Electronics World

NOVEMBER, 1970
60 CENTS

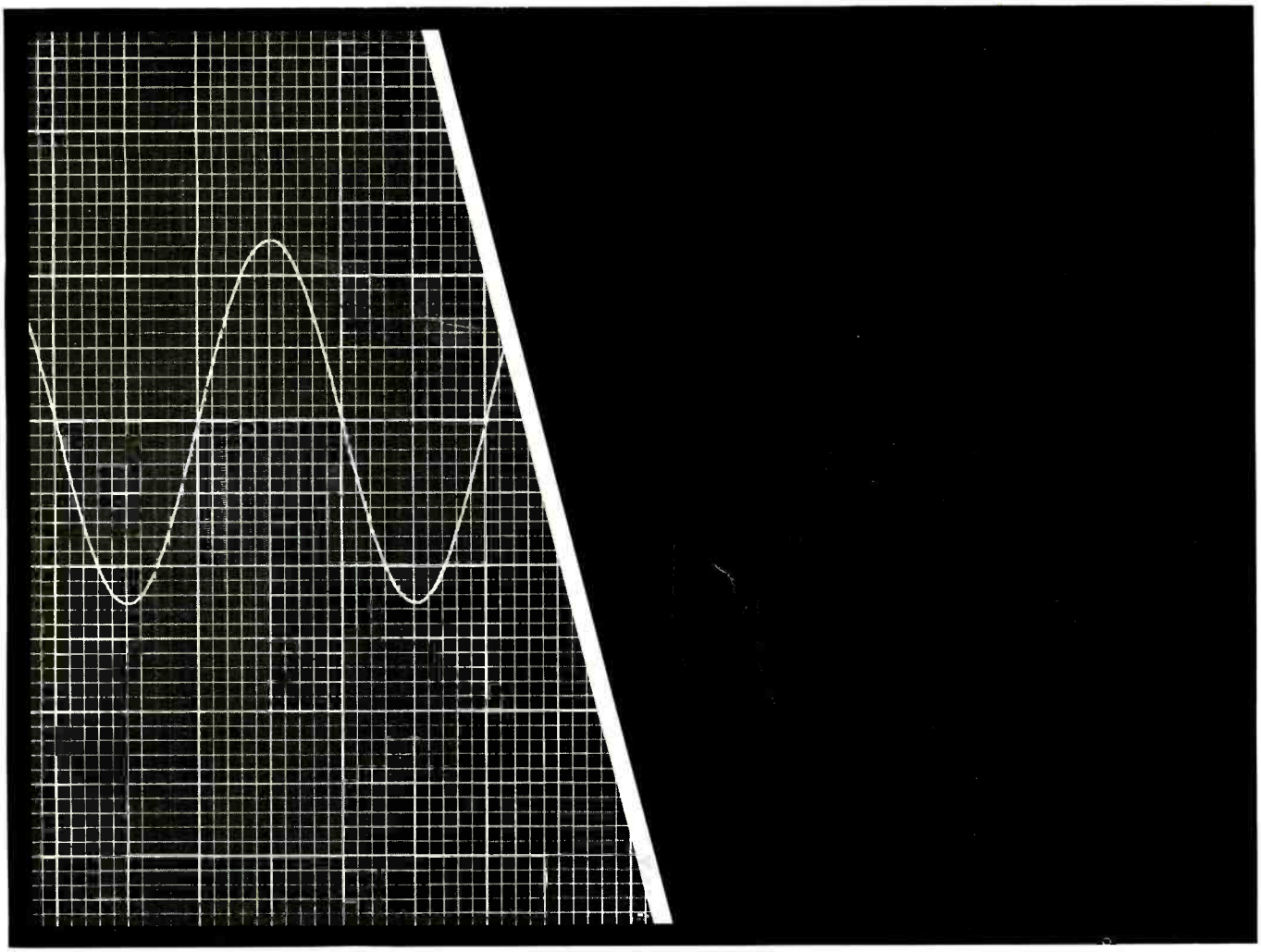
MARINE ELECTRONICS SERVICING—A Vocation Profile

4-CHANNEL AMPLIFIER FOR MULTI-SPEAKER SYSTEMS

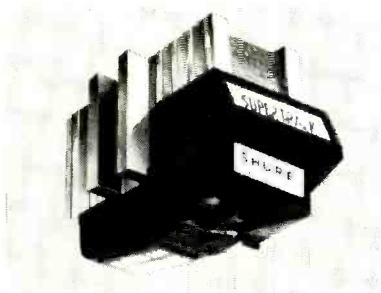
DIGITAL INSTRUMENTS—24-Hour Digital Clock

LASER-BEAM COMMUNICATOR

WEATHER FORECASTING
—100th Anniversary



Finally! A visually perfect sine wave!



The sine wave above was generated by Shure's design computer—it looks like the sine wave that was generated by the *Shure V-15 Type II Improved* Super Track Cartridge in the Hirsch-Houck testing laboratories . . . "the first cartridge we have tested to have done so," according to their published report. This perfect sine wave was generated during the playing of the heavy bass bands on the Cook Series 60 test record at ¾ gram, and the 30 cm/sec 1,000 Hz band of the Fairchild 101 test record at 1 gram. They were impressed, and we were pleased. And we'll be pleased to send you the full Hirsch-Houck Report on the "trackability champion." Shure Brothers Inc., 222 Hartrey Ave., Evanston, Ill. 60204.

SHURE

CIRCLE NO. 108 ON READER SERVICE CARD

CAN YOU GUESS

WHICH FACTOR IS MOST RESPONSIBLE FOR THE LEADING POSITION OF THE BOSE 901 DIRECT/REFLECTING™ SPEAKER SYSTEM?

IS IT:

1 The Rave Reviews?

(Circle the number at the bottom of this page on your reader service card for complete reprints of the seven reviews and a list of BOSE dealers in your area.)

2 The 12 Years of Research? — research that went beyond the collection of graphs and numerical data into the basic problems of correlating the perception of music with speaker design parameters.

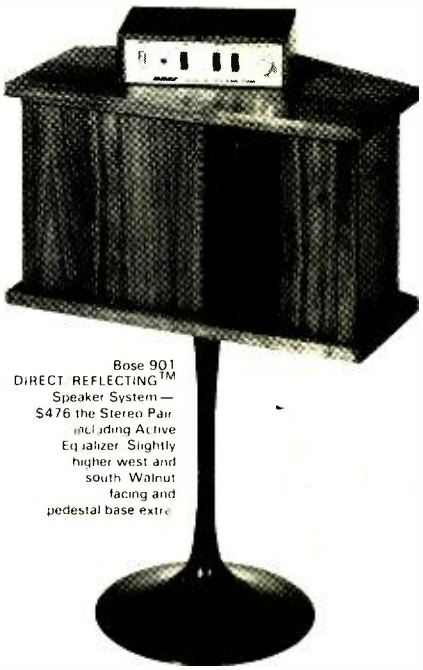
(Copies of the Audio Engineering Society paper 'ON THE DESIGN, MEASUREMENT AND EVALUATION OF LOUDSPEAKERS', by Dr. A. G. Bose, are available from BOSE Corp. for fifty cents.)

3 The Sound of Music Through the 901?

(Enjoy it at your nearest BOSE dealer or in the more comfortable surroundings of your friend's home.)

THE ANSWER:

(AS INDICATED BY CUSTOMER SURVEYS)



Bose 901 DIRECT REFLECTING™ Speaker System — $476 the Stereo Pair including Active Equalizer. Slightly higher west and south. Walnut facing and pedestal base extra.

The research made it all possible and the rave reviews cause people to listen to the BOSE 901. BUT, the surveys show that the sound of the 901 is, by far, the major reason that owners of large and small speakers trade for the 901 and that newcomers to stereo select the 901. That's how it should be — you are not buying reviews or research the relevance of which rests completely upon the 901's ability to produce music with a fidelity that you will immediately recognize as superior. You are buying sound.

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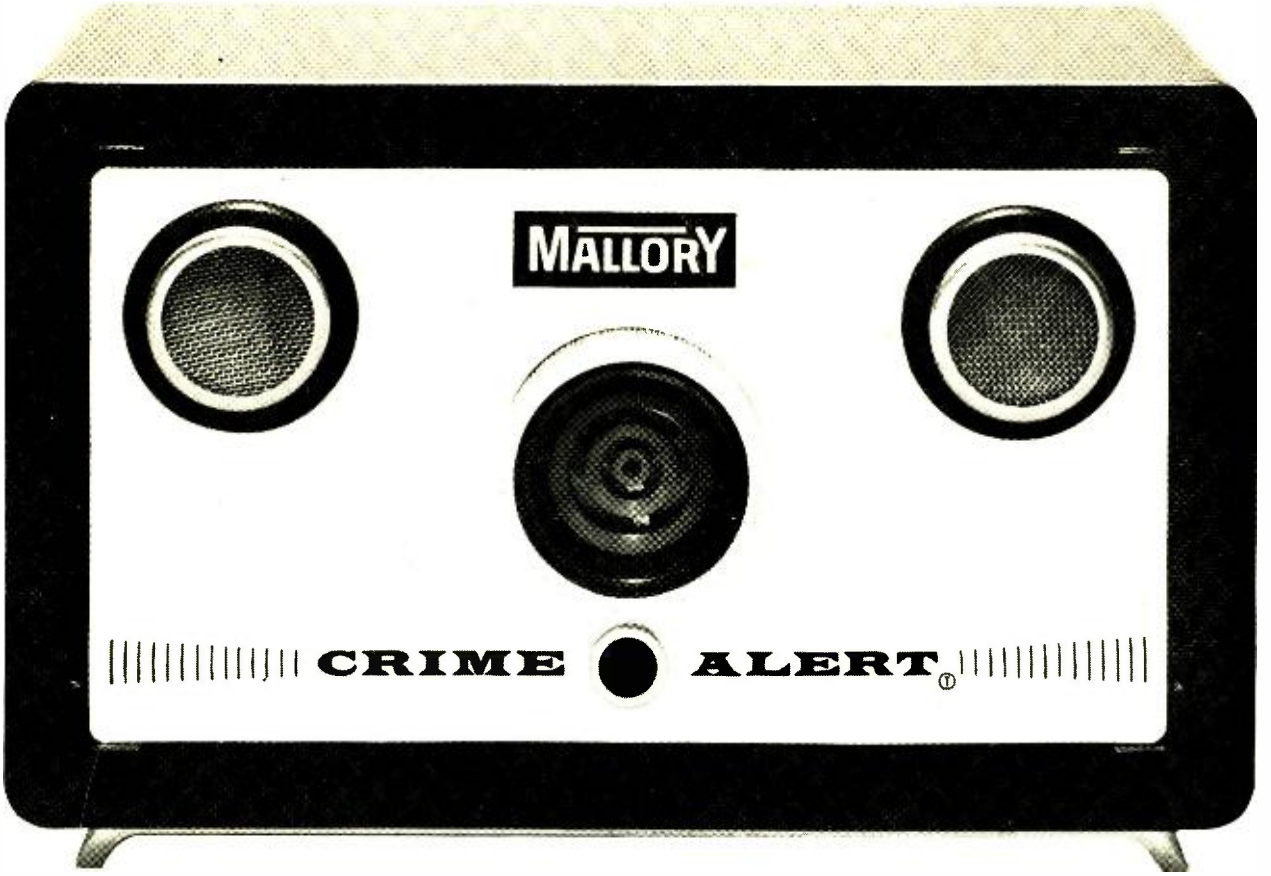

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CIRCLE NO. 127 ON READER SERVICE CARD

Electronics World

NOVEMBER 1970 VOL. 84, NO. 5

Contents

THIS MONTH'S COVER shows two meteorologists from Weather Bureau's National Meteorological Center preparing weather maps from thousands of bits of data received from automatic weather stations, radar, satellites, computers, etc. It is only through the constant vigilance of these modern-day "Paul Reveres" that we can be sure of receiving adequate warning of approach of destructive storms such as the one shown in inset. See the story on page 31 describing the history of the Weather Bureau. Cover photos: Courtesy of the ESSA.

MONTHLY FEATURES

Coming Next Month

Special Feature Article

EW Lab Tests Stereo Receivers

A round-up of the newest models, including performance data, features, and special circuits. In addition to discussing each unit individually, Julian Hirsch of Hirsch-Houck Labs provides a quick-check list of comparative specifications. The latest models from a number of the leading component hi-fi equipment manufacturers are covered in this survey.

