of the more compliant cartridges), and a separate stylus-force gage is a necessity for initial setup. Very critical listeners may find traces of "wow" occasionally, and the moderate rumble levels may preclude use of speakers having high output in the 30-Hz region.

These turntables, with the appropriate cartridge, are capable of producing thoroughly high-fidelity sound albeit without some of the "frills" and refinements of their costlier relatives.

Between $50 and $60 (the *BSR McDonald* 500A and *Garrard* SL55B) we find slightly improved arms, but fundamentally their performance is similar to the lower priced models.

The next category of turntables, priced between $75 and $90, offers very good performance, comparable in all important respects to the most expensive ones. Examination of the characteristics of the *BSR McDonald* 600, *Garrard* SL65B and SL72B, and the *Dual* 1212 will make this clear. These units have low-friction arm bearings, calibrated stylus-force gages (a separate gage is still desirable), and heavier turntable platters that bring wow and rumble down to levels compatible with most home music system requirements.

Individual features and styling begin to play a prominent part in making one's choice in this and higher price ranges. For example, if precise speed adjustment is required, the variable-speed *Dual* 1212 is indicated. If line voltages fluctuate widely, the constant speed of one of the *Garrard* "SL" series should be of advantage.

Between $100 and $130 we find the highest level of performance, with a wide range of special features. If most of your listening is to single records, the convenient manual operation of the *Dual* or *Miracord* units can be of value. On the other hand, if you regularly play a stack of records automatically, the *Miracord* requirement that the spindle be taken out before removing records from the turntable may seem like an inconvenience (but don't overlook the over-all fine performance and construction of the *Miracord* products).

Variable speeds, offered on *Dual* and *PE* turntables, are sometimes a "must." If you are a purist, the vertical angle adjustment of the *PE* players can be a significant factor (the *Dual* 1219 has a similar ability, but at a much higher price).

The premium priced models, from $150 to $175, offer refinements which, although real, are not necessarily obvious or audible to the user. If money is no object, they cannot be surpassed, but you should be aware that the law of diminishing returns sets in rapidly above the $130 level. There may, however, be aspects of the construction and quality-control techniques that play a part in establishing the price of the most expensive units, yet would not be revealed in the tests we performed. ▲

Add-Subtract Decimal Counter

(*Continued from page* 48)

while the DT1075C uses an identical 10-pin base with the extra pin falling in the normal locating "hole." The *Itron* units have flying leads. Decimal points are simply an extra anode in the shape of a dot rather than a bar-shaped plate.

Prototype Circuit

The four-decade counter assembly is shown in the lead photo and diagrammed in Fig. 3. Grounded-base RTL translators are included on all "active" inputs. The translators convert 0- to +2-volt logic signals from conventional DTL or RTL integrated circuits into the 0 to −27 volts needed for the MEM1056. Four of these IC's are combined with four of the nine-pin, no-decimal-point readouts, using four PC-type tube sockets. A single-sided PC board is used with all parts mounted on the foil side. Insulating tape is placed under the IC's as needed. Four jumpers are used.

Supply power consists of −13 and −27-volt supplies with a floating 1.6 volt (a.c. or either polarity d.c.) tied to one side of the −27-volt line. This voltage is somewhat critical and should range between 1.45 and 1.65 volts. *Be extremely careful when testing.* Even momentarily applying reverse (positive) supply voltages to the IC's will destroy them.

Mechanical contacts and push-buttons must be conditioned to be used with this counter just as they have to in practically all other electronic counters where contact bounce "counts" just as much as keeping the button down for several seconds. A suitable test push-button is shown in Fig. 4. Its output goes to the In (Clock) terminal of the Clock RTL translator (Fig. 3).

More or fewer decades can be used as needed. Remember that in a digital instrument, your answer will be no more accurate than the accuracy of the input data, irrespective of how many decades are in use. So, for best economy, always use the minimum number of decades commensurate with the input accuracy.

Translators are only needed on "active" inputs and may be added or deleted as required. To permanently add, connect the MOS Count Down input (module's Add/Sub input) to ground instead of to its translator; to permanently subtract, connect it to −27 volts. To eliminate display blanking, connect the Blank Input (MOS) to ground rather than to a translator. To eliminate gating, connect the MOS Count Disable input (module's Gate input) permanently to ground.

Features may be added by adding translators. To be able to control the display storage, remove the Storage Entry (MOS) lead (pin 13 of IC) from −27 volts and run it to a new translator. Call the new input Store. Make the RTL Store input positive by 2 volts, and the display will keep the old number even while the counter is working on a new one; grounding this new input will allow the display to follow the counter. Direct input operation (parallel 1-2-4-8 entry) may be picked up in the same way, adding four more translators.

The *Itron* readouts may be connected by their flying leads directly to the PC pattern if desired. If the eighth and ninth bars are to be used to create a centered "1" and a more pleasing "4," external logic will have to be worked out and added.

The DT1705C may be used by drilling out the tenth position on a nine-pin miniature tube socket and adding a new clip; −27 volts extinguishes the decimal point; ground lights it. Internal decimal-point storage and control can also be worked out using the IC.

Some sources for obtaining the components needed to construct the Add-Subtract MOS IC Decimal Counter are listed in Table 1. ▲

BOOKS

"TELEVISION SERVICE MANUAL" by Edwin P. Anderson, revised by Robert G. Middleton. Published by *Theodore Audel & Co.*, Indianapolis. Ind. 46206. 535 pages. Price $5.95.

There must be whole generations of technicians familiar with the practical, no-nonsense approach of the various manuals and guides issued by this publisher. This volume is no exception.

This completely revised and updated Third Edition is directed to students, TV technicians, and electronics technicians and provides the necessary information in easy-to-grasp form.

Sixteen illustrated chapters cover TV broadcasting, TV transmitters and receivers, receiver placement and adjustment, TV antennas and transmission lines, antenna installations, TV interference, r.f. tuners, the video channel, sync and a.g.c. circuits, deflection circuits, power supplies, sound i.f. amplifiers and audio detectors, color TV, TV alignment, and TV test equipment.

The treatment is non-mathematical and those with basic skills in a.c. and d.c. circuitry and a knowledge of semiconductor operation should find this volume helpful.

* * *

"ENGINEERS' RELAY HANDBOOK" sponsored by The National Association of Relay Manufacturers. Published by *Hayden Book Company, Inc.*, New York. 345 pages. Price $13.95.

This is a revised Second Edition of a handbook which made its original appearance in 1966. In its expanded and updated format the material reflects recent advances in the state-of-the art. There are new sections on reed and mercury-wetted relays and solid-state devices.

Emphasis is on practicality and the handbook brings together information to simplify and clarify specifying and obtaining correct relays. The roster of contributors to this volume is a veritable "who's-who" of relay manufacturers—some 25 of whom are represented.

The twelve, lavishly illustrated chapters cover relay terminology, classes of service, relay classifications, principles of relay operation, relay application considerations, relay reliability, how to specify a relay, testing procedures, government specifications, electro-mechanical relays and solid-state devices/hybrid combinations, reed switches and reed relays, and NARM standard specifications.

It is hard to see how any one who has ever had to specify a relay or order one requested by a design department could get along without this valuable *"vade mecum"* of relays.

* * *

"PRACTICAL SEMICONDUCTOR DATA BOOK FOR ELECTRONIC ENGINEERS AND TECHNICIANS" by John D. Lenk. Published by *Prentice-Hall, Inc.*, Englewood Cliffs, N.J. 07632. 255 pages. Price $10.95.

The "Practical" in the title of this book sums up the author's approach to providing the data most often used in working with semiconductors. Since the thousands of semiconductors on the market represent basically only a dozen different types, this volume concentrates on their operating characteristics, circuit design procedures, and applications as working tools for engineers and technicians.

In fourteen chapters the author provides an introduction to semiconductors, basic transistor circuit data, practical transistor testing, practical diode testing, semiconductor power supplies, unijunction and field-effect transistors, basic transistor circuit design, controlled rectifiers, photocell data, voltage-variable junction-diode capacitors, typical semiconductor circuits, transistor parameter data, and IC data. The author has managed to cover all these topics in clear and largely non-mathematical terms to meet the requirements of his diversified audience.

* * *

"CLASSIFICATION, DEFERMENT AND DELAY" by Carlton S. Dargusch and John D. Alden. Published by Engineering Manpower Commission of Engineers Joint Council, 345 E. 47th St., New York, N.Y. 10017. 61 pages. Price $5.00. Soft cover.

This is the fifth edition of EJC's authoritative guide to Selective Service and military policies as they affect engineers. This new volume covers in detail all the recent changes in draft procedures and policies and is designed to help personnel officials of industrial concerns and educational institutions handle problems related to occupational deferments or military reserve call-ups. Individual Selective Service registrants and reservists will also find this book useful.

In addition to information pertaining to draft status, this edition provides information on draft liability of aliens, describes armed forces programs that use engineers and scientists, and summarizes reserve obligations. Addresses of key Selective Service officials, reproductions of pertinent forms, and the text of the recent Executive Order and Proclamation establishing random selection are also included.

* * *

"101 TV TROUBLES" by Art Margolis. Published by *Tab Books*, Blue Ridge Summit, Pa. 17214. 218 pages. Price $7.95 hardcover, $4.95 paperbound.

Subtitled "From Symptom to Repair," in this volume an old-hand at the servicing business is passing along to his fellow technicians some of the knowledge he has acquired over the years. As with all of Mr. Margolis' books, the treatment is concise and no-nonsense and he assumes that his readers, being practicing technicians, don't need "basic training."

The book is broken down into 15 chapters, each dealing with a common TV symptom. In each category he deals with the probable cause and outlines the procedure for locating the trouble. The text is lavishly illustrated with diagrams, partial schematics, tables, actual photos of the troubles as taken from the picture-tube face, and photos and descriptions of test equipment to be used.

* * *

"CHARACTERIZATION OF SEMICONDUCTOR MATERIALS" by Philip F. Kane and Graydon B. Larrabee. Published by *McGraw-Hill Book Company*, New York, 333 pages. Price $18.50.

As the tenth volume in this publisher's *Texas Instruments* Electronics Series, this book is for both engineers and technicians who must evaluate semiconductor materials but lack the requisite background in semiconductor technology.

In spanning several disciplines, the authors have produced a useful and comprehensive handbook on all the techniques, both compositional and structural, used in assessing material quality in producing modern semiconductor devices.

The text is divided into ten major chapters covering an introduction to semiconductors, semiconductor principles, bulk-material characterization, materials characterization in single-crystal growth, analysis of single crystals for chemical imperfections, characterization of single crystals for physical imperfections, characterization of semiconductor surfaces, characterization of epitaxial films, diffusion, and characterization of thin films.

In addition to assembling pertinent material on their subject, the authors have compiled an extensive list of references which the reader can consult for amplification of specific points. Well written, well illustrated, and all-encompassing, this volume would seem to be a "must" on any reference shelf with pretentions to completeness. ▲

Cesium-Beam Atomic Clock

(*Continued from page* 41)

allowing the standard frequency to be distributed over a long distance without loss of accuracy. Even radio signals, the ideal solution for many years, no longer provide the strict precision standards required by today's sophisticated technology.

The Solution

The only solution to the problem was to resort to a method which might seem ludicrous at first: transport the clock from one center to another in order to compare hourly impulses on location. Recent improvements in the development of portable atomic clocks have made it possible to effect these comparisons under almost ideal conditions; their precision being limited only by the stability of the standard clock during the journey.

The first comparison tests with portable atomic clocks were made in 1960 by U.S. Army laboratories, and in 1965 and 1967 by *Hewlett-Packard*.

In 1967, when the Oscillatom was chosen for the Swiss Time Center of the Montreal World Exhibition, it was decided to take this opportunity to carry the cesium-beam clock from Neuchâtel to Montreal and test its synchronization with American, Canadian, and Swiss time services. Consequently, two Oscillatom clocks left Neuchâtel on March 29, 1967, after being synchronized with a laboratory standard at the Cantonal Observatory. Shortly after arrival in New York one of the Oscillatom clocks was transported directly to the NASA Space Flight Center at Greenbelt, Maryland, where the first comparison took place.

Comparison Results

Results of this comparison showed that the Oscillatom had gained 100 microseconds on NASA time. The second comparison was made at Washington's U.S. Naval Observatory and the Oscillatom was found to be 76 microseconds behind the time of this observatory. Other comparisons were made at the National Research Council and at the Dominion Observatory in Ottawa. At the latter observatory, the difference of time between the local atomic standard and the Oscillatom was 16.5 microseconds.

One of the Oscillatom clocks was then sent to the Expo 67 Swiss Time Center in Montreal and the second returned to Switzerland. At the termination of Expo 67, the Oscillatom was not sent immediately to Switzerland but flown to the Far East where comparisons of time and frequency were made with the quartz standards of the Royal Observatory, the Hong Kong University Time Center, and others. In Singapore, the Oscillatom enabled engineers of the Radio Space Research Station to determine, with great exactness, the transmitting time of clock signals sent by Hawaii (WWVH), thus testing the accuracy of their own installations. In Tokyo, the Oscillatom was compared to the atomic standards of the Radio Research Laboratory at Kaganei, the official time-signal emitting station (JJY).

On December 8th, the Oscillatom was returned to Neuchâtel where it was compared with the laboratory standard and a difference of 26.7 microseconds noted. This marked the end of the experiment.

Applications

Air traffic is becoming increasingly heavy at large airports, adding to the danger of air collisions. To prevent such accidents, several systems are currently being developed. One of these systems, CAS (Collision Avoidance System) may well be adopted on an international scale. CAS is based on the use of cesium clocks on land and precision clocks (quartz, rubidium, or cesium) in aircraft. Each station taking part in CAS (on land or during flight) is assigned an interval of 1500 μs within a period of 3 seconds and, during this interval, emits a series of signals permitting other stations to calculate the distance, relative speed, and altitude of the emitting station. For the CAS to work all atomic clocks must be synchronized to within a microsecond.

Among numerous applications for atomic clocks, guidance and trajectography of missiles and satellites is one of the most important. Four atomic clocks with a stability of 10^{-11} are placed as follows: three at a certain predetermined point on the earth's surface and one on board the missile or satellite. All four are synchronized and every 1/10 second each of the atomic clocks simultaneously emits an exactly determined pulse.

The pulse produced by the atomic clock on board the missile or satellite is sent by radio to the three bases and is received with a slightly different delay in time at each base. Knowledge of the exact difference of each time delay makes it possible to calculate the radial distance from the vehicle to the three land stations having the same time scale.

Other applications for atomic clocks are: in the controls of emitting radio stations used in navigation systems; in the study of various propagations of radio electric waves; in geodesy, for precision long-distance triangulation; to check the influence of gravity on the clock, proposed by the theory of relativity; and in radio astronomy, to increase the angular resolution power of radio telescopes. ▲

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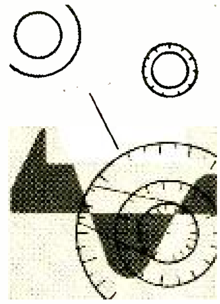
G. O. Allen

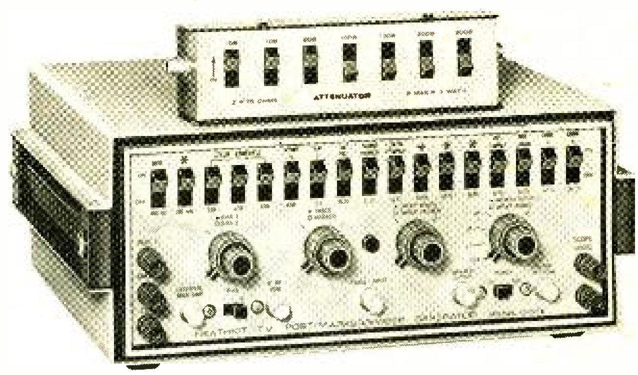


TEST EQUIPMENT

Product Report

Heath IG-57A Sweep/Marker Generator

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



JUST about two years ago, the *Heath Co.* introduced two pieces of advanced test equipment for the color-TV service technician. These units, designed for sweep alignment of TV receivers, were the Model IG-14 marker generator (see "Test Equipment Product Report," July 1968 issue) and the Model IG-57 sweep/marker generator. The former used 16 separate, stable oscillators (15 of them were crystal-controlled) to generate just about all the markers needed by the technician to sweep-align a receiver. The latter used all these same marker circuits plus r.f. sweep oscillators to generate the response curves (on a scope) on which the various markers were displayed.

Now, the company has come out with an improved Model IG-57A at the same price ($135 in kit form, or $199 factory-wired). The new unit differs from the previous sweep-marker generator in two respects. First, it has an additional bias supply; there are now two separate 0-15 V supplies whose output polarity may be either positive (for transistor TV's) or negative (for tube sets). Second, the new unit has an additional built-in detector, along with appropriate input and output connections, for providing video-sweep modulation. This permits the chroma bandpass curve to be displayed on the scope.

As with other recent marker-generators, the IG-57A uses post marker injection. By introducing the markers after detection, it is possible for the technician to see each marker clearly, even those that would fall in one of the trap frequencies. What is more, the markers do not distort or otherwise affect the shape of the response curves.

The sweep generator has three linear sweep ranges whose sweep width and center frequency are adjustable. These ranges permit r.f. alignment, i.f. alignment, and video alignment. As many as six crystal-controlled markers can be placed on an i.f. curve simultaneously so that the curve can be defined completely and accurately. The technician doesn't have to chase a single marker up and down the response curve in order to check it.

The usual blanking switch, trace-reversing switch, and phase controls are also included. A separate step attenuator, made up of 7 rocker switches and resistors with extensive internal shielding to prevent radiation and leakage, is provided. All necessary leads, cables, and probes are included. The generator is completely solid-state and uses printed-circuit boards.