Chip Capacitors for IC's

Capacitor companies are now in production on single-chip capacitors—which are no bigger than a match head—in the 100-pF to 1-μF range for use in integrated circuits. David Heiserman explains the advantages and disadvantages of ceramic versus tantalum chip types and tells who is making which.

Light Displays That Enhance Music

Color organs and strobe lights are experiencing a tremendous boom as listeners discover the "pleasure plus" offered by "visual sound." Fred W. Holder offers a list of various commercially available models and explains what features are provided in each model.

Relaxation Oscillators Old & New

R. Clement and R. Starliper of Western Electric present a useful collection of circuits for pulse generation which employ various solid-state switches to do the job.

Computers That Talk

Sophisticated inventory control by computer, abetted by ingenious automatic "stock picking" equipment, help keep production lines rolling at Rohr Corp. So successful has this operation proved to be that a large supermarket chain is adapting technique to processing customer's phoned-in orders.

All these and many more interesting and informative articles will be yours in the ***December*** *issue of ELECTRONICS WORLD . . . on sale* ***November 19th.***

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Editorial and Executive Offices
One Park Avenue
New York, New York 10016
212 679-7200

NEW YORK OFFICE
212 679-7200
Joseph E. Halloran, Adv. Mgr
Michael E. Kelman

MIDWESTERN OFFICE
307 North Michigan Avenue
Chicago, Illinois 60601 312 726-0892
George B. Mannion, Jr

WESTERN OFFICE
9025 Wilshire Boulevard
Beverly Hills, California 90211
213 CRestview 4-0265, BRadshaw 2-1161
Western Advertising Manager, Bud Dean

JAPAN: James Yagi, Ishikawa Mansion, #1, Sakuragaoka Shibuya ku, Tokyo 462-2911-3

CIRCULATION OFFICE
P.O. Box 1093, Flushing, N.Y. 11352

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Radio & Television news

Consumer Protection Plans

In an attempt to stimulate slumping color-TV sales, manufacturers have been offering consumers incentive-type warranties. (See this department, August, 1970 issue.) *Zenith* recently announced a new "Consumer Protection Plan" for purchasers of company's 1971 color-TV sets. Plan offers service (from dealer or dealer's servicing contractor) at no cost to consumer for parts or labor during first 90 days of set ownership. Also continues no-charge replacement warranties for color-TV picture tube that becomes defective within 2 years and parts that become defective within 1 year of original purchase. Two plans are offered: in-home service for consoles and large-screen table models (20-in diagonal or larger) and in-shop service for portable and compact table models (14- to 19-in screens).

Here's one for the books! *Teletronics Industries, Inc.*, in a newly announced sales program, is offering its 18-in table model (solid-state) with a guarantee to perform all necessary service and replace all defective parts, including costly color picture tube, for five years without charge. Big catch is that set must be brought to *Teletronics* plant in suburban Mesquite, Texas for repairs, otherwise a nominal charge will be levied for pick up and delivery. By the way, this revolutionary sales program is initially limited to the Dallas market and will last only three months. Any future expansion into other areas will be contingent on results of sales campaign. Should be quite interesting to watch since, prior to this sales pitch, *Teletronics* sold its TV sets to franchisers who, in turn, leased the sets to their own customers for a monthly fee that covered usage plus full maintenance. Feasibility of this plan is attributed to special computerized diagnostic equipment which slashed production-line and servicing costs 90 percent, one-third cut in picture-tube price, and 20 percent saving on components resulting from refinements of sets' PC boards.

Hi-Fi Reminders

For all you audiophiles who missed last month's Hi-Fi Show in New York, here's a little reminder about a second Hi-Fi Show, sponsored by the Institute of High Fidelity, to be held October 30 through November 1 at the Marriott Motor Inn in Newton, Massachusetts, a suburb of Boston.

Another goodie for hi-fi enthusiasts is the "Stereo 71" Hi-Fi Home Entertainment Show to be held at the Royal York Hotel in Toronto, November 5-7, 1970. This show is designed to provide prospective buyers of sound equipment a chance to see what's new in the field from all major manufacturers. For those interested in additonal information on this event, contact either Show Manager J.R. (Tom) Graham or Show Coordinator Barbara Longo, "Stereo 71" Hi-Fi Home Entertainment Show, *Maclean-Hunter Limited*, 481 University Avenue, Toronto 2, Ontario.

Electronic Sales

Electronic Industries Association (EIA) reports that electronic sales show a strong rise over slower pace of early months of this year with television sales off only 8% over June 1969. Color-TV sales were off only 8.4% compared with June 1969 and monochrome TV had just a 7.6% decrease. Total radio sales showed definite improvement for month of June, declining only 3.7% over June 1969 and total phonograph sales down 13.4% over June 1969. . . . Both *RCA* and *Zenith* reported lower sales and earnings for first six months of 1970, putting blame on strikes and impact of national economic slowdown. *RCA's* profits and sales for first half of 1970 were $42.3 million and $1.57 billion, as compared to record $69.8 million and $1.63 billion, respectively, for same period in 1969, while *Zenith's* earnings and sales for first six months were $4,629,000 and $210,441,000 as against $16,276,000 and $135,385,000, respectively, in same period last year.

What's a Watt?

It's beginning to look like the consumer who has been thoroughly confused over conflicting claims of amplifier output power will soon get a break. On July 30 a conference was held by the Federal Trade Commission to get comments on appropriate standards and to consider proposed Trade Regulation Rules. Although a final decision has not been reached, most seemed to favor rating amplifiers in terms of continuous sine-wave (r.m.s.) power output per channel. In addition to this requirement, equipment may also be rated

(but less prominently) in music power or peak power provided these are clearly specified as such and the testing methods or standards used are disclosed.

Along these same lines, on July 31 the EIA issued a new standards proposal for packaged-type equipment. This closely follows the previous IHF Standard on power-amplifier measurements, although it does introduce a new term "momentary power output" which is the same as the old IHF "music-power" rating. Although not accepted as yet by all EIA members, at least the two organizations seem to be drawing closer together in their rating systems. Unfortunately, even if and when the proposal is approved, it will probably take 6-12 months before all EIA members convert their advertising/promotion literature to new Standard.

Making Life Easier

Now you can turn appliances off by clap of a hand or toot of a whistle at distances of up to 100 feet. *Sonus Corporation*, Natick, Massachusetts is offering sound-activated remote-control switches which can be plugged into any electrical appliance. The sound switch responds to two sharp sounds (two handclaps, key jingles, or even loud "psst, psst" sound) in the high audio range of 14-18 kHz within ½-second interval and the whistle switch responds exclusively to single whistle toot in narrow frequency range of 13.5 kHz. . . . Or how about *General Electric's* clock radio that contains a "Magic Snooz" alarm, a special electronic proximity circuit that shuts off radio or alarm when a hand is waved over it? Wave-off action can be repeated up to 4 times. All clock-setting functions performed by front-mounted push-buttons. This unit (Model 4570) is priced at $59.98. . . . And to really top things off, *Panasonic* may soon be offering us (still in experimental stage) an AM-FM clock radio (Model RC-6900) that announces time at a flick of a switch. Can be set to announce time at preset time and then automatically switch to radio program. When "Call Switch" is pressed, motor drives a magnetic head about a rotating magnetic disc sheet, synchronized with clock timer, to pick up recorded voice from disc sheet. Contains two disc sheets—one for the hour and one for minutes.

NEA Award Presentations

Here are some of the National Membership Awards presented at the Sixth Annual National Electronic Associations' Convention, held in St. Louis, Mo. from July 15-19: the Greatest Achievement Award to the Bloomington-Normal Electronic Technicians Association, Bloomington, Ill. (BETA has been active in promoting the "Certified Electronic Technician" program in the Central Illinois region); the 1969-70 Highest Membership Achievement Award to the California State Electronics Association (CSEA). CSEA also has the distinction of being the largest trade association in state and now ranks as largest state association of electronics sales and service dealers in country; Outstanding State Association President Award (one of the highest awards in the independent servicing business) to Arthur Clough, President of the Television Service Association of Ohio; the Man of the Year and the Outstanding National Committee Chairman Awards to Vincent J. Lutz; the Outstanding National Officer Award to Lewis Edwards, Jr., region vice-president for New England area, for his work as regional vice-president and for special work on the technical examinations given in the International "Certified Electronic Technician" program; and the Outstanding Local Association President Award to John Jage, President of the Lake County Chapter of the Indiana Electronic Service Association. Special recognition was also given to ELECTRONICS WORLD for "outstanding service to the independent electronic service dealers and technicians."

By the way, National Electronic Association's new address is the ITTA Building, 1309 W. Market Street, Indianapolis, Ind. 46222.

News Briefs

James S. Sommerville, senior technical correspondent for *Allied Radio Shack* and known to thousands of hams and CB operators the world over as "Trader Jim," W9WHF, died recently. An active radio ham for over 33 years, he was instrumental in helping many young people get started in amateur radio. In his 13 years with *Allied*, he made it a point to personally answer letters from beginners and hobbyists requesting advice or information. . . . Sherman Unger, long-time political associate of President Nixon and current General Counsel for Department of Housing and Urban Development, has been nominated by White House to fill remaining months of FCC Commissioner Robert Wells' term. Nomination must be approved by Senate. Rumors have it that appointment is only temporary and that come next June Rep. Charlotte Reid (R-Ill.) will be named to post—making her first woman FCC Commissioner. . . . According to survey conducted by the National Association of Broadcasters, 223 colleges and universities (as against 147 two years ago) offer courses in radio and television. Of these, 173 confer Bachelor degrees, 87 a Master's, and 23 a Doctorate. In addition, 62 two-year schools offer work in broadcasting. . . . James J. Noble, *Altec Lansing* vice-president of engineering, named a Fellow of the Audio Engineering Society. ▲

LETTERS

RCA's "SERVICEAMERICA"

To the Editors:

I am in agreement with much of what you say in your August editorial on *"RCA's ServiceAmerica."* Without doubt, *RCA* lawyers are confident they can cope with the legal problems.

I, too, question that it can survive, but I'm concerned that it will encourage universal captive service because no marketer can be expected to permit a competitor to be in position to pass judgment on a set when it needs service. Captive service can succeed when combined with extended warranties, limitations of chassis type, and concentration of customers. "Eight-week wonders" are now being used by *RCA*, so service can be automated if backed by sufficient superior technicians.

One other area where *ServiceAmerica* and/or captive service companies under these conditions have a tremendous advantage, is the power of a factory name used by an expert contract-selling force at the dealer level.

All of these special advantages can be overcome by independents but the price is partial relinquishing of "independence," a cost that to this very moment appears far too high. This very element of "independence" killed the neighborhood grocer, druggist, gas-station operator, and other independent entrepreneurs, and yet that lesson has not been absorbed.

Independents *can* survive by trading part of independence for inter-dependence on their competitors. The Total Service concept is a real solution. It will give independents a superior range of talents, facilities, and a selling force that will permit independents to beat the giants to the customers.

FRANK MOCH
Exec. Dir., NATESA
Chicago, Ill.

The Total Service concept advanced by Mr. Moch is one in which a consortium of independents handles servicing of every type of electronic-electromechanical home and commercial equipment.—Editors

* * *

FUTURE OF HAM RADIO

To the Editors:

After reading John Frye's article in your August issue concerning the future of amateur radio, I was momentarily overcome by a feeling of nostalgia, for it was twenty-one years ago last month that I was introduced to this very fine and worthwhile hobby.

I certainly agree that an early exposure to ham radio can produce a long-lasting interest in the field of electronics. It may be difficult to find additional space within our crowded bands; however, I would always heartily recommend ham radio as an excellent hobby for any youngster.

LARRY STELLER, W0MRU
RCA Consumer Electronics
Denver, Colorado

* * *

ONE-YEAR LABOR WARRANTY

To the Editors:

We noted the item in Forest Belt's "Radio & Television News" column (the August issue) on the one-year labor warranty.

You are absolutely right. One-year labor warranty is not brand new. There is a major difference, however, in the *RCA* program: the consumer can select the serviceman of his own choice and the serviceman is paid at *the going rate prevalent in his operating area.* There is no control over the rates for service labor on the part of *RCA* and this fact makes our program quite unusual.

THOMAS J. BRADSHAW
Mgr., Editorial Services
RCA
Indianapolis, Ind.