The 118-page assembly-operating manual is, as with all *Heath* products, complete and excellent. Detailed information is included on how to use the generator for TV sweep alignment. ▲

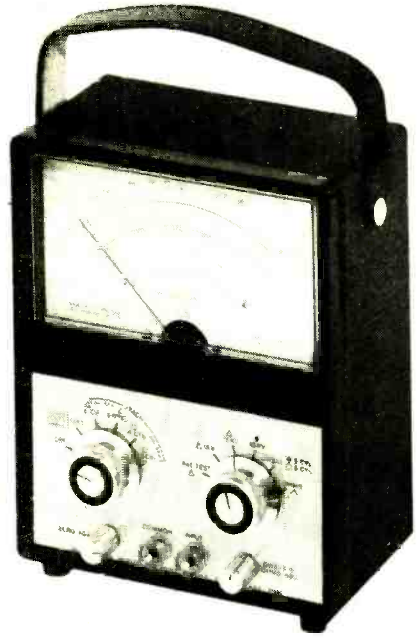
Delta Model 3100 Auto Engine Analyzer

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

DELTA *Products*, long known for its capacitive-discharge ignition system, has added a new product to its line of automotive test equipment. The Model 3100, which has many functions of some other auto engine analyzers or testers we have discussed previously in this column, is also able to measure directly the high voltages produced in the auto ignition system. Hence, the manufacturer refers to it as a "Hi-Volt Analyst."

Actually the instrument is a combination tachometer, dwell meter, ohmmeter, and high- and low-voltage voltmeter. The portable unit provides all the instrumentation required for testing the ignition and electrical systems of a car or boat, including checks of spark-plug condition, wiring, coil, and capacitor; and for adjusting the carburetor and timing. The meter can be used on all makes of cars, U.S. or imported, whether 4-, 6-, or 8-cylinder, 6 or 12 volt with either positive or negative ground.

There are two tachometer ranges (1500 and 6000 r/min), a dwell range, an ohmmeter range (10k-ohms, center-scale), and three voltmeter ranges (15 V, 15 kV, and 45 kV). Accuracy is within ±1 to ±5 percent, depending on range and function.

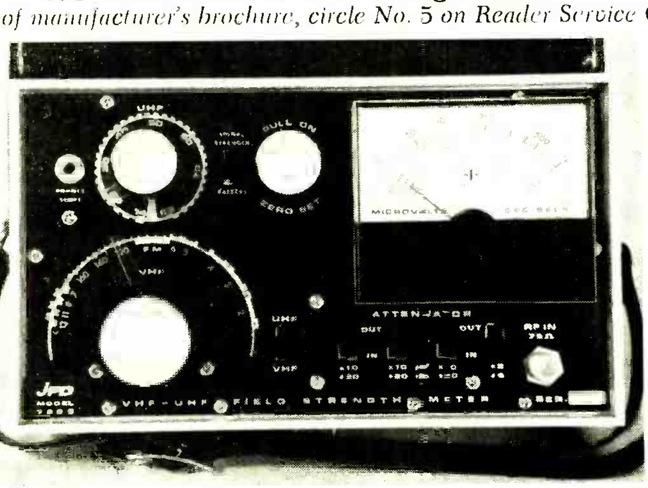


The metering circuits use a pair of cascaded FET's for high input impedance. These are connected to a two-transistor unity-gain feedback amplifier to achieve low output impedance to drive the meter movement. The circuit also includes two other transistors used as clippers to prevent overvoltage damage to the field-effect transistors.

The instrument is battery-operated, using eight standard penlight cells. It comes complete with leads and high-voltage probe. Price is $79.95 factory-wired or $59.95 in kit form. ▲

JFD Model 7200 TV Field-Strength Meter

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



THE service technician installing a large antenna system for a cable-TV or master-antenna system has to be sure that the antenna orientation is optimum for the channels the system is to pick up. Therefore, he should have some means of measuring the field strengths of the various TV channels produced by his antenna. One convenient way of doing this is to connect a field-strength meter, such as the new *JFD* Model 7200, to his antenna. He can then orient the antenna for maximum meter readings on the channels that must be received. A field-strength meter is also useful for home antenna installations, particularly in fringe areas where a rotator is not used and where antenna direction is so important.

The Model 7200 is light in weight and easy to use. It provides direct, accurate readings on all v.h.f. as well as u.h.f. picture and sound carriers. These carrier frequencies are clearly marked for each channel. The FM band is also available on the meter so that large FM antennas can be properly installed.

The meter is calibrated to read inputs from 10 microvolts to 2 volts. A jack is provided so that the technician can listen to the sound output of a TV or FM station on a high-impedance crystal earphone. A tape recorder or an oscilloscope can also be connected to record the sound or observe the video signals.

The meter operates from four 9-volt batteries. To conserve battery power, the unit automatically turns itself off when the cover is closed.

The Model 7200 lists for $395. ▲

NEW PRODUCTS & LITERATURE

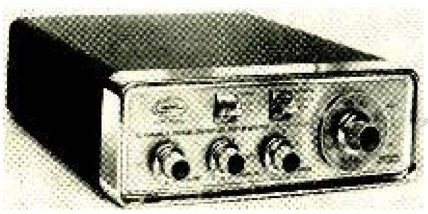
For additional information on items identified by a code number, simply fill in coupon on Reader Service Card. In those cases where code numbers are not given, may we suggest you write direct to the manufacturer on business letterhead.

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

FM-V.H.F. MONITOR

A new hi/lo band FM-v.h.f. monitor is now being offered as the Model COP-50HL. The receiver permits monitoring of the fire and police bands and weather services.

The unit has a built-in 117-volt a.c. power supply for home or office use. It can also be mounted



in a car (where legal) to operate off a 12-volt d.c. car battery. It has six high-band frequencies (150-175 MHz) and six low-band frequencies (25-50 MHz). The receiver features crystal-control on all channels (crystals not included). The solid-state design incorporates IC's, an exclusive r.f. peaking control for receiver sensitivity, an adjustable squelch which keeps the receiver quiet until a signal is received, and a tone-control switch.

The receiver measures $8\frac{3}{8}''$ x $7\frac{1}{2}''$ x $2\frac{5}{8}''$. Courier Communications

Circle No. 6 on Reader Service Card

NEW BATTERIES

New battery types that are designed to extend the range of portable-powered electrical products in both consumer and industrial use have just been introduced.

Based on the mercury/alkaline principle, the new units provide more energy than conventional batteries, greater reliability, and longer service over extended periods of time, according to the company.

Applications for the new batteries include communications equipment, lighting, photography, recording devices, and other cordless appliances. P. R. Mallory

Circle No. 7 on Reader Service Card

12-VOLT INVERTER

The "Quad-Continental" inverter (Model 50-110) is designed to permit the operation of 117-volt, 60-Hz a.c. equipment from the 12-volt d.c. battery of cars, trucks, buses, boats, and aircraft.

The inverter will handle loads from 1000 to 1200 watts. Frequency is maintained within ¼-Hz irrespective of input voltage on the load. The unit is completely filtered for operation of sound equipment and comes complete with control harness, solid-state circuitry, and uniform forced-air cooling. Terado

Circle No. 8 on Reader Service Card

DESOLDERING TOOL

The "Soldavac" is a low-cost desoldering tool whose high vacuum operation is accomplished by releasing a spring-loaded plunger. The tool is reloaded by pushing forward on the plunger tab until latch.

To desolder, the tip of the loaded tool is positioned against a heated solder joint and the trigger lever is depressed. Molten solder is instantly drawn up into the barrel by the high vacuum stroke.

The tool is made from lightweight, durable plastic that is easy to handle. It self-cleans the tip each time it is loaded. Edsyn

Circle No. 9 on Reader Service Card

SNAP-AROUND V.A.

The new M-series snap-around volt-ammeter is a six-range instrument with 3 voltage and 3 current ranges. It comes in a grey plastic housing for instant identification. It features a rotary dust-proof meter compartment that snaps into five different positions. The scale always faces the user irrespective of conductor position and permits easy readings in crowded switch boxes.

The snap-around jaws allow instant and accurate current readings without shut down or service interruptions. Voltage and current readings are on a graduated scale. The rotary selector switch snaps the scale selected into position.

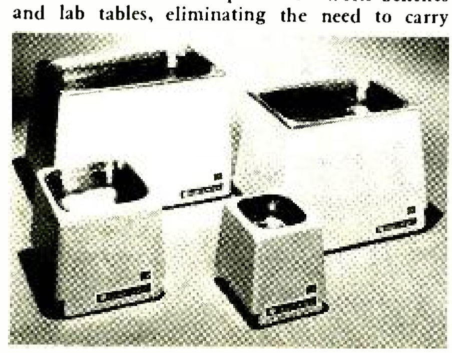
The meter is available in two models: M-100 with ranges of 10/50/100 A and 150/300/600 V a.c., and the M-300 with ranges of 25/100/300 A and 150/300/600 V a.c. Both models come with test leads and roomy carrying cases. A. W. Sperry

Circle No. 10 on Reader Service Card

ULTRASONIC CLEANERS

Ultrasonic cleaners that are smaller, simpler, and lower in cost than any previous industrial-quality units are now available in various sizes and capacities.

The cleaners can be placed on work benches and lab tables, eliminating the need to carry



parts to a central point for cleaning. The smallest of the new units is only 5″ square and the largest is 14″ x 9″ x $8\frac{1}{2}''$. Completely self-tuning, there are no adjustments or control knobs, only an "on-off" switch and pilot light.

All circuitry is solid-state, mounted on G-10 board, anchored in the base. Integral is the generating transducer, made of lead zirconate titanate and virtually indestructible. The tanks are stainless steel with rounded corners and the housings are Duralac-coated steel. American Beauty

Circle No. 11 on Reader Service Card

CASSETTE PLAYER FOR P.A.

A new cassette playback accessory, designed to be used with the firm's Power-Line public-address amplifiers, has been introduced as the Model CP-1.

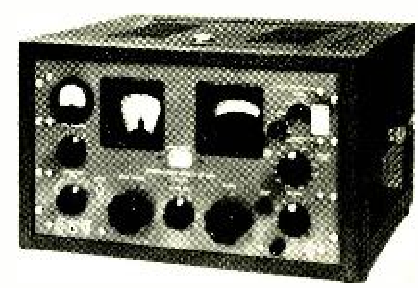
Although designed to fit as a custom installation on top of the company's amplifier, the unit can be used with any high-impedance, high-level-input p.a. amplifier. The unit features simple piano-key controls and a pop-up loading door so that even inexperienced personnel can operate the cassette.

The unit will play back any pre-recorded cassette tape, stereo or mono. The CP-1 can be installed on any Power-Line amplifier with a screw-driver. The peacock blue metal case locks on top of the amplifier. A phonograph outlet cord and power cord are included. University Sound

Circle No. 12 on Reader Service Card

COMMUNICATIONS RECEIVER

A new general-purpose communications receiver has been introduced as the SP-600 JX21A. The unit incorporates an advanced-design product detector and other special features such as a built-in frequency control unit which accepts up



to six crystals, rear-panel i.f. outputs for diversity and teletypewriter or other uses where a source of 455-kHz is required, a.v.c. and diode outputs at the rear apron, and continuous tuning of all frequencies from 540 kHz to 54.0 MHz in six bands.

A "VLF" version, tuning 10 kHz to 540 kHz, is also available. Hammarlund

Circle No. 13 on Reader Service Card

FLAT PLASTIC SPEAKERS

A new series of flat plastic speakers has been added to the "Poly-Planar" line as the "Roly-Poly" series. The new speakers feature a round, thin silhouette construction which permits exact EIA replacement of the cone speaker equivalent. Constructed entirely of polystyrene material, the new speakers provide wide-range reproduction, low distortion, bi-directional wide-angle dispersion, and high sensitivity, according to the manufacturer.

Light in weight, impervious to moisture and climatic conditions, and with minimum depth, the new speakers are available in a number of sizes and power handling capacities. ERA Acoustics

Circle No. 14 on Reader Service Card

VIDEO TAPE RECORDERS

A new series of advanced "Videocorder" tape recorders, using the half-inch format, has been introduced as the AV-Series.

The VideoRover II is a completely portable, battery-operated VTR system that can be carried and operated by one person. It consists of a hand-held video camera (with zoom lens and built-in electret capacitor microphone) connected to a shoulder- or back-carried Videocorder. An a.c. power adapter serves as a battery recharger and

also allows the unit to operate on 117-volt, 60-Hz a.c.

The AV-3600 is a lightweight unit that provides one hour of monochrome recording and playback and offers resolution of more than 300 lines. The AV-5000 records and plays back in either color or monochrome on half-inch tape. Recording and playback time is also one hour. The unit features both slow-motion and stop-action in the playback mode, camera insert edit capability, audio dubbing after recording, and an optional r.f. modulator that enables tapes to be played back on any regular TV receiver. Sony Corp.

Circle No. 15 on Reader Service Card

SSB/CW HAM TRANSCEIVER

A new 180-watt ham radio transceiver, the SB-102, features an all-solid-state linear master oscillator which provides faster warm-up time, greater stability and freedom from drift, and more accurate dial tracking, according to the manufacturer.

Sensitivity is 0.35 μV for 10-dB S+N/N to improve the operator's signal copying ability under fading band conditions.

Coverage is 80 through 10 meter bands, SSB input is 180 watts p.e.p., 170 watts on CW input, 1-kHz dial calibration, and front-panel switch selection of built-in 2.1-kHz SSB or optional CW crystal filters. Heath

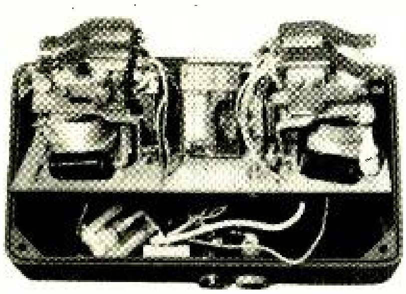
Circle No. 16 on Reader Service Card

"KEYLESS" LOCK

A system which the manufacturer claims virtually eliminates auto theft by replacing the standard ignition locking mechanism with a combination of electrical impulses is being marketed as the "Kode-Kee" system.

A toggle switch or proximity switch on the dashboard takes the place of a key. Only the right combination of impulses, right and left, on the Kode-Kee will permit the car to start. Because of the various combinations available, no two are alike.

A built-in alarm hook-up automatically blows



the car's horn if an attempt is made to bypass the Kode-Kee unit by short-circuiting the starter. A gasoline shut-off system and an anti-towing unit are available as optional accessories. H R Enterprises

Circle No. 17 on Reader Service Card

LOW-COST SCOPE CAMERA

Teledyne Camera Systems, 131 N. Fifth Ave., Arcadia, Calif. 91006 has introduced the new Telford type "P" oscilloscope camera which the company claims combines lower purchase and operating costs with superior performance.

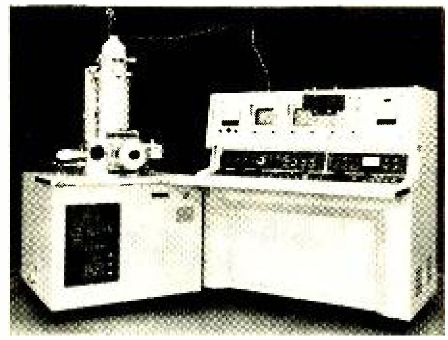
Controls have been reduced to a minimum, thus simplifying operation. The camera is pre-focused and lens aperture is pre-determined for Polaroid Land Type 20 film (ASA 3000). Each roll contains eight exposures 3½" x 2¼".

The company will supply full details on this camera upon letterhead request.

SCANNING MICROSCOPE

Hitachi, Ltd. has developed a scanning electron microscope that permits precise examination of three-dimensional objects.

Designated the HSM-2, it scans the surface of the object under study with a finely focused elec-



tron probe. Signal intensities of secondary electrons, backscattered electrons, absorbed electrons, transmitted electrons, cathode luminescence, and e.m.f. are fed to and displayed on a synchronously scanned cathode-ray tube as a bright, contrasty image.

The instrument provides a greater depth of focus than conventional electron and optical microscopes, according to the company. This feature provides more precise examination in three dimensions of such specimens as metal fractures, blade or runner edges, ceramic fractures, textiles, and micro-organisms.

For fuller details on this new unit, write on your business letterhead directly to Hitachi America, Ltd., 437 Madison Ave., New York, N.Y. 10022.

3-CHANNEL RC SYSTEM

The GD-57 3-channel digital proportional radio-control system for guiding model planes, gliders, cars, and boats is now available in kit form. It contains a transmitter, receiver, two servos, all plugs, connectors, cables, charging cord, battery pack, along with a special soldering iron.

The buyer gets his choice of five operating frequencies in each of three bands: 27, 53, or 72 MHz. The transmitter has a factory-assembled r.f. circuit and the receiver, in a nylon case, weighs only 2 ounces and measures 1⅛" w. x 1⅛" d. x 2⅛" l. and features ceramic i.f. filters for sharp selectivity.

Details on this system will be supplied upon request. Heath

Circle No. 18 on Reader Service Card

WET-ANODE ELECTROLYTIC

Mallory Capacitor Company, 3029 E. Washington St., Indianapolis, Ind. 46206 has introduced the industry's first wet-anode tantalum electrolytic capacitor with a positive hermetic glass-to-metal seal to prevent electrolyte leakage.

The new TLW capacitor is particularly suited for use in high reliability aerospace, computer, and instrumentation applications. The unit is a gel electrolyte, sintered tantalum anode polarized electrolytic in a hermetically sealed silver case. The capacitor is designed to meet the requirements of MIL-C 39006/9A style CLR 65.

The TLW is available in three miniature case sizes with axial leads. The unit has voltage ratings from 6 to 125 volts and a capacitance of 560 μF at 6 volts and 25 μF at 125 volts.

Bulletin 4-607 with complete technical data is available on letterhead request.

CIRCUIT TEACHING AID

The EU-53A "Stack-n-Patch" incorporates a new technique for circuit design and teaching that the company claims is faster, easier, and more economical than conventional breadboarding.