* * *

HIGH-POWER COLOR ORGAN

To the Editors:

The schematic diagram of the "High-Power Color Organ" on page 79 of your September issue looks fine except for one thing. With the three input pots wired the way they are shown, you won't be able to turn the organ completely off. Is the diagram correct?

ALAN STONER
Stanford, Cal.

There is an error in the schematic diagram as shown. The bottom of the three input pots, R1, R2, and R3, should be connected directly to ground and the connections between the wipers and the bottom ends of the pots should be deleted. There is also a minor error in the parts listing for PL1, the 125-volt pilot light. The lamp used should be a type 6S6-125 and not a 12.5 volt pilot lamp as indicated in the parts listing—Editors ▲

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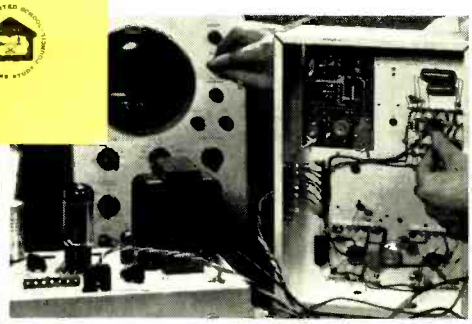

Competent technical ability
so necessary for careers in Industrial Electronics is easily acquired through NRI training. As you learn, you actually build and use your own motor control circuits, telemetering devices and even digital computer circuits. All major NRI courses include transistors, solid-state devices, printed circuits.

To call it "an amplifier" would be like calling a Porsche "Basic transportation."

There is unusual satisfaction that comes from fulfilling a prosaic task in a far from prosaic manner.

Hence this amplifying system: the Sony TA-2000 professional preamplifier and the Sony TA-3200F power amplifier. Together, they perform all an amplifier's standard tasks in a satisfyingly impeccable manner; but their 67 levers, switches, meters, knobs and jacks allow you to perform some interesting functions that are anything but standard.

Dual-purpose meters.

The two VU meters on the preamplifier front panel, for example, are no more necessary than a tachometer on an automobile. But they do serve the dual purpose of simplifying record-level control when the TA-2000 is used as a dubbing center, and of allowing you to test your system's frequency response and channel separation (as well as those of your phono cartridge) and to adjust the azimuth of your tape heads.

A broadcast/recording monitor console in miniature.

The TA-2000 resembles professional sound consoles in more than its VU meters. In addition to the 20 jacks and seven input level controls provided on its rear panel for permanent connections to the rest of your hi-fi system, the TA-2000 boasts a professional patch board in miniature on its front.

Thus, you can feed the inputs from microphones, electric guitars, portable recorders or other signal sources into your system without moving the preamplifier or disturbing your normal system connections in the least. And a front-panel Line Out jack feeds signals for dubbing or other purposes into an external amp or tape recorder, with full control of tone and level from the front-panel controls and VU meters.

The tone correction and filtering facilities are also reminiscent of professional practice, allowing a total of 488 *precisely repeatable* response settings, including one in which all tone controls and filters are removed completely from the circuit.

The amplifier—no mere "black box"

A power amplifier can be considered simply as a "black box" with input and output connections, a power cord, and an on/off switch; and such an amplifier can perform as well (or poorly) as the next one. But in designing the TA-3200F Sony took pains to match the amplifier's facilities to the preamplifier's.

Thus to complement the TA-2000's two pairs of stereo outputs, the TA-3200F has two stereo pairs of inputs, selected by a switch on the front panel. Other front panel controls include independent input level controls for both channels, a speaker selector switch, and a power limiter (in case your present speaker should lack the power handling capacity of the next one you intend to buy).

Circuitry unusual, performance more so

The single-ended, push-pull output circuitry of the TA-3200F amplifier is supplied with both positive and negative voltages (not just positive and "ground") from dual balanced power supplies. This system allows the amplifier to be coupled directly to the speakers with no intervening coupling capacitors to cause phase shift or low-end roll-off (A switch on the rear panel does let you limit the bass response below 30Hz if you should want to, otherwise, it extends all the way down to 10Hz.)

The individual stages within the amplifier are also directly coupled with a transformerless complementary-symmetry driver stage, and Darlington type capacitorless coupling between the voltage amplifier stages.

As a result, in part, of this unique approach, the TA-3200F produces 200 watts of continuous (RMS) power at 8 ohms, across the entire frequency range from 20 to 20,000 Hz; IHF Dynamic Power is rated at 320 watts into 8 ohms (and fully 500 watts into a 4-ohm load).

But more important by far is the quality of the sound; intermodulation and harmonic distortion levels are held to a mere 0.1% at full rated output, and 0.03% at the more likely listening level of one-half watt. The signal-to-noise ratio is an incredible 110dB. And the full damping factor of 170 is maintained down to the lowest, most critical frequencies (another advantage of the capacitorless output circuit).

The companion TA-2000 preamplifier also boasts vanishingly low distortion and a wide signal-to-noise ratio, but this is less unusual in a preamplifier of the TA-2000's quality (and price). What *is* unusual is the performance of the phono and tape head preamplifier circuits; for though they have sufficient sensitivity (0.06mV) for the lowest-output cartridges (even without accessory transformers), these preamplifier circuits are virtually immune to overload—even with input signals 80 times greater than normal.

Their sole vice: they are hardly inexpensive

Of course, at a price of $329.50 (suggested list) for the TA-2000 preamplifier, and $349.50 (suggested list) for the TA-3200F power amp, this system cannot be considered other than a luxury. But then, it was intended to be. For there are those to whom fulfillment of prosaic tasks is unfilling. And among them are not only many of our customers, but also many of our engineers. Sony Corporation of America, 47-47 Van Dam Street, Long Island City, New York 11101.

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What Should You Pay for a Phono Cartridge?

Including Lab Tests of the Complete Line of Shure Cartridges

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Results of our lab tests show that, although differences are slight, higher priced cartridges offer extended and smoother high frequencies, ability to track higher recorded velocities, and operation at lower stylus tracking forces.

IF you have ever tried to make listening comparisons among various phono cartridges, you have probably been struck—as we have—by their similarities, rather than their differences. If they sound so much alike, at least superficially, why do their prices vary so widely, from about $10 to $100? And, even more to the point, why should you spend more than the minimum for a cartridge?

One could infer from this situation that modern cartridges are so refined that they contribute practically no coloration to the reproduced sound, and therefore tend to sound alike. Another point of view, held by some critical listeners, is that most cartridges are designed according to the same principles, and therefore all have the *same kind* of coloration, rather than an absence of any! We are not going to attempt to settle that thorny issue at this time, but would like to review some of the factors influencing the cost and sound of a cartridge.

Factors Affecting Cost and Sound

Several basic parameters directly affect the performance of a cartridge. In addition to these fundamental considerations, proprietary manufacturing methods account for much of the audible differences between competitively priced cartridges from different manufacturers. The *compliance* of a stylus system, expressed in cm/dyne, is a measure of the ease with which the stylus is deflected by the groove modulation. A high number, such as 20×10^{-6} cm/dyne, means that little force is needed to move the stylus and that the vertical tracking force required to keep it in contact with the groove is correspondingly small. If the compliance were low (for example, 2×10^{-6} cm/dyne), about 10 times more force would be needed to maintain contact with the groove walls.

High compliance is necessary for using a low tracking force at low frequencies, where the recorded amplitude can be quite large and the stylus must be displaced a relatively large amount by the groove. A compliant design usually is characterized by a relatively delicate and costly stylus structure. A high-compliance cartridge not only *can* be operated at low tracking force, it *must* be so operated. Excessive tracking force will displace the stylus vertically so that it eventually contacts the cartridge body and produces severe distortion. Since certain arms and record-changer mechanisms require a minimum level of tracking force for proper operation, a highly compliant cartridge may not be usable in all record players.

At higher frequencies, the recorded amplitude is low (although the velocity may be very high) and stylus compliance is not a factor in their reproduction. The problem in tracking high frequencies is not one of moving a stylus back and forth through a large amplitude displacement. Instead, the stylus and the generating elements coupled to it must be reversed in direction many thousands of times each second. This requires a large acceleration—perhaps thousands of G units—to be applied to the stylus by the record groove wall.

The force required to produce this acceleration must come from the recorded material and, in turn, is exerted on the plastic record material by the stylus. It is proportional to the *effective moving mass* of the stylus structure, referred to the tip, and to the acceleration required. A massive moving system inevitably causes increased record wear at high frequencies, since the force against the record material can exceed its elastic limits and cause a permanent deformation. This can result in distortion and, ultimately, in literally "wiping off" the highest frequencies from the record groove.

A low-mass moving system is more delicate and fragile than a heavy one. The stylus jewel is physically smaller and the cantilever that couples it to the generating elements is slimmer and more easily damaged. The extra care required in assembling a low-mass stylus system is reflected in its higher price.

Elliptical styli are now widely used, especially in the more expensive cartridges. It is generally agreed that a good elliptical stylus with radii of 0.2×0.7 mil can produce sound that is somewhat better than a conical stylus on some records, although the improvement is slight in most cases. However, the elliptical stylus is more expensive to manufacture, and must be oriented on the cantilever with greater precision than is required for a conventional conical stylus. As a result, a cartridge with an elliptical stylus costs the consumer some $10 to $15 more than the same cartridge with a conical stylus.

In addition, an elliptical stylus should be used only at low tracking forces, preferably under 1½ grams for a 0.2×0.7-mil stylus, to minimize record wear. This limits their application to the more expensive cartridges. Sometimes

BEFORE BUYING A CARTRIDGE

BEFORE buying a phono cartridge, it is necessary to consider the other components of the music system. The tonearm design may place a lower limit on the usable tracking force. Most separately mounted tonearms, and those on the better automatic turntables, can be used with cartridges tracking at 1 gram or less. Some intermediate-priced automatic turntables have enough pivot friction so that a force of 1½ to 2 grams is advisable. The least expensive models should be operated with 2 to 3 grams of vertical force.

The comprehensive report on automatic turntables in the June 1970 issue of Electronics World will provide guidance in selecting a cartridge whose tracking force is compatible with your record-player arm. Since cartridges are normally rated for operation over a range of forces, there may be an overlap region where several cartridges would seem to be suitable. A good rule is to operate the cartridge near its *maximum* rated force. Thus, with an arm requiring a 2½-gram force, a cartridge rated at 1½ to 3 grams would be preferable to one rated at 2 to 4 grams.

Another factor is the electrical output voltage from the cartridge. Most amplifiers will work satisfactorily with most cartridges. However, some amplifiers can be overdriven through their phono preamplifier stages by inputs as low as 30 millivolts or less. Although the average output of any cartridge is safely below this level, it may become four or five times greater during the peaks of loud recorded passages. If your amplifier or receiver can only handle about 30 millivolts before distorting, pick a cartridge whose average output does not exceed 6 or 7 millivolts. On the other hand, some older amplifiers have relatively little gain and a high-output cartridge may allow you to turn down the amplifier gain and reduce noise and hum pickup.

In general, a cartridge selling for a third to half the price of the arm/turntable combination will provide a reasonable balance of quality in the record-playing system. Exceeding that ratio may actually degrade performance, since a highly compliant cartridge cannot function properly above its rated force, and a low-priced record player arm may have pivot friction comparable to the rated force of a good cartridge. Using an inexpensive cartridge in a top-quality arm is obviously wasteful and uneconomical.

there is a compromise, with a less exaggerated ellipticity such as 0.4 × 0.7 mil. This can be used at forces up to several grams, although it offers little, if any, improvement over a 0.7-mil conical stylus. The decision as to whether to use an elliptical stylus, if a choice exists, is a personal one. The advantages of the elliptical stylus are difficult to show in any objective test and its added cost is considerable.

In view of the complex interrelationship among mass, compliance, stylus shape and dimensions, tracking force, and the tracking requirements over the full frequency range, many factors must be considered in arriving at a final cartridge design. It is clear that the consumer is in no position to evaluate the significance of these and other parameters affecting cartridge performance. How, then, can a cartridge be specified in a meaningful and easily interpreted manner?

Aside from physical characteristics such as weight and size and stylus dimensions, the most universally available specification for a cartridge is the recommended range of *tracking force.* It is fortunate, indeed, that this is the most informative specification available to the consumer for judging the worth of a cartridge. This is not as illogical as it might seem, since the tracking force is a function of the total design of the cartridge, including its compliance, moving mass, damping, and stylus dimensions. A careful study of published cartridge specifications will show the inverse relationship between tracking force and price (and, by implication, with the sonic qualities of the cartridge).

Representative Group of Cartridges

To test the validity of this seemingly arbitrary criterion for cartridge selection, we have tested and evaluated a representative group of cartridges from a single manufacturer. The *Shure Brothers* product line is typical, in price and application, of the variety of cartridges offered by other manufacturers.

The published characteristics of the selected cartridges are listed at the top of Table 1. The oldest design, still widely used in lower priced record players, is the M3D, whose 0.7-mil stylus tracks between 3 and 6 grams. Next is the M44 series, for which several styli are available. We tested the M44-7, which has a 0.7-mil conical stylus tracking between 1½ and 3 grams, and the M44E, which has a 0.4 × 0.7-mil elliptical stylus for use between 1¾ and 4 grams.

At approximately the same price as the M44E is the newer Model M75-6. This cartridge has an integral, swing-away stylus guard, similar to that used on the manufacturer's most expensive cartridge, and a 0.6-mil conical stylus for operation between 1½ and 3 grams. This, and the more expensive *Shure* cartridges, carry a "trackability" rating, about which we will have more to say shortly. The M93E and M91E are similar except for styli. The former has a 0.4 × 0.7-mil elliptical stylus operating at 1½ to 3 grams, the latter a 0.2 × 0.7 stylus which works at half as much force.

Installation of these cartridges is simplified by a removable mounting clip which is first installed in the arm and the cartridge merely snaps into it. At the top of the line is the V-15 Type II (Improved), which has the same stylus dimensions and tracking force range as the M91E, but with higher trackability.

Examination of Table 1 shows many points of similarity between the cartridges. Except for the M3D, they all have the same coil inductance and resistance, frequency response of 20-20,000 Hz [25,000 Hz for the V-15 Type II (Improved)], and channel separation of 25 dB. The M3D specifications are not strikingly different—its frequency response is 20-15,000 Hz±3 dB and its separation is rated at 20 dB. Except for tracking force and price, there seems to be little in their specifications to distinguish one cartridge from another.

Laboratory Measurements

We made measurements on each cartridge, installed in an *SME* 3012 arm. High-velocity test bands were used to determine the minimum force needed to track low and middle frequencies, and for each cartridge we selected a value which we felt would be suitable for tracking any commercial pressing with satisfactorily low distortion. The *CBS Labs* STR100 test record was used for measuring frequency response, channel separation, and output voltage while the *CBS Labs* STR111 record was used for 1000-Hz square-wave response testing. (*Response curves shown in this article have been corrected below 500 Hz to take into account the response of the test record used.—Editor*) IM distortion was measured both with the *CBS Labs* STR111 and *RCA* 12-5-39 records, as a function of recorded level.

The "trackability" (a term coined by *Shure* to describe the ability of the cartridge to trace high velocities at different frequencies) was evaluated with the company's "Audio Obstacle Course" record, which has various instrument sounds recorded at successively higher velocities. We assigned arbitrary demerits for different degrees of audible mis-tracking, adding them to obtain a number whose magnitude is *inversely related* to the cartridge's tracking ability. Since, to some extent, "trackability" is a function of tracking force, we multiplied the score by the tracking force to obtain what might be termed an *index of merit* for each cartridge.

We have been using this "trackability" test for some time in evaluating cartridges. It is an excellent guide to how well

a cartridge can track some of the most demanding program material on records and correlates well with other listening evaluations. We normally do not publish the actual score or index for any cartridge, since it is meaningless by itself and, being derived arbitrarily, is subject to misinterpretation. However, in tabulating our data, we were struck by the close correlation between our "index" and the price of the cartridge. We are therefore showing the scores we obtained for these cartridges, together with other test results, at the bottom of Table 1. Bear in mind, however, that differences of a few points in ratings are not significant.

On the basis of absolute tracking ability, the top three cartridges are quite comparable, as are the bottom three. The M44E falls between the two groups. The index of merit separates them more distinctly: the V-15 Type II (Improved) and the M91E are very much the same, followed by the M93E and M44E. The M44-7 and M75-6 are quite close to each other, while the M3D, with its 3-gram test tracking force, is definitely last.

This data shows, in an unmistakable manner, that the tracking ability, that is, how cleanly the cartridge can play high-level recordings, is related to the rated tracking force and to the price in this family of cartridges. Regardless of any unpublished or difficult-to-interpret specifications, each price increment buys a definite improvement in listening performance, as does going from one cartridge to another rated to operate at a lower force.

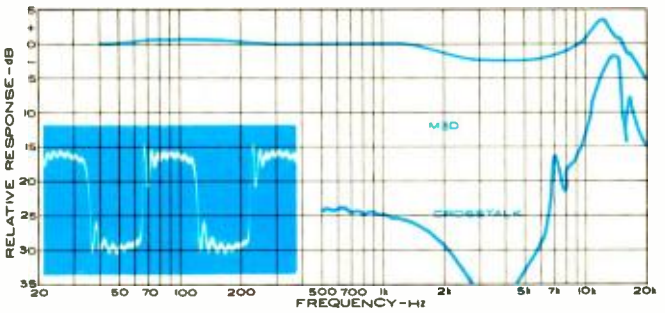
All the cartridges have very similar frequency response curves below 10 kHz, indicating for the most part the characteristics of the test record. The stylus mass of any cartridge resonates with the compliance of the record material at some high frequency, although the resonance may be above the 20-kHz limit of the record, or may be so damped that it is not apparent in measurements. We found the resonance of most of the cartridges falls between 13 and 16 kHz. The M3D resonance was lowest, at about 11.5 kHz, while the V-15 Type II (Improved) resonated above 20 kHz. The square-wave responses shown with the curves reflected the frequency and amplitude of the high-frequency resonance by the degree of ringing observed.

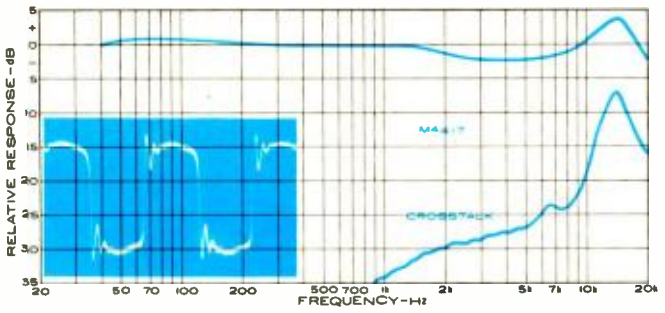
The channel separation of all the cartridges was more than adequate, between 27 and 32 dB at middle frequencies, and from 13 to 19 dB at 10 kHz. The V-15 Type II (Improved) had somewhat better high-frequency separation than the others, measuring 23 dB at 10 kHz.

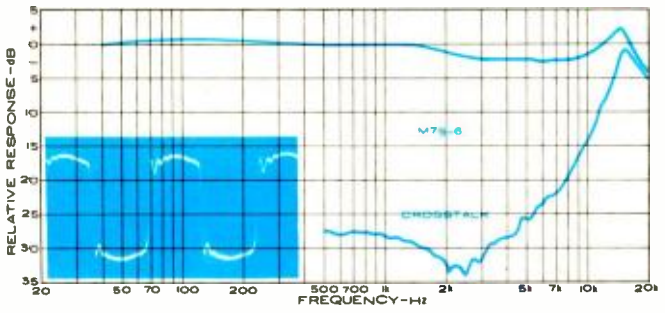
Most of the cartridges were able to track satisfactorily at 2 grams. The

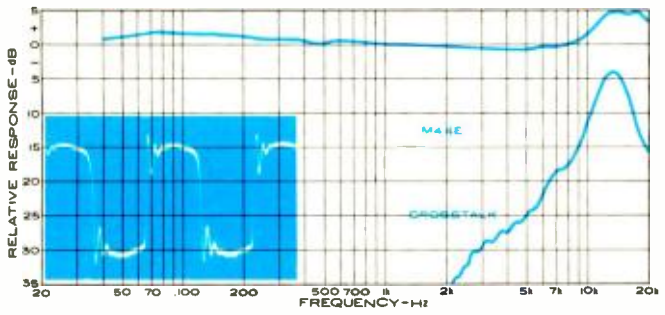
Table 1. Specs and test results on line of Shure cartridges tested. The figures under Test Results are averages for both channels while curves shown are for one channel.

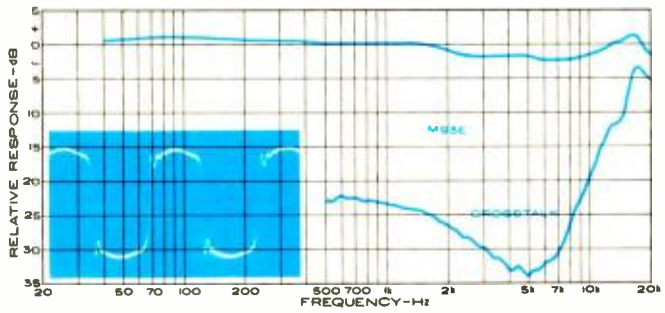
Model	M3D	M44-7	M75-6	M44E	M93E	M91E	V-15 (II)
SPECIFICATIONS							
Tracking Force (g)	3-6	1½-3	1½-3	1¾-4	1½-3	¾-1½	¾-1½
Stylus (mil)	0.7	0.7	0.6	0.4 x 0.7	0.4 x 0.7	0.2 x 0.7	0.2 x 0.7
Freq. Resp.	20-15k ±3 dB	20-20k	20-20k	20-20k	20-20k	20-20k	20-25k
Trackability (cm/s) 400 Hz 1 kHz 10 kHz	NA	NA	(2 g) 18 25 14	NA	(2 g) 18 25 13	(1 g) 20 28 18	(1 g) 28 35 22
Channel Sep. @1 kHz (dB)	20	25	25	25	25	25	25
Inductance (mH)	420	720	720	720	720	720	720
Resistance (ohms)	280	630	630	630	630	630	630
Weight (g)	8.5	7	6	7	5	5	6.8
Price ($)	15.00	19.95	24.50	24.95	39.95	49.95	67.50
TEST RESULTS							
Test Force (g)	3	2	2	2	2	1	1 & ¾
Output (mV) @3.54 cm/s	8.3	10.1	6.25	10.65	6.65	5.45	4.25
Response Variation (dB) 500-20 kHz	+3.2 −3.2	+4.5 −1.8	+2.8 −2.0	+4.8 −1.8	+3.3 −2.7	+4.0 −2.0	+0 −3.0
Separation 500-10 kHz (max./min.)	28/15.5	31/19	32/12.8	28/14.5	32/16	27/13.5	31/23
Stylus H.F. Resonance (kHz)	11.4	14	14.2	13	16.2	15.5	above 20 kHz
Trackability Score	32	40	38	28	10	6	8
Index of Merit (score x force)	96	80	76	56	20	6	6

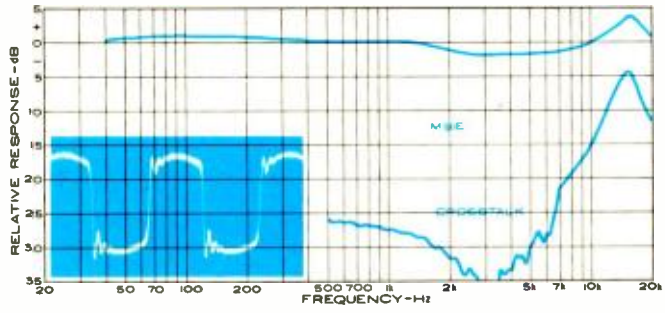












M3D required 3 grams, while the M91E and V-15 Type II (Improved) operated well at 1 gram. The V-15 was able to cope with most music records at ¾ gram, but had considerable IM distortion at high velocities with that force and we would favor operating it at 1 gram.

Most of the cartridges had outputs between 4 and 8 millivolts and would be compatible with any preamplifier. The M44, however, has between 10 and 11 millivolts output from average recorded velocities. This is fine for driving a low-gain amplifier. However, some preamplifier stages can be overloaded by as little as 30 millivolts, and we would caution against using the M44 with such an amplifier.