The new unit consists of a small desk-top chassis, a power patch card, and a component patch card. Patching up a design is fast and simple. The power supply is connected to the power patch card, the component and power patch cards are stacked in the chassis, and the components or hook-up wire are patched into the component card. The unit eliminates soldering and the special connectors make a tight, electrically stable connection just by inserting the wire into the connector. Heath

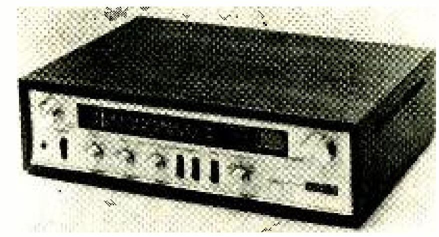
Circle No. 19 on Reader Service Card

COMPACT STEREO RECEIVER

The Model STR-222 AM/stereo-FM receiver incorporates an FET and 28 transistors for reception, 3 transistors for auxiliary circuit, and 19 diodes. Tuning range of the FM tuner section is 87-108 MHz with 2-μV sensitivity and stereo separation better than 38 dB at 1 kHz. HD is 0.5% mono and 0.8% stereo.

The amplifier section provides 24 watts at 8 ohms (IHF) dynamic power both channels driven. Harmonic distortion is less than 0.8% at rated output. Frequency response is 20-50,000 Hz ±3 dB.

Inputs include ceramic and magnetic phono, tape, and auxiliary. Outputs are provided for record player, headphone, and speaker (4-16 ohms).



There are bass and treble tone controls, a 6 dB/octave filter above 5 kHz, and a loudness control.

The entire unit measures 16 9/16" w. x 4⅝" h. x 12 3/16" d. It comes complete with an FM ribbon dipole antenna and two speaker cords. Sony Corp.

Circle No. 20 on Reader Service Card

PLUG-IN PC BOARDS

Newly designed plug-in circuit boards, called Modutrons, are now being incorporated in the company's component hi-fi equipment to eliminate long service delays and costly servicing and repair charges.

Out-of-warranty units that require servicing can be repaired in a day or two at a very nominal

cost per board, plus labor. The Modutron boards are simply plugged in to replace the board which tests have shown to be at fault. This new technique is designed not only for the convenience of the owner, but as a means of speeding up servicing by cutting the time required to repair the equipment. H. H. Scott

Circle No. 21 on Reader Service Card

SIREN/P.A. SYSTEM

The GD-18 siren/p.a. system is available in kit form to those authorized to have sirens on their vehicles.

The unit provides both "wail" and "yelp" warnings, depending on the position of the control-panel function switch. The siren can be momentarily interrupted for the p.a. function. Pitch of the siren is adjustable and siren power output is 55 watts. The p.a. output is 20 watts.

A radio-call-alert feature (when connected to a receiver) amplifies incoming radio calls with 20 watts of power and routes them through the external speaker. A radio input-level control sets a top limit on volume so that full radio call alert

volume is always at a predetermined level.

The solid-state circuit is designed to operate under −20 to +150 degree F conditions. A lift-out circuit board makes assembly and service checks easy. A choice of exposed or concealed horn is offered. The concealed speaker requires a space of 4½" h. x 4¼" d. x 13" w. behind the vehicle grille. The exposed speaker features tamper-proof terminals. Heath

Circle No. 22 on Reader Service Card

WWV RECEIVER

A fixed-frequency portable WWV radio receiver, which its manufacturer claims provides extremely accurate voice time signals on a continuous basis, has just been introduced.

Called the Simex Time Standard, the signal received is accurate to within one-tenth of a second and can be converted to correct time for any

location by simply applying the proper number of hours in the particular zone description involved. Time given is Universal Time, referred to the Zero meridian at Greenwich.

The receiver operates on fixed frequencies at 2.5, 5, 10, 15, and 20 MHz to receive signals from WWV broadcasts from NBS in Fort Collins and WWVH in Hawaii. A special additional frequency of 7.335 MHz provides for signal reception from the Dominion Conservatory in Ottawa. Coast Navigation School

Circle No. 23 on Reader Service Card

MANUFACTURERS' LITERATURE

LONG-RATE STORAGE BATTERIES

Three new plastic-container batteries—in 320, 350, and 415 ampere-hour capacities—are described in a new specification catalogue, AG-425, just published by NIFE Incorporated, Copaigue, New York 11726.

These long-rate nickel-cadmium batteries are particularly well suited for communications systems, transit applications, fire alarms, and marine use. The catalogue provides complete performance data for 15 plastic-container and 19 steel-container batteries, ranging from 10 to 1245 ampere-hour capacities.

DIODE ASSEMBLIES & ARRAYS

A 24-page designer's guide which outlines the opportunities for improving discrete diode designs by means of multi-functional diode assemblies and monolithic arrays has been announced by Fairchild Semiconductor.

This two-color, illustrated publication shows how the multiple diode design approach can achieve better performance at less cost, using either standard or custom-made products. The brochure presents several diode charts containing electrical parameters, thermal ranges, and matching data needed for the evaluation of assembly and array designs. Accompanying the charts are typical applications and schematic drawings.

When writing the Distribution Services, Box 1058, Mountain View, Calif. 94040 for a copy of this guide, please specify "Fairchild Specialty Diode Products."

NON-STANDARD RESISTORS

Engineers whose circuit designs involve use of non-standard discrete resistors can obtain design and special assistance from the new "Functional Guide to Non-Standard Resistors" just published by Dale Electronics, Inc., P. O. Box 609, Columbus, Nebraska 68601.

The guide details the extended performance levels available in various types of non-standard resistors. This information is matched with charts showing the range of readily available lead and packaging variations. Using these charts, engineers can "build" resistors to meet their special needs.

Copies of this 16-page guide may be obtained by addressing your request to Department 860 of the company.

NOISE MEASUREMENTS

A second edition of the "Primer of Plant-Noise Measurement" is now available without charge. This revised 24-page booklet features "how-to-do-it" discussions on making noise measurements consistent with the latest provisions set forth in the Safety and Health Standards of the Walsh-Healey Public Contracts Act.

A special section on measurement of impact noise has also been included. General Radio

Circle No. 24 on Reader Service Card

TERMINALS/SOCKETS

James Millen Manufacturing Company, Inc., Malden, Mass. 02148 has just published a new 16-page bulletin which describes an extensive line of terminals, plate caps, and sockets. The bulletin describes both standard size and miniature components.

Also included is information on high-voltage feedthrough safety terminals, binding posts, ceramic insulators, crystal sockets, special industrial sockets for large tubes, insulated plate caps, hold-down clamps, coil sockets, and aluminum shield cans.

BNC CONNECTORS

King Electronics Co., Inc. has issued a comprehensive catalogue covering its BNC series of r.f. coaxial connectors. Construction and cable group data is given for 658 individual items, comprising a wide variety of adapters, jacks, panel jacks, bulkhead jacks, plugs, angle plugs, panel receptacles, bulkhead receptacles, terminations, and accessories. Each items is illustrated and pertinent dimensions indicated.

Your letterhead request for a copy of this 48-page catalogue should be addressed to the Technical Services Department of the company at 40 Marbledale Road, Tuckahoe, New York 10707.

D.C.-D.C. TRANSFORMERS

Microtran Company, Inc., Valley Stream, N.Y. 11582 is now offering a d.c. to d.c. converter transformer selector guide which has been specifically designed to assist engineers working with circuitry using magnetic components.

The guide presents a complete listing of the company's line of d.c. to d.c. transformers in a comprehensive, tabulated form. A full electrical and mechanical description accompanies each catalogue listing and is further implemented with supporting circuitry.

GLOW LAMPS

A 12-page, illustrated technical discussion on the design of neon glow lamps, their operational characteristics, and their applications is now available from Signalite, Inc., 1933 Heck Avenue, Neptune, N. J. 07753.

The brochure is a comprehensive presentation which covers a broad range of information starting with a discussion of what a neon lamp is, how it works and why, and what the operational characteristics of the device are. It includes both

What is said to be the world's most powerful sound system is scheduled to go into operation this summer at the giant $25.5 million Ontario Motor Speedway, 40 miles east of Los Angeles. The system is made up of 400 Altec Lansing multi-cellular horn speaker systems and 84 special Altec power amplifiers, which will generate an audio output of more than 30,000 watts. (By comparison Indianapolis Motor Speedway has a 14,000-watt system and all of Cape Kennedy has an audio output capability of about 20,000 watts.) With more than 30 million feet (600 miles) of audio and communication cable, the speaker lines will operate at 210 volts to reduce line transmission losses in the system. When completed, the speedway will have facilities for seating 140,000 and a total capacity of 200,000 spectators. The complex consists of a 2.5-mile oval track, a 3.2-mile road race circuit, and a quarter-mile drag strip. Hannon Engineering, Inc. of Los Angeles, an Altec sound contractor, is the designer-builder of the new sound installation.

two- and three-element lamps showing how light is generated and what the spectral distribution of the light is. Ignition characteristics and methods are discussed with many curves and charts showing how the lamps act under different conditions.

EMERGENCY NUMBERS IN BRAILLE

Vacations and Community Services for the Blind, 117 W. 70th St., New York, N. Y. 10023 is now distributing copies of "New York City: Emergency" to the sightless free of charge.