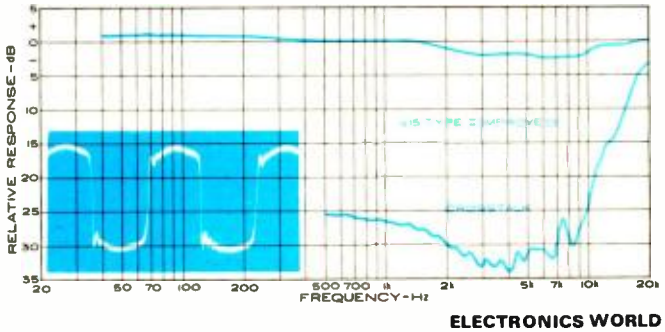
Listening Tests

We listened to the cartridges in pairs, comparing each against the V-15 Type II (Improved), playing the same record. As might be expected, there was little or no audible difference with most records, whose maximum velocities were within the capabilities of all the cartridges. Only with records having very high recorded levels, particularly at high frequencies (such as bells, harpsichord, etc.) was the superior tracking ability of the top-ranking cartridges immediately obvious. The IM distortion measurements made with the *CBS Labs* and *RCA* test records are most useful as an indication of how much mid-range (400-Hz) velocity the cartridge can track without losing contact with the groove. The actual distortion readings, below the point of mis-tracking, are not particularly significant, hence, they are not included here. Most of the cartridges had very similar characteristics in this respect, with some notable exceptions. For example, the V-15 Type II (Improved) was the best of the group at 1¼ grams, but the worst at ¾ gram, with the *CBS Labs* test record. The M44E at 2 grams "broke up" at 3 dB lower velocity than most of the others. It might have matched them at a higher force, but we are reluctant to play our records with elliptical styli at more than about 2 grams. The M3D had a different characteristic, not mis-tracking seriously at any velocity which the other cartridges could handle, but with about twice as much distortion at all lower velocities.

A comment is in order on the *Shure* "trackability" ratings. These are shown at the top of Table 1 for the cartridges so rated. It is expressed in cm/s at various frequencies and represents the maximum velocity which the cartridge can track at a rated force. This specification is useful for comparing different *Shure* cartridges since you can see at a glance where a more expensive model should give better performance and by how much. Obviously, it cannot be used for comparison with other makes of cartridges.

Our own relatively crude and limited "trackability" test correlates reasonably well with the published data, except in the case of the M93E and the M75-6, which carry almost identical trackability ratings but were distinctly different in our tests. The considerably higher price of the M93E, as well as its superior performance, suggests that there are other factors involved.

As far as listening quality is concerned, the principal difference among these cartridges, assuming that they are not mis-tracking, is in the highest octave. The frequency and amplitude of the stylus resonance can affect the clarity and



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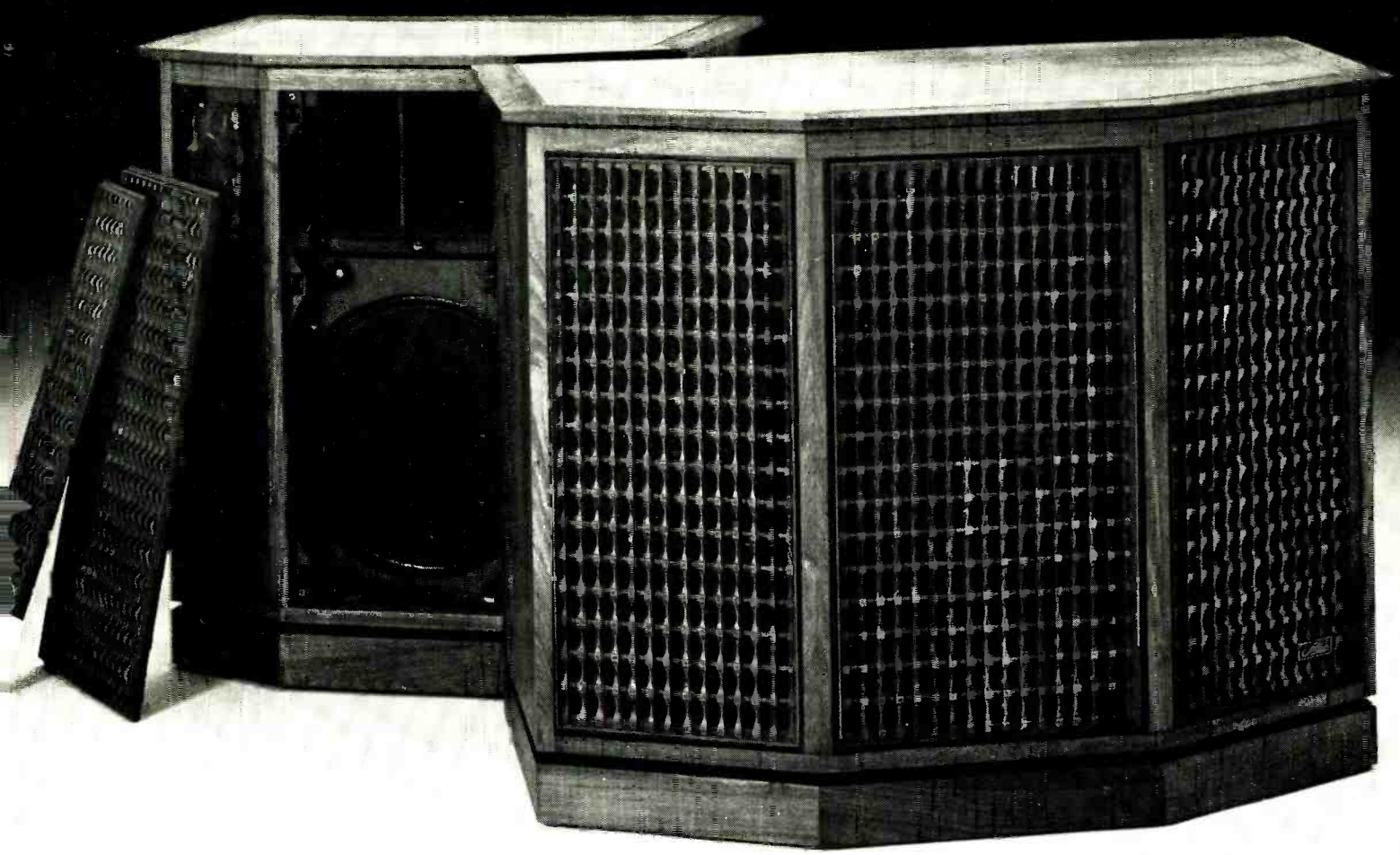

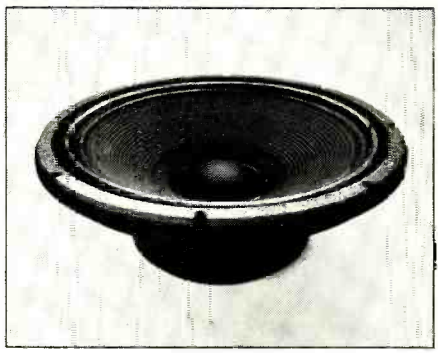

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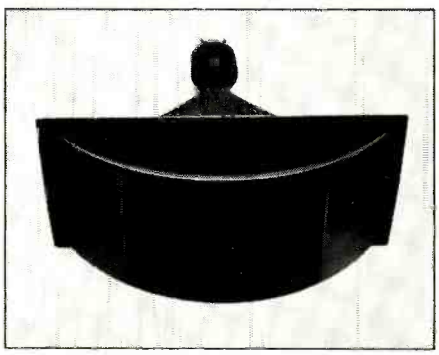

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definition of certain sounds, such as string instrument overtones, bells, cymbals, and other instruments having appreciable high-frequency energy. In our view, these differences as they exist among this group of cartridges are quite subtle. They could only be detected by careful instantaneous switching between the cartridges being compared.

In Summary

Summarizing, the higher priced cartridges offer:

1. Extended and smoother frequency response above 10 kHz.
2. Ability to track higher velocities without distortion.
3. Operation at lower tracking forces.

These are objectively demonstrable and are quite distinct from the extremely subtle differences in clarity, when reproducing complex passages, that are associated with different makes or designs rather than with differently priced models of a single manufacturer.

Even if, like some people, you can't detect any difference between a $15 cartridge and one costing $67.50 the first time you hear them, don't assume that the higher price buys nothing but prestige. Sooner or later, you will encounter an unpleasantly distorted passage on one of your records and the chances are good that a better cartridge would have played it without distortion. Then, too, in time you may notice a fuzziness and distortion on your favorite records, telling you that they have been damaged by a high tracking force. It is doubtful if a good cartridge, tracking at 1 gram, will wear a record significantly before you have long since tired of hearing that particular record.

Although we have illustrated this discussion with tests of one manufacturer's cartridges, the same relative performance differences exist in other manufacturers' lines. *Pickering* uses what it calls "Dynamic Coupling Factor (DCF)" as the equivalent of *Shure's* "Trackability" rating. Higher values of DCF indicate that a cartridge will track at lower forces and will be able to handle higher velocities. Other manufacturers do not assign such arbitrary ratings, but make a broad line of cartridges with different tracking force requirements and a corresponding range of prices. These include *ADC, Elac, Empire, IMF, Stanton*, and others. All the cartridges we have discussed happen to be magnetic types. Since criteria for tracking are functions of the mechanical design of the cartridge rather than of the method of transduction, they would apply equally well to piezoelectric or other types of cartridges. ▲

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NEWS HIGHLIGHTS

Thermal Pollution

To help evaluate effect of heated water discharges from electric generating plants on marine environment, *Electronic Communications, Inc.* (*ECI*) has developed an oceanographic data acquisition system for *Florida Power Corp.* System consists of shore station and series of buoys in Gulf of Mexico near power plant site. Shore station will interrogate each buoy at regular intervals which, in turn, will respond by telemetering water temperature at various depths. Data will be analyzed on computer so that a mathematical model can be developed that will predict "thermal plume" characteristics which result from heated water discharge. *Florida Power* thus hopes that information gained through study will help in design and location of other power plant sites so that thermal pollution can be kept at a minimum.

Electronics in Medicine

Zenith has developed a classroom training system designed to increase learning rate for hard-of-hearing students. System, called "FM Auditory Trainer," radiates FM signal from a compact solid-state transmitter through an enclosed antenna system encircling classroom. . . . An experimental pacemaker that uses the energy of the heart to trigger the heart may avoid the need for periodic surgical battery changes. The new pacemaker, being developed at *Bell Labs*, uses piezoelectric discs to convert variations in blood pressure into electricity. . . . A thin-film disposable medical thermometer has been developed by *Sloan Technology Corp.* The new device enables a temperature to be taken accurately to within 0.3 degree. Because it features disposable sensors, it eliminates the danger of cross-infection present with reusable glass thermometers.

Heart Beat Produces Magnetic Fields

Recent studies being conducted at Syracuse University under direction of Drs. Gerhard Baule and Richard McFee point out that a pulsating heart produces an electric current that sets up tiny magnetic fields (one-millionth of earth's magnetic field). Some of these magnetic fields have been found to leave body from chest area, circle the person and return to the body in the rear. Such studies may usher in use of new equipment now being experimented with as a means of checking human heart quickly and accurately in a minute or two where it now takes 20 minutes or longer using electrocardiogram. Unit, called a "Magnetocardiogram," consists of two coils wound on a dumbbell-shaped core of magnetic material about a foot long. Output voltage of coils is magnified by an amplifier and passed through a filter. A special electrical alloy steel (4750), produced by *Allegheny Ludlum Steel Corp.*, is used to shield out interference and stray magnetic fields that may alter Magnetocardiograph reading.

Radiation Incidents Registry

A Radiation Incidents Registry to record cases of injury or potential injury resulting from exposures to radiation from electronic products has been established by the Environmental Health Service's Bureau of Radiological Health. Local and State radiological health authorities, Federal agencies involved in radiation control, hospital administrators, labor union officials, etc. have been asked to report all radiation accidents or suspected incidents for possible inclusion in register. Complete details of radiation incidents from x-ray machines, lasers, microwave ovens, TV receivers, diathermy units, high-voltage vacuum switches and rectifier tubes, shunt-regulator tubes, and CRT's should be reported to Bureau as soon as possible. Report should include: description of when, where, and how incident occurred; type of radiation and estimated exposure; age, sex, and occupation of persons exposed; and health effects noted and medical treatment given. Report incidents directly to Radiation Incidents Registry, Bureau of Radiological Health, 5600 Fishers Lane, Rockville, Md. 20852.