The Braille chart lists telephone numbers in New York City to call for help with a variety of problems. The chart, adapted from a printed version which has been made available to contributors, can be attached to the cover of a telephone book, tacked on a kitchen bulletin board, or posted next to the telephone.

CAREER TRAINING COURSES

An elaborate 52-page, four-color guide which lists home-study courses in ten different electronics fields is now available on request.

Complete details are provided on practical and master courses in radio-TV servicing, color-TV servicing, electronic communications, FCC license courses, electronics technology, industrial and automatic electronics, computer electronics, and basic electronics. Details are also included on the various kits that accompany the courses to provide practical training in electronics. National Technical Schools

Circle No. 25 on Reader Service Card

MSI POCKET GUIDE

Fairchild Semiconductor has issued a new 100-page "MSI Pocket Guide" as a reference source for design engineers and technicians looking for basic information on the company's MSI (medium scale integration) products.

Measuring less than six inches long, the booklet will easily fit into a shirt pocket. The guide provides easy-to-find data on MSI circuit functions, pin-out, and loading rules, eliminating the time-consuming task of extracting this information from data sheets. The guide also gives a basic description of many simple bipolar IC's commonly used with devices in the MSI family.

The index lists 56 devices covering the entire range of MSI building blocks in the 9300 series and MSI support functions in the 9000 and 9600 series. An introductory section explains the inherent efficiency of MSI functions and outlines their advantages.

For a copy of this valuable guide, write the Distribution Center, Fairchild Semiconductor, Box 880, Mountain View, Calif. 94040 on your business letterhead.

HUMIDITY CHAMBERS

Hotpack Corporation, 5141 Cottman Ave., Philadelphia, Pa. 19135 has just published a comprehensive guide to humidity chambers. This 28-page guide gives detailed specs on a complete line of chambers for temperature-humidity testing.

For the first time, the guide describes the new rectilinear program control system which is designed to eliminate the tedious time-consuming process of designing programs usually associated with conventional programming systems. With the new system, programming becomes almost instantaneous as the plastic card-type cams can be cut with a pair of scissors.

The chambers described and illustrated include a full range of units for performing typical MIL, JAN, ASTM, PI, TAPPI, and NEMA spec tests.

CATHODE-RAY TUBES

A new 8-page technical catalogue (ETD-6001) for selection of cathode-ray tubes is now available from General Electric.

The new brochure, in three separate tables, lists 41 registered screen phosphors, and 165 magnetic deflection or electrostatic deflection CRT types, according to physical dimensions and operational characteristics.

CRT types listed are categorized as general-purpose, military, industrial, or special-purpose. Footnotes are used to denote special characteristics such as flat faceplate, gray faceplate, magnetic focus, or spherical faceplate.

Copies of the guide may be obtained by addressing your request to R. L. Toth, Inquiry Processing, Tube Department, General Electric Co., 316 E. Ninth St., Owensboro, Ky. 42301.

PARABOLIC ANTENNAS

Prodelin Inc., P.O. Box 131, Hightstown, N.J. 08520 has issued a 40-page catalogue section describing its line of parabolic antennas and ITFS transmitting and receiving antennas covering frequencies from 450 MHz to 13.2 GHz. Details on mechanical and electrical specifications are provided. Radomes, mounting information, adapters and cable, and connector accessories are also included.

LOW-COST COLOR CAMERAS

RCA Professional Electronic Systems, Building 15-5, Camden, N.J. 08102 has issued a 12-page brochure and a series of catalogue sheets detailing a complete complement of color-television equipment offered by the department.

The brochure provides an overview of innovative cameras priced under $10,000. Color film systems and video tape recorders are also described. Several typical TV systems for instructional and training applications are pictured and discussed.

P.A. EQUIPMENT

A new and comprehensive catalogue which provides complete technical data on an extensive line of commercial p.a. equipment is now available.

The publication contains information on all p.a. products from Power-Line amplifiers to portable Powrpage systems. Copies are available on request. University Sound

Circle No. 26 on Reader Service Card

HAM-BAND CHARTS

Volume 30, No. 1 of "Ham Tips" contains valuable ham-band charts covering FCC allocations, sub-allocations, and authorized emissions from 3.5 to 450 MHz. These charts reflect changes contained in the second phase of the FCC's new amateur radio incentive license regulations which went into effect on November 22, 1969.

A copy of this handy chart, with its explanatory material, is available on request. RCA Electronic Components

Circle No. 27 on Reader Service Card

HEADPHONES & ACCESSORIES

A handy, two-color 4" x 9" brochure which features the company's entire line of stereo headphones and accessories is now available for distribution.

In addition to the stereo and dynamic headphones, the brochure includes information on a line of accessories encompassing remote-control stations, connector boxes, monitoring adapters, extension cables and cords, and a high-impact plastic headphone carrying case with sponge liner. Koss

Circle No. 28 on Reader Service Card

SEMICONDUCTOR CATALOGUE

The Semiconductor Assembly Division of General Instrument Corp., 65 Gouverneur Street, Newark, N.J. 07104 has issued a 12-page brochure which gives ratings on a wide range of silicon and selenium bridges, high-voltage rectifiers, and other assemblies.

Custom circuits, package drawings, and photos are also included. A brief discussion of the relative merits of the two materials—silicon and selenium—is presented at the start of the booklet.

MONOLITHIC CHIP CAPACITORS

A 28-page manual on practical considerations in selecting and using monolithic chip capacitors has been issued by U.S. Capacitor Corporation, 2151 No. Lincoln St., Burbank, California 91504.

Answers to important electrical and environmental characteristics questions, asked by engineers and engineering designers who specify chip capacitors, are also covered in depth.

PANEL INSTRUMENTS

A new 50-page catalogue describing and illustrating the various designs of panel instruments in the Jewell Electrical Instruments line has been issued.

The publication contains engineering specifications and dimensions on each meter in the line, which includes elapsed-time indicators, taut-band panel meters, and null indicators. The meters are available in round, square, rectangular, wing, and edgewise styles to fit various equipment designs. Sizes range from 1½" through 5½".

Write on your business letterhead for a copy of the catalogue to the company at Grenier Field, Manchester, N.H. 03105.

CAPACITOR CATALOGUE

Standard Condenser Corporation, 1062 W. Addison St., Chicago, Ill. 60613 has announced release of a new 16-page catalogue featuring its line of polyester film, metalized polyester film, polystyrene, and polycarbonate capacitors. Case types listed in the catalogue include ceramic, phenolic, and tape-wrap—in cylindrical and flat configurations.

Photos, dimensional drawings, and performance charts supplement the listings, which include tolerances, temperature-range ratings, and lead specifications where applicable. Information on RC networks and special capacitors is also provided.

Ask for Catalogue C-70 when writing the company at the above address.

THUMBWHEEL SWITCHES

Interswitch, 770 Airport Boulevard, Burlingame, Calif. 94010 has issued a 6-page, two-color condensed catalogue (No. 704) describing its complete line of thumbwheel switches, including four completely new series.

The catalogue emphasizes both the convenience of operation of the switches and the enormous number of standard configurations or standard design variations that are available. Several styles also feature dimensions much smaller than usual for applications where panel or cabinet space is critical.

HAND-TOOL CATALOGUE

Upson Tools, Inc., P.O. Box 4750, Rochester, N.Y. 14612 has announced the availability of a new catalogue, No. 171, which pictures and describes an extensive line of hand tools, including 44 new items.

(*Continued on page 82*)