Domestic Satellite System

The *Western Union* company has filed with the FCC a proposal for a high-capacity multi-purpose domestic communications satellite system to serve all 50 states. The company was the first to respond to the Commission's invitation to file such license applications. The proposal talks about three synchronous satellites, each with 12 transponders, six earth stations, and 31 ground microwave relay stations to tie up with firm's existing transcontinental microwave network.

Electronic Industries Hit $25.8 Billion

Total factory sales for the electronic industries reached $25.8 billion during 1969, a 5.3% increase from the previous year. Expansion occurred in each major equipment market except for the federal government segment where purchases were down a bit to $12.4 billion. Biggest gains were in the computer area where sales climbed 27% to reach $4.7 billion during 1969. Total U.S. sales of consumer electronic products reached an all-time high of $5.3 billion, including phono records and tape. Consumer products accounted for nearly 20% of total. Both unit and dollar sales of color-TV sets remained the same in 1969 as 1968. All figures are from the EIA Electronic Market Data Book, which is sold for $15 by EIA's PR Dept., 2001 Eye St., NW, Washington 20006.

Engineering Enrollments Down

Figures from the nation's 269 engineering schools confirm a general decline in enrollments ranging from 18% in master's degree programs to smaller losses in almost every other class. On the other hand, enrollments in engineering technology programs increased substantially in the 52 schools having curricula accredited by the Engineers' Council for Professional Development. Four-year programs, leading to a bachelor's degree were particularly popular, registering an enrollment gain of almost 250% since 1968. In addition 506 other schools reported having students enrolled in various technology and pre-engineering curricula.

Chips Off Old Block

Westinghouse Electric Corp. recently announced formation of the *Westinghouse/Hagan Computer and Instrumentation Div.* in Orlando, Florida. New operation will produce and market a new line of minicomputers. . . . and *North American Rockwell Corp. (NR)* has formed a new commercial microelectronics firm, called *North American Rockwell Microelectronics Co.*, based in Anaheim, California. New division—based on available sales and production information—will start business as the world's largest manufacturer of metal-oxide semiconductor large-scale integrated circuits (MOS/LSI).

Electronics Honor Roll

Dr. James R. Killian, Jr., Chairman of the Corporation, Massachusetts Institute of Technology, will be the recipient of the Prometheus Award at the National Electrical Manufacturers Association (NEMA) Annual Meeting Dinner, November 10 at the Americana Hotel, New York City. Citing Dr. Killian for his "dedicated and enlightened service in broadening engineering education and in strengthening Government policies for science and technology," the NEMA board of Governors chose him for the Association's highest honor. ▲

It's not an easy decision to make. There's such a wealth of precision built into every Dual that even the testing laboratories can measure only small differences in performance among the Dual 1215 at $99.50, the 1209 at $129.50 and 1219 at $175.00.

This raises an interesting question for you to consider: What are the important differences to you among these three Duals?

Let's consider them in turn.

Even our lowest priced turntable, the 1215, boasts features any turntable should have (and few do).

Its low-mass counterbalanced tonearm accepts the most sensitive cartridge available today and tracks flawlessly as low as ¾ gram.

Tracking force and anti-skating settings are ingeniously synchronized, so one setting does for both. The cue control is silicone-damped, and eases the tonearm onto the record more gently than a surgeon's hand.

The hi-torque motor brings the heavy 3¾ pound platter to full speed in less than a half turn, and maintains that speed;within 0.1% even if line voltage varies widely.

And it even has a control to let you match record pitch with less fortunate instruments such as out-of-tune pianos.

Even a professional doesn't need more.

But you may want more. In which case the 1209 offers some refinements that are both esthetically pleasing and add something to performance.

For example: its tonearm tracks at as low as a half gram. Its anti-skating system is calibrated separately for elliptical and conical styli. Its counterbalance features a 0.01 gram click-stop. And its motor is hi-torque and synchronous.

Now what could the 1219 add to this?

The only true gimbal suspension ever available on an automatic arm. Four identical suspension points, one ring pivoting inside another.

And the Mode Selector, which shifts the entire tonearm base — down for single play, up for multiple play — so that the stylus will track at precisely the correct angle (1.5°) whether playing one record or a stack. The tonearm is 8¾" long, and the 12 inch dynamically balanced platter weights 7 pounds.

So the question really isn't which Dual is good enough, but how much more than "good" your turntable has to be. If our literature doesn't help, perhaps a visit to your dealer will.

United Audio Products, Inc., 120 So. Columbus Ave., Mt. Vernon, New York 10553. **Dual**

Now that you know you want a Dual, the next question is which one?

1219 — $175.00

1215 — $99.50

1209 — $129.50

CIRCLE NO. 115 ON READER SERVICE CARD

A Vocation Profile:

Marine Electronics Servicing

By ROBERT PATTON

Have a good basic electronics background and looking for a challenging career? Here's the description, requirements, and the pay scale for just such a job.

This is no job for the fainthearted. On this vessel access to the two radar antennas is through the hollow mast of ship; on many other vessels, external ladder is provided. Note the radio-direction-finder (RDF) loop visible on the lower platform.

YOU may see him on any waterfront pier, in any major port of the United States. He will probably be carrying a large bag weighted down with an assortment of tools. He may be wearing a coat and tie, but is more likely to be dressed casually. His car, parked near the pier, will be heavily ladened with what appears to be a huge collection of odds and ends.

All-in-all, not a very imposing figure. But, without him, great ocean freighters remain fastened to their piers, tugboats suspend operations at the first sign of fog, and well-heeled world travelers are left standing at the dock—their sailing "unavoidably postponed."

This man is a marine service technician (Fig.1). It is his job to maintain the complex electronic systems upon which the modern mariner has come to depend. In the field, he usually works alone on jobs for which the customer will ultimately pay from $50 to as much as $3000. His responsibility is immense, for his failure to repair a crucial piece of equipment can hold up the sailing of a large ocean-going vessel—and cost the ship owner many thousands of dollars.

The day of a typical field technician begins at the dispatcher's desk where the initial assignments are handed out. From that point on, he is pretty much on his own. He must be prepared to tackle repair assignments on an awesome variety of equipment. In a single day, he may dirty his hands on the electromechanical intricacies of a radar "antenna box," tax his troubleshooting ability on a "tough dog" problem with a loran set, and then—when his counterparts in other fields are packing up their tools to go home—be prepared to "turn to" on a defective radar indicator that must be operational in time to meet a commercial vessel's scheduled 6 a.m. sailing date. It is a rare individual that can wind up a workday like this with a feeling of accomplishment rather than resentment. As one satisfied marine technician smilingly puts it: "You have to be a little crazy to work in this field."

This is clearly not a job for a man who cannot function well under pressure or for one who wishes to put in his working hours with time-clock regularity. A marine technician must be prepared to work late into the night on a ship that is scheduled for an early morning sailing. He must be prepared to work on weekends or holidays when circumstances demand it. If a radar scanner strips its gears in a gale, he is the man who must go up on the "stick" to repair it (see lead photo). And, even if the temperature should be below freezing, the job still must be done.

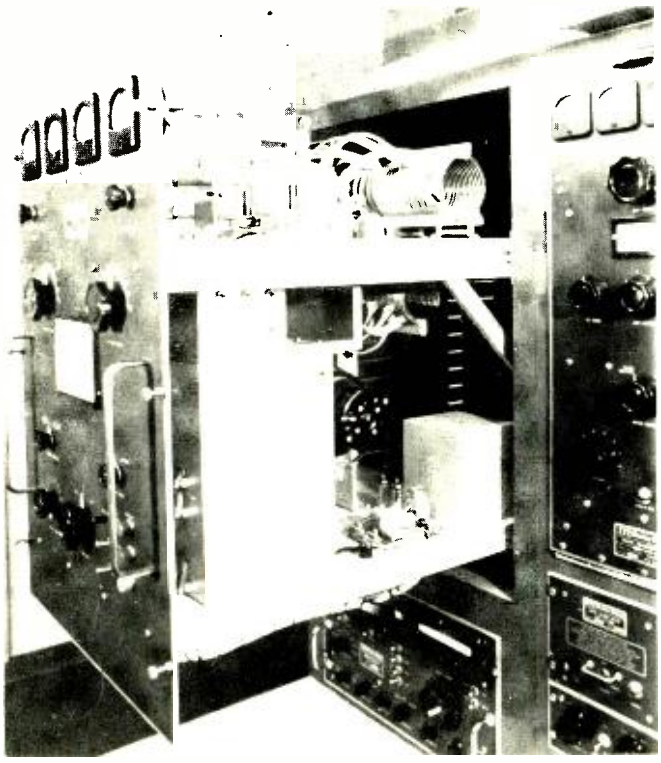
But the field also has its rewards. The marine technician will never go stale working on the same type of equipment day in and day out. If he takes full advantage of the available overtime, he will take home a paycheck that matches one received by most engineers. He will never punch a time clock nor work with a supervisor breathing down his

back. And, if he likes the feel of a deck swept by a crisp sea breeze, he will rejoice at freedom from a nine-to-five routine under the sterile illumination of fluorescent lights.

Minimum requirements for a beginner in marine electronics service include a 2nd Class FCC Radiotelephone operator's license and training, formal or informal, in basic electronics. Prior experience in some phase of electronic servicing is, of course, desirable, but not necessary. At least one employer, *Mackay Marine*, has a training program that accepts unlicensed men, but even here preference will always be given to the man who already has his "ticket." An even higher priority will be given to an applicant that has either a 1st or 2nd Class Radiotelegraph license and this applies to promotion as well as to hiring.

Fig. 1. A marine service technician shown on the job. He must be able to use all basic hand tools, be adept at wiring, harnessing, cabling, and soldering, and above all, to work quickly and neatly when under pressure.

Fig. 2. Typical marine radiotelegraph transmitter (ITT Mackay Marine) serviced by marine technicians. Note open parts layout on transmitter which reduces heating problems and makes components easier to service.



There are several reasons why a radiotelegraph license is so highly valued in the marine field. Without it a man cannot legally key a radiotelegraph transmitter (unless a qualified operator is on hand to take responsibility). And radiotelegraphy is still the mainstay of communications on the high seas. Furthermore, all large commercial ships of U.S. Registry are required by law to undergo yearly inspections by FCC field engineers. During such inspection a legally qualified operator representing the station licensee *must* be present to put the equipment into operation and to make any necessary adjustments and repairs that come up in the course of the inspection. Since the station licensee is usually the company that maintains the equipment aboard the vessel, they must supply the licensed technician to assist with the inspection. For this reason, none of the big marine electronics service companies ever has enough men with radiotelegraph licenses and the door is almost always open to the man who has one.

A Changing Field

Formerly a haven for old timers who didn't want to learn a new technology, the marine service field has, at last, caught up with itself and now demands a steadily increasing level of skill from technicians. Marine electronic equipment has been revolutionized in the past few years. New gear is largely transistorized and the increased use of integrated circuits is on the horizon. The trend toward containerization of cargo is one big factor that has put pressure on both the marine equipment designer and the service technician. Where formerly a ship might remain in port for a week, a modern container vessel can be in and out in as little as 24 hours. Because fast turnaround has become essential, there is a trend toward modular equipment design to facilitate fast on-board repairs. Today's service technician must know his stuff more than ever before to get the job done without holding up a vessel.

Tightening FCC requirements is another reason why service firms are demanding a greater level of expertise from the technician and greater precision from his equipment. As the radio spectrum becomes more and more crowded, tighter tolerances are being imposed on transmitters to hold down spurious emissions and single sideband is rapidly replacing AM for commercial marine radiotelephony. In fact, on the FCC calendar, AM is scheduled to be completely phased out by January, 1977. One seasoned veteran with a quarter-century of experience in marine electronics described the changing nature of the field this way: "The fix-it-with-a-hammer-and-a-V.O.M. philosophy is on the way out."

Versatility is the Keynote

Versatility is an essential trait of any successful marine electronics technician. The problems of the TV technician are not as variable as those of his counterpart in the marine field who must know the ins and outs of a bewildering variety of equipment. The list includes radiotelegraph transmitters (Fig.2), communications receivers (Fig.3), auto alarms, loran sets (Fig.4), radar (Figs.5 and 6), FM radiotelephones, SSB equipment, gyrocompasses, etc. To compound his difficulties, the marine technician is frequently called upon to service foreign equipment—often without the aid of an English-language service manual. The biggest hang-up with foreign equipment is parts. Where the successful completion of a repair job requires the replacement of a non-standard foreign part, the technician must use his ingenuity to devise a temporary substitute.