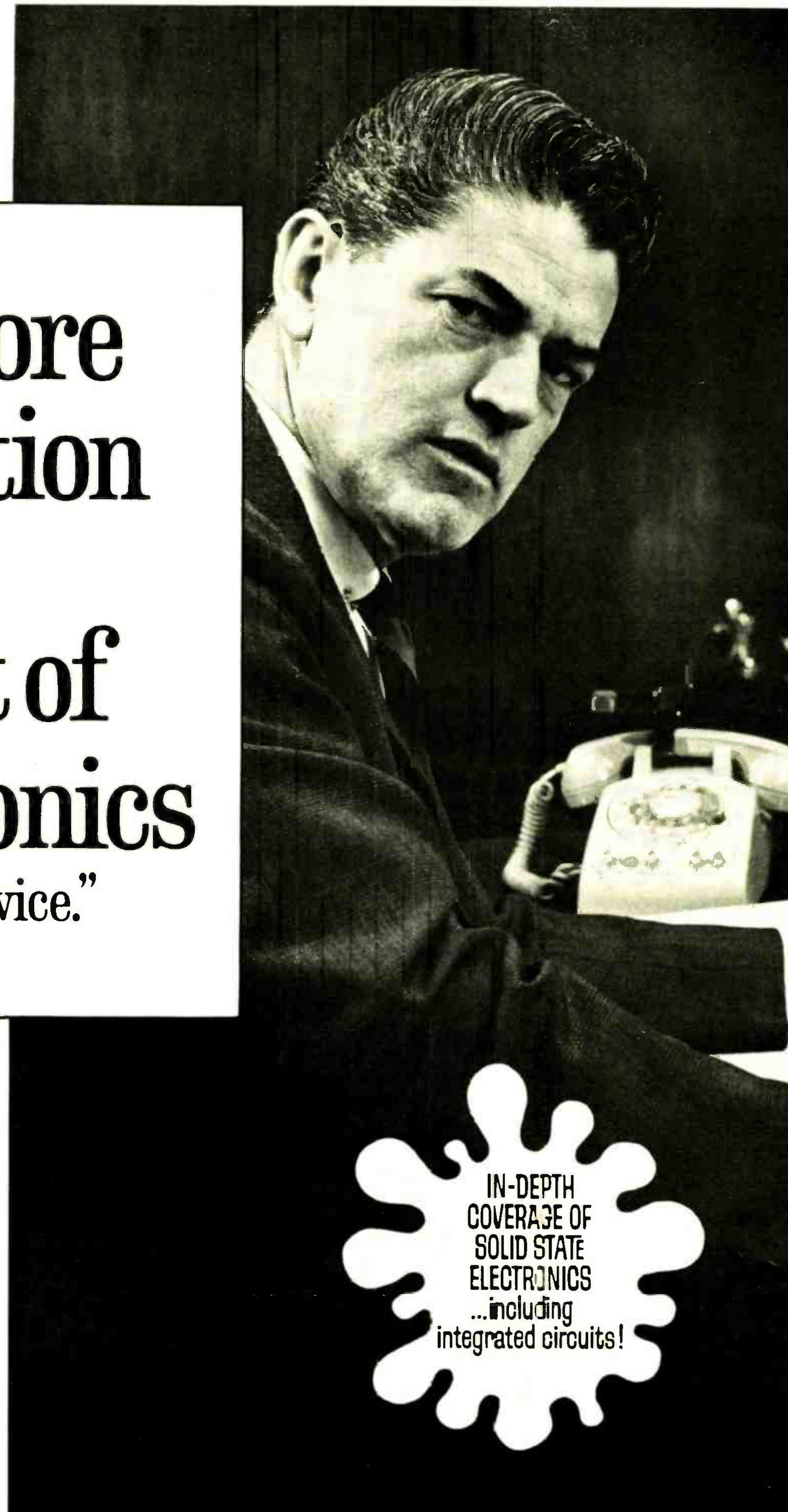
CB RADIO JAMBOREE

THE Fourth National Air Capital CB Jamboree, sponsored by Wichita Air Capital C. B. Radio Club, Inc., has been set for July 17, 18, and 19 at the 4-H Bldg., Central and Tyler Road, in Wichita, Kans.

The Jamboree Coffee Break which will kick off the event has been scheduled for July 17, beginning at 6 p.m. The Jamboree will open each morning at 10 on July 18 and 19.

Free camper and trailer parking will be provided on the Jamboree Grounds. The sponsors will provide live entertainment, a dance on Saturday night, door prizes to be awarded every 30 minutes, and four grand prizes.

For details, write C. A. Morrow, Jr., Jamboree Chairman, P.O. Box 841, Wichita, Kansas 67201. Also monitor channels 9 and 11 (KRH9348 is the Jamboree Control on channel 9). ▲



IN-DEPTH COVERAGE OF SOLID STATE ELECTRONICS
...including integrated circuits!

The catalogue also includes a list of the firm's sales representatives and conversion tables applicable to the hand-tool industry.

DRAFTING/ENGINEERING DATA

Alvin & Co., Inc., Windsor, Conn. 06095 has recently published a new 72-page catalogue covering a wide selection of drafting, drawing, and engineering supplies.

This new catalogue is a supplement to the company's general catalogue "H-J" and represents a compact version illustrating the popular key items. Included are drawing sets, beam compasses, scales, slide rules, T-squares, triangles, irregular curves, lead holders, drawing leads, lettering pens, visual aids, and templates.

In making your request for a copy of this catalogue, address your letter to Dept. CC of the firm.

HYBRID-CIRCUIT CATALOGUE

A 36-page catalogue of hybrid semiconductor circuits is now available for distribution. Listing hybrid devices with their schematic diagrams and physical and electrical characteristics, the catalogue is intended for engineers and engineering designers in the military, aerospace, and industrial fields.

Copies of the catalogue will be supplied without charge upon request to the Marketing Manager, Teledyne Amelco Semiconductor, 1300 Terra Bella Ave., Mountain View, Calif. 94040.

INSTRUMENTATION CATALOGUE

The 1970 edition of the Honeywell Instrumentation Handbook, which describes the division's line of electronic test instruments and customer services, has been published by the firm's Test Instruments Division.

Technical information on instruments and systems, application notes explaining how and why particular instruments are used, and descriptions of supporting services available to customers are covered in separate sections of this 276-page hard-cover book.

Other sections explain how certain functional and design features are used to accommodate particular customer requirements and give definitions of technical terminology used in the instrumentation industry.

Product lines covered include oscillographic recorders, magnetic tape recorders, X-Y recorders, digital voltmeters, signal-conditioning equipment, transducers, amplifiers, monitor scopes, data-acquisition systems, electronic biomedical systems, patient-monitoring equipment, RFI/EMI instrumentation and metrology service, plus related instrumentation and services provided by other divisions of the company.

To find out how to obtain a copy of this handbook, write directly to C.F. Creswell, Honeywell Test Instruments Division, P.O. Box 5227, Denver, Colorado 80217 on your business letterhead.

GAS SYSTEM DATA

Matheson Gas Products, P.O. Box 85, East Rutherford, N.J. 07073 is offering a new, revised edition of its catalogue, "Gases and Systems for the Electronics Industry."

The 56-page catalogue contains condensed technical data sheets on each of the 23 gases and volatile liquids listed. Included are basic epitaxial materials, doping gases, organo metallic compounds, pyrophoric compounds, regulators, valves, and complete gas systems. An important new item, "E-Gas," is covered in depth since it is specifically prepared for etching silicon.

To obtain a copy of the catalogue, address your letterhead requests to the attention of Paul Sennett at the above address. ▲

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Answers to C.E.T. Test, Section #4

Published in Last Month's Issue

1. (a) The working voltage of capacitors in series is additive, so two 50-V capacitors in series have a working voltage rating of 100 V. Two capacitors of identical capacitance value in series halves the total capacitance.
2. (b) $P = I^2 R$ or $(1/2)^2 \times 100 = 25$ watts.
3. (c) Capacitive reactance decreases as frequency increases.
4. (c) $P = E^2/R$. In the 2-ohm resistor, $P = 10^2/2 = 50$ watts. In the 4-ohm resistor, the power dissipated is 25 watts. Total power in both resistors is 75 watts, therefore the 2-ohm resistor dissipates $2/3$ of the total power.
5. (b) At resonance, the total impedance is lowest. Lower frequencies are blocked by the capacitor and, as frequency decreases, this capacitive reactance is greater. Higher frequencies are blocked by the inductance. At resonance, capacitive and inductive reactances are equal.
6. (a) As shown in question 4, the larger resistor will dissipate less power, as indicated by $P = E^2/R$.
7. (b) Inductive and capacitive reactance are expressed in ohms. Inductance is expressed in henrys.
8. (c) $I = E/R = 5/50$ or 0.1 A (100 mA).
9. (c) Capacitors in parallel add.
10. (c) Resistance is exactly right. Wattage is safe with this combination.

SCR Controls

(*Continued from page 36*)

than that of some plastic-cased SCR's. It is also rugged, reliable, and hard to burn out, and as cheap as any. This type is rated for use off the 120-volt a.c. line, with a maximum average d.c. load current of 1.3 amperes, and is housed in a TO-8 case. For larger load currents, the same insides are available in a flange-type TO-66 case for mounting on a heat sink, as *RCA's* 2N3228. Some versions of the *Singer* circuit use a 1k-ohm resistor between gate and cathode of the SCR. In this version, it has no effect. Incidentally, it is not advisable to connect a capacitor of any size—such as 0.1 μF or more—between gate and cathode, or gate and anywhere else, unless there is enough resistance in series to limit surge currents to a value safe for the gate. Also, do not connect capacitance across the motor in an effort to make it run more smoothly. All it does is raise the peak current to a high spike when the SCR fires, making the control action unstable, and often blowing out the SCR.

The choke, *L*, in series with the motor is optional. Its main effect is to make motor operation smoother at very low speeds, which it does by rounding off the current peaks to the motor. In the coil-winder application mentioned, a small 0.1-henry choke was used having a d.c. resistance of about 8 ohms. This is not a stock item, but it can be approximated by taking a *Triad* C-40-X choke, prying off the "I" laminations, and inserting a piece of cardboard about 0.03" thick as an additional air gap. The original inductance is too high and the value is not critical; it depends somewhat on the particular motor. A high-quality motor such as the *Bodine* NSE-11 requires no choke, but the low-priced *Dayton* 2M033 (sewing-machine replacement) does.

Bouncing

This matter of smoothness at low speeds is related to the effect called "skip-cycling" by *RCA* ("bouncing" might be a better term). What happens is this: suppose the pot in Fig. 1B is set low, and the motor is coasting down from a higher speed. When it gets down to a slow enough speed, the SCR starts firing and gives the motor a healthy kick, sending it up to a higher speed than the pot is actually set for. The SCR promptly quits firing and the motor, deprived of its input, slows down again. When it is slow enough, the SCR gives it another oversized kick. And so on. It is a form of oscillating servo system. The cause is rooted in the fact that, in these simple circuits, the SCR cannot be phase-controlled over the full 180 degrees.