Even more versatility is required in smaller ports or with smaller companies where there may only be one or two men available to repair a given piece of gear. In a larger operation it is sometimes possible for a man who is not up on, say, loran to pass the buck to a specialist; in a small facility this is simply impossible. In some ports with only a

single technician, the field man may even operate out of his own home. This situation often leads to domestic friction as the man's wife finds herself serving as an unpaid answering service and a large parts stock crowds her out of the laundry room. On the other hand, some men (with long-suffering wives) thrive on the independence offered by the one-man port.

All of the larger employers maintain well-equipped shops in one or more of the major ports. In these locations, the field man operates with only a well-stocked tool bag and a multimeter since other instruments can be checked out from the shop when the occasion demands it. Shop support is also useful when a technician is faced with a problem that cannot be easily handled in the field. A replacement unit can be substituted temporarily while the defective assembly is given an extensive shop overhaul. A complete marine radar overhaul would be a shop job and could cost the customer as much as $5000.

Where the Jobs Are

The two biggest domestic employers of electronics technicians in the marine field are *RCA Service Co.* and *ITT Mackay Marine*. Both are based in New Jersey and both have repair operations at major deep-water ports in the United States. *RCA* also maintains repair depots at such river ports as Cleveland, Chicago, Baton Rouge, Pittsburgh, and St. Louis, although this phase of its business seems to be on the wane.

RCA has facilities in New York City, Boston, Philadelphia, Baltimore, Norfolk, Tampa, Jacksonville, Mobile, New Orleans, Port Arthur, Houston, Galveston, Los Angeles, San Francisco, and Seattle. Outside of New York, hiring is done through regional field managers who have responsibility for more than one port. New York is *RCA's* largest facility with New Orleans running a close second.

Mackay Marine's deep-water operations are conducted in New York, Baltimore, Mobile, New Orleans, Wilmington (Calif.), San Francisco, Portland, and Seattle. Business elsewhere and abroad is handled by agents.

Smaller operations exist in both these large ports and in smaller ports and anywhere else where there are boats carrying electronics. Working for one of the large companies is good experience for the man who hopes to eventually set up his own business. Employment with smaller outfits, such as *Raytheon, SAIT, Decca*, etc., as well as with small independent shops is also possible.

Independent shops fall into two general categories. In smaller deep-water ports where the larger companies may not find it profitable to operate a full-scale repair facility, they often farm out their work to independent agents who maintain a small parts stock and are equipped to carry out all but major repairs. The work of these independents usually includes work on large commercial vessels only when an emergency necessitates it. Their normal business involves work on local vessels, such as fishing boats and pleasure craft.

In the northern part of the United States this work is, of course, highly seasonal and most small operators do not limit their work to the marine field. This applies equally to the second category of smaller companies, those that are more or less exclusively concerned with the recreational boating field. In both cases, work on land mobile equipment, entertainment electronics, Citizens Band, or ham radio is often needed to keep the operation going during the colder months. The technician whose beat is the marinas of the nation's rivers, lakes, and seashores is simply not in demand during the winter. If he is not ready and able to tackle other types of jobs, he can not expect to hold down a full-time position. But for the technician who is capable and qualified, opportunities in the pleasure-craft field are plentiful. The big gripe of most shops is that there are just not

(Continued on page 50)

Fig. 3. Radio room of modern ship. It is responsibility of service technician to see that this equipment functions in event of emergency on high seas. Once ship is at sea, radio officer (showing tuning low-frequency receiver to transmitter frequency) hasn't time nor equipment for major repairs.

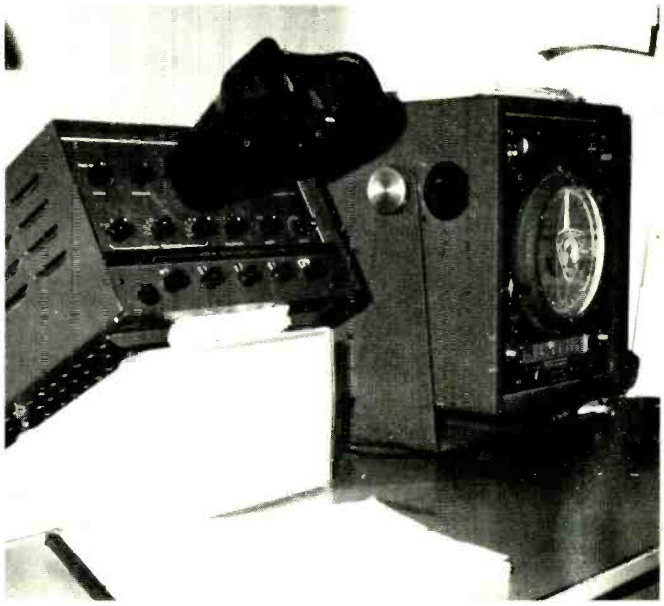
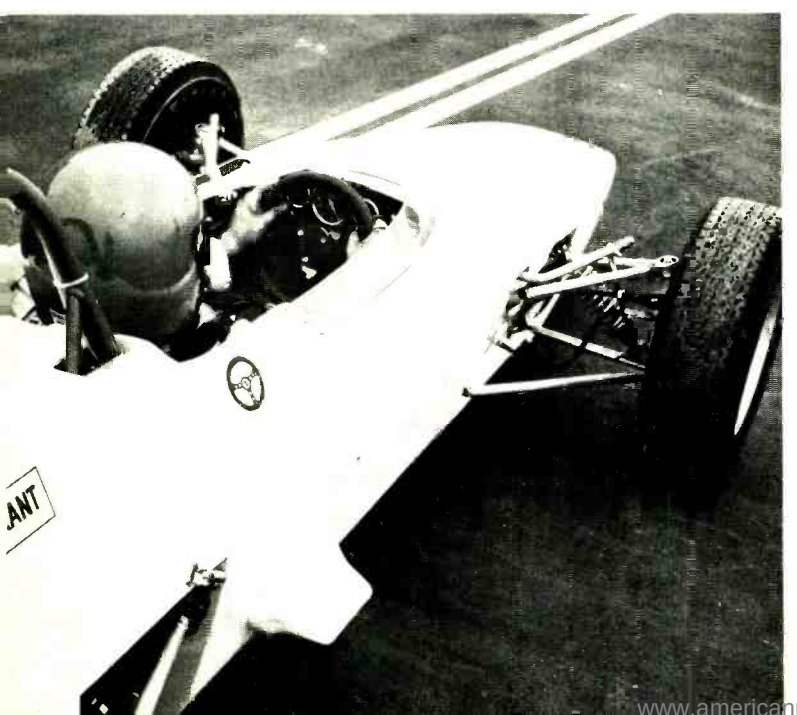


Fig. 4. Shown here are (left) modern loran set and (right) radio direction finder that marine service technicians must be thoroughly familiar with in order to make needed repairs.

Fig. 5. Marine service technicians must be prepared to go anywhere at any time when emergency arises. Technician is shown repairing radar reflector on ship's mast seen in lead-in photo.



Recent Developments in Electronics

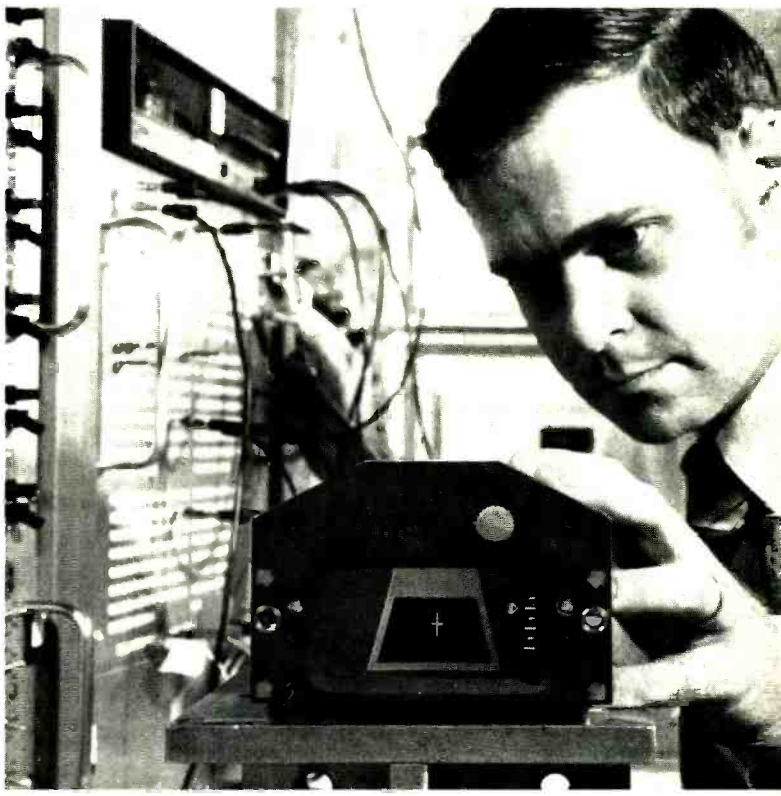
Surface-Wave Line for High-Speed Trains. (Top left) A prototype surface-wave transmission line for communicating with vehicles has been successfully tested by ESSA scientists. This was done in connection with the government's interest in developing high-speed rail transportation. A section of the 918-ft r.f. transmission line is shown here along with one of its cone-shaped transducers. The line is made of spirally corrugated, flexible copper tubing covered with a layer of polyethylene dielectric, and mounted 6-ft high on plastic pipes. Since there was no sufficiently long high-speed rail track available for the test, the line was erected along a roadway and a motor van was used for the tests. Mounted on the van was a 30-ft section of the line with cone-shaped transducers at both ends. Distance between the road-mounted line and the section on the vehicle was between 1 and 2 ft. The system was tested as follows: A TV signal was picked up by an antenna on the van; this modulated a 525- or 750-MHz r.f. carrier fed to the 30-ft line section. The signal was then coupled to the fixed long line, from which it went to terminal equipment and a TV monitor. The final television picture had little apparent degradation after passing through the entire system.

Computer for Air Traffic Jams. (Center) Everyone seems to have a solution to the problem of the nation's air traffic jams. One solution we have heard about recently is a new high-speed computer and display system built by Goodyear Aerospace Corp. The computer, called "Staran IV," can perform more than 40-million mathematical operations per second in predicting which planes are on collision courses and determining evasive maneuvers. Its speed and capability also would allow a reduction in aircraft separation distances in airport landing and takeoff patterns—one of the main causes of air traffic tieups and long waiting and circling periods for airline passengers. The company claims that four times as many planes could be safely accommodated in the same amount of air space by using the computer in air traffic control systems. After we get the situation straightened out up in the air, maybe something can be done about the traffic jams on the ground on the way to the airport.

Electronic Timing Transmitter for Racers. (Below left) The fin protruding from the side of this racer contains a solid-state timing and scoring transmitter. Radio signals from such transmitters, to be installed in all cars in a race, are picked up by underground sensors. These identify each car by the frequency of its signal, record crossing times to 1000th of a second, and transmit the data to a computer which will print out the race order of all cars. The system, produced by Conrac Corp., is being used at Ontario Motor Speedway outside of Los Angeles. It is capable of keeping up with a field of 50 cars running at speeds of more than 200 mi/h. The timing method is so accurate that if cars cross the finish line only six inches apart at top speed, the system can identify the leader. Outputs from the system will also be displayed on three 65-ft high three-sided pylons which will be visible to all spectators at the Speedway, as well as on a huge display board, measuring 246 ft long and 47 ft high. The giant scoreboard is expected to be completed sometime in 1971.

Night-Vision System for Helicopters. (Top right) This copter pilot is wearing the special eyeglass display for an experimental night-vision system that will permit him to see in the dark. The image is picked up by a low-light-level TV camera in the nose of the aircraft. The picture is displayed on a miniature CRT whose image is made to appear through the pilot's eyeglass. The eyeglass is partly transparent so that the pilot sees the image superimposed on what he is looking at. An electro-mechanical headtracker automatically aims the TV camera to wherever the observer is looking. Bell Helicopter Co. developed the system.