The "bounce" effect is greatly attenuated when the motor is connected to a mechanical load. When it is belted to a sewing machine, for example, the bounce is barely noticeable. Complex circuitry helps, but that is another subject. The choke, *L* in Fig. 1B, can eliminate it, but at the expense of reducing the torque at low speeds. How much choke you need, if any, will depend on the particular motor and on its mechanical application. In a stirring machine, the motor is connected to a viscous damping load, and requires no choke. Circuits of the type shown in Fig. 1B are very practical.

Shunt Motor Control

While the textbooks prefer to show complex full-wave, pulse-fired circuits for controlling shunt and PM motors, the simple half-wave circuit of Fig. 1C is very effective. It is a feedback circuit of the same class as those of Figs. 1A and 1B, where the back-e.m.f. of the motor is compared with a bias applied to the gate of the SCR from a pot. The relation between the motor speed and the pot rotation is linear, which is an advantage over the circuit in Fig. 1B. Control is good because the field is on all the time, so that the "tachometer" back voltage generated by the motor obtains its full value during the negative (or off) half-cycles.

Shunt and PM motors, unfortunately, are not readily available in standard stock sizes, so that it is difficult to make responsible general statements about them. The circuit of Fig. 1C was used successfully with two surplus units. One was rated 1/6 hp, 2500 r/min, 120 V at 1.3 A and the other 1/100 hp, 3400 r/min, 75 V at 0.35 A. The first had a PM field and an armature resistance of 10 ohms; the second an armature resistance of 100 ohms and a shunt field of 800 ohms. *D1* is the rectifier for the field supply and the filter capacitor should be chosen to give about the correct d.c. voltage across the field. The series-gate 1k-ohm resistor is there to limit the gate current to a safe value under the worst condition, which occurs when the potentiometer is all the way to the top and the motor speed hasn't caught up with it.

Again, a choke can be put in a series with the motor, and will have the same effect of smoother operation and lower torque at very low speeds. With this circuit, however, it was possible to run the motor all the way down to 1 r/s without bouncing.

For controlling little hobby motors of the PM battery-powered type, the transistor control of Fig. 1A is best. If a silicon transistor is used, the value of the pot can be up to 5k ohms, and the only thing to watch is the dissipation.

The 1.5 A fuses should be of the AGC (formerly 3AG) type. These have the correct blowing speed. ▲

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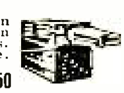

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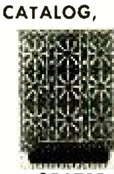
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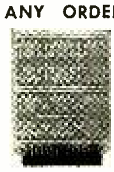
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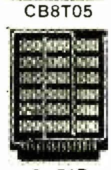
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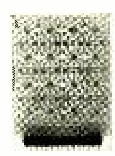
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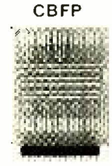
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ELECTRONICS WORLD
June 1970

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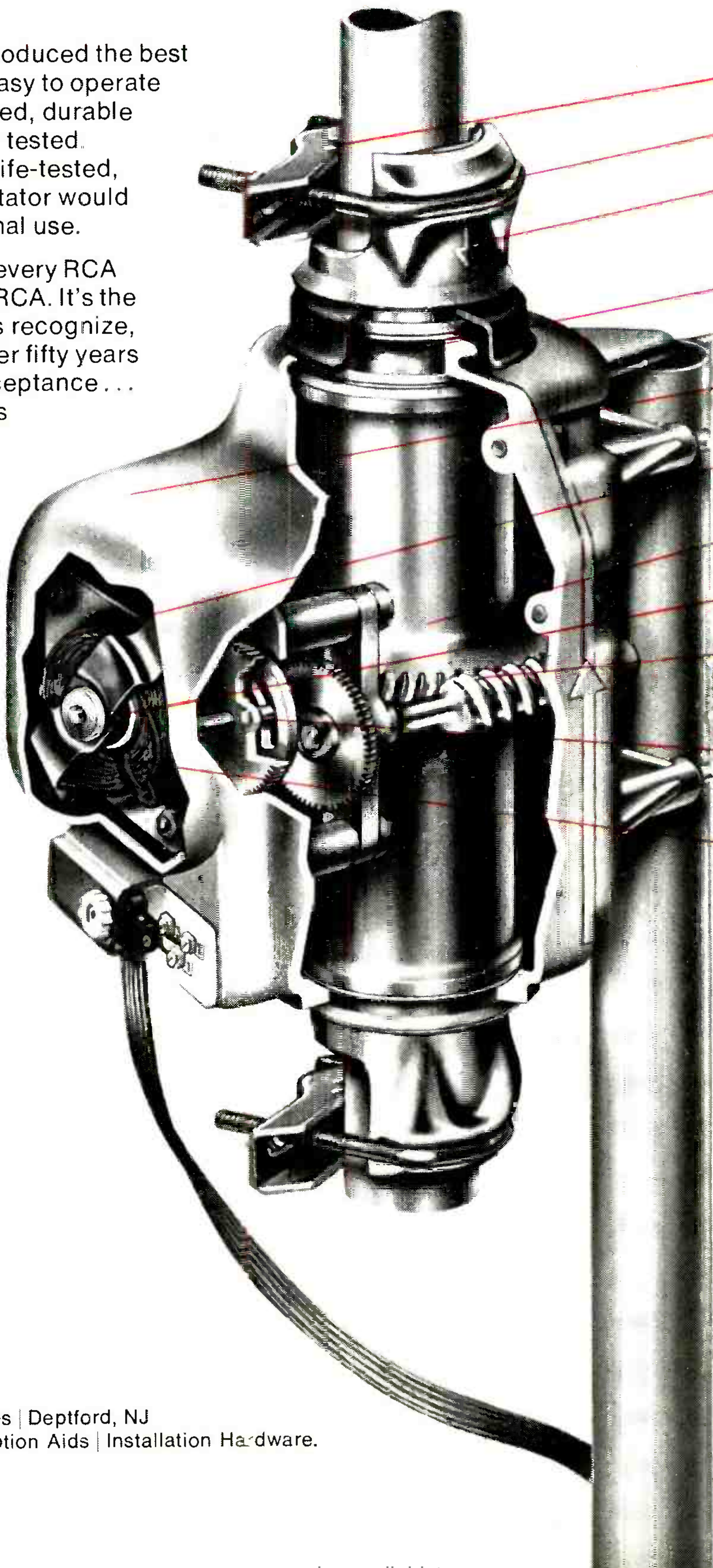

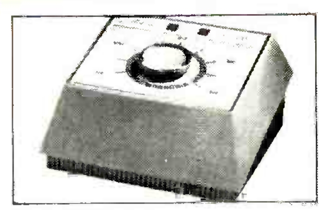

Model 10W707
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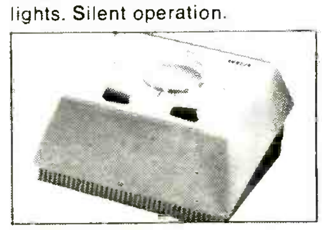

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The first Eliminator was built to prove a point. Because young musicians, in a search for more volume, were literally driving the guts out of some very good speakers mounted in some very poor enclosures.

It started an intensive investigation into the failure of speakers (ours and the competition) used by guitars and organs. The testing was very rugged. For instance, we took miles of high-speed motion pictures while test speakers destroyed themselves with sound.

We found out a lot about how to improve our speakers. But we also learned that by simply putting our SRO/15 speaker in a folded horn enclosure we created a combination that was unbeatable for efficiency, high power handling capacity, low distortion, and extended bass. It was an important first step.

Of course, this now meant we needed a solid high end. So we added the time-tested 1829 treble driver and 8HD horn, or (optionally) a T25A treble driver plus a pair of T35 super tweeters. These combinations were a revelation to musicians. They got more sound power per watt than they thought possible. And they could use the Eliminator for both vocals or instruments.

But we weren't quite satisfied. If the Eliminator was good for popular music, what would it do with other kinds of program material? So we tested it in good rooms and bad rooms. With test instruments and with live audiences. And we decided that the Eliminator was too good to sell only to the young.

For example, in one test installation in a difficult domed building, four E-V Eliminator I speakers far out performed an elaborate multicell installation in naturalness of sound for voice and music, in uniform sound pressure level throughout the listening area, and in the ability to reproduce the extremes of loudness of a big, driving jazz band with ease.

Granted, the E-V Eliminators have a flash of chrome. But don't be misled. They perform to beat the band. And they solve problems. Get turned on to the great sound of the E-V Eliminators today. It can open up an important new market . . . and shock your old ones!

ELIMINATOR I 3-way system: Response 55-15,000 Hz; Power Handling Capacity 100 watts RMS (white noise shaped to stringent lead guitar frequency spectrum); Dispersion 100°; Sound Pressure Level 122 db at 4' with full power input; Suggested Resale $465.00.

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