Color-CRT Display for New Jet. (Center) The new DC-10 giant jet, which is McDonnell Douglas' answer to the Boeing 747, is going to have a color CRT display in its cockpit. It won't be for color TV, however, but it will be used for the performance and failure assessment monitor, built by Honeywell. The monitor watches over the performance of the plane's automatic landing system. This is done by computing as much as 150 seconds ahead of time how the landing is progressing as determined by signals from radios, altimeters, and inertial sensors. The CRT display shows a symbolic runway with predicted touchdown cross. If performance is predicted to be unsatisfactory, a takeover command replaces the landing symbols and the pilot either lands the aircraft himself or else performs a normal go-around maneuver.



Laser Pulse Photographed. (Below left) Here is a stop-motion photo of a pulse of laser light traveling through a rectangular bottle of water. The pulse was stopped in flight by a camera equipped with a new ultra-fast shutter. Triggered by the laser pulse itself, the shutter opens and closes in ten billionths of a second. Bell Labs scientists who developed it say that it's about 100 times faster than previous ultra-high-speed shutters. A camera mounted behind the shutter is used to photograph the pulse. The same laser that fired the pulse is synchronized to trip the shutter when the pulse is midway through the bottle. From tip to tip, the laser pulses measure approximately one-fifth of an inch.

Color Slide TV Studio for Industry. (Below right) A compact TV studio which transmits 35-mm color or black-and-white slides to TV sets by way of community antenna, CCTV, or standard broadcast facilities has been introduced by Sylvania. The system, which uses a flying-spot scanner to convert images on the slides to TV signals, appears to be similar to the device introduced by the company some time ago for home TV viewers. This version, however, is slanted toward the industrial, educational, and commercial markets. The studio, with its carousel of slides, can operate unattended. Prices are around $3000 to $4000, depending on options.

A 4-Channel Amplifier for Multi-Speaker Systems

By L. H. GARNER

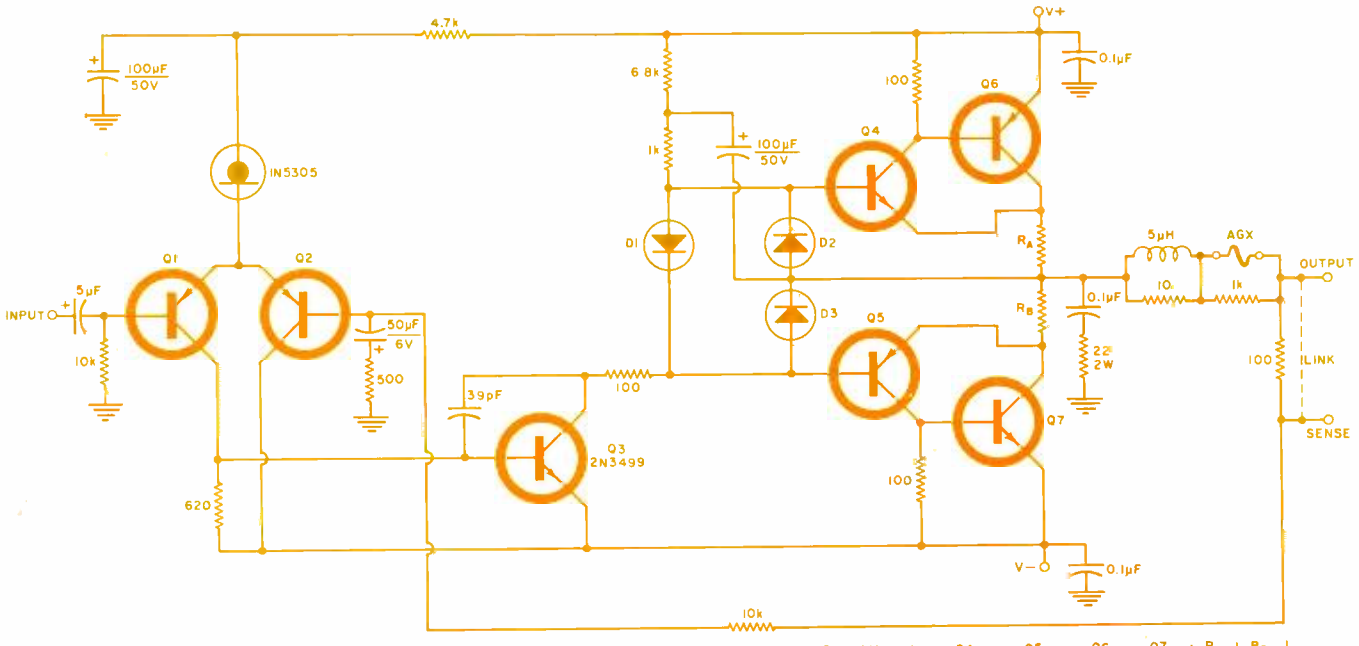
Design of ultra-low distortion amplifier that can drive pair of 2-way speaker systems using frequency-selective networks at input. Can provide power amplification for 4-channel use.

NOW that the "talk of the industry" seems to center around four-channel sound, the need for additional power amplifiers becomes immediately apparent. Until we have more 4-channel program material, having four power amplifiers may seem to be a bit of gilding on the proverbial lily. However, where it is already practical is in driving multi-speaker systems, where frequency division is made *prior* to the power amplifier and not at the speakers themselves. This article describes a four-channel amplifier with two high-power channels for low frequencies and two lower power channels for high frequencies. The high-power channels differ from the lower power channels only in the output stage. A description of a simple frequency-dividing network is included, along with a short discussion of damping factor.

Power-Amplifier Circuit

The schematic of Fig. 1 shows one of the four power-am-

Fig. 1. Schematic of one of the four power-amplifier channels. By changing supply voltages and output transistors, output of either 60 watts/channel or 30 watts/channel can be produced. By making use of frequency-dividing networks at input, two high-power channels can be made to carry bass frequencies; two lower power channels can be made to carry treble frequencies for pair of 2-way speaker systems operating from 2 channels. By omitting the networks and using four identical power-amplifier channels, the amplifier can be used to accommodate 4-channel program material.



P_O	+V	−V	Q4	Q5	Q6	Q7	R_A	R_B
30W	+25	−25	MPS-U02	MPS-U52	2N3790	2N3715	0.47	0.43
60W	+36	−36	2N4238	2N4235	2N4399	2N5302	0.36	0.33

Q1, 2: SELECTED 2N3906 OR SEE TEXT
D1, 2, 3: MZ2361 (MOT.) OR MPD-200 (GE)

plifier channels. All four channels are identical, the only difference being in the supply voltage and the output stage. The two low-frequency (or high-power) channels deliver a sustained 60 watts per channel, both channels driven, into 8-ohm loads; the two high-frequency (or low-power) channels deliver 30 watts each. Even with low-efficiency speakers, this is generally enough power to all but destroy the most rugged eardrums. More important, it can provide a margin of power to eliminate waveform clipping due to the high crest factors (peak-to-r.m.s. ratio) found in music and speech.

The typical harmonic distortion over the frequency range of 20 to 20,000 Hz, at any power level below clipping, is less than 0.1% and below 10 kHz is typically less than 0.03%. IM distortion, at any power level below clipping, is on the order of 0.05% using a combination of any two frequencies between 20 Hz and 20 kHz in the usual 4:1 ratio. This kind of electrical performance, coupled with the lack of amplifier adjustments, demands the finest quality input signal and loudspeaker systems to show the amplifier to its best advantage.

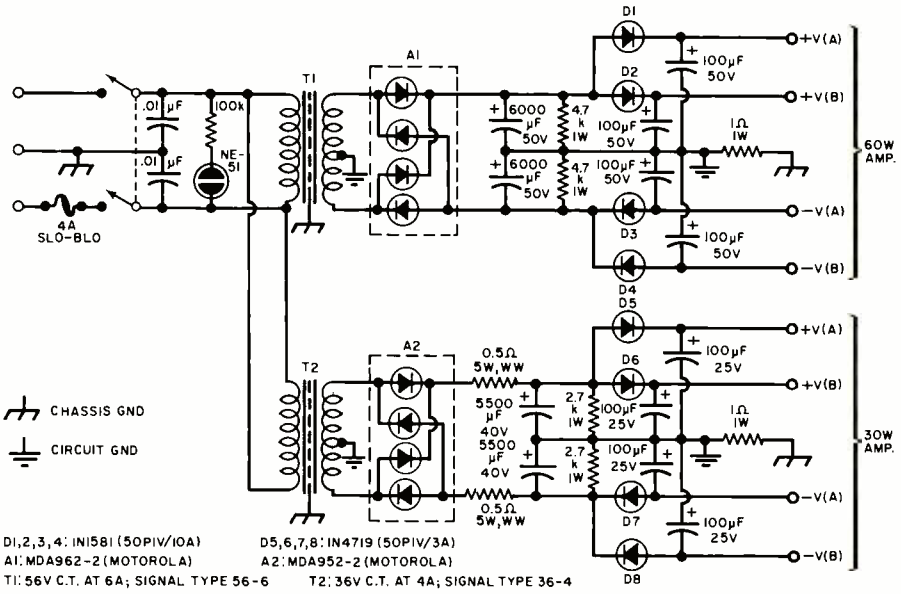


Fig. 2. Dual power supply used for 4-channel amplifier. The voltages marked "A" go to one channel, while those marked "B" go to other channel. In all there are two 60-watt power amplifiers and two 30-watt power amplifier channels.

This basic power amplifier has a few unique features which will appeal to even die-hard audiophiles. The input signal goes into a differential amplifier, referenced to ground, which maintains the output at zero volts d.c. (within a tolerable offset error) and consists of two transistors selected for V_{BE} matching at 1.0 mA. As an alternative to matching, suitable substitutions are the 2N3350 or 2N4023, which are matched pairs.

The differential V_{BE} is what appears at the output terminal. If low-cost transistors such as the 2N5086 are used, their initial cost is so low that they could easily be selected for output offset right in the amplifier. Devices from the same production lot will be typically within 15 mV, which is satisfactory. The differential amplifier emitters are connected to a 2-mA FET diode used as a constant-current source. The inherently high dynamic impedance of this diode, coupled with a low V_{BE} offset, produces a rejection ratio to common-mode signals (hum) and power-supply ripple of better than 80 dB.

In conjunction with the input differential amplifier is a 10,000-ohm feedback resistor connected directly to the output Sense terminal, and through a 100-ohm resistor to the Output (speaker) terminal. With short speaker runs—less than 10 feet—the shorting link shown (dotted) would normally be used. For longer wire runs, however, the link is removed and a separate "sense" lead connects directly to the speaker terminal, thus eliminating the voltage offset created by the IR drop in the speaker lines. It permits feedback to be taken directly at the speaker rather than at the amplifier. (The separate "sense" lead is connected to the same terminal of the speaker as is the output lead. The other speaker terminal is connected to the ground side of the amplifier.)

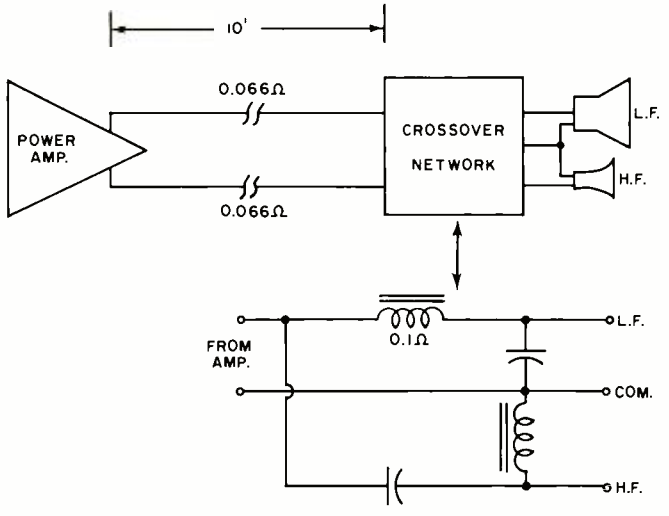
The resistor across fuse AGX (a 1 to 2 A, fast-blow type) maintains feedback in the event the fuse should open. It should be noted that when the feedback is taken directly at the output terminal, the effects of non-linearities which exist in the parasitic suppressor (r.f. choke, effective when driving highly capacitive loads, such as an electrostatic loudspeaker) and the fuse are thus minimized. This also tends to lower the output impedance of the amplifier by having all elements within the feedback loop.

In concept, the over-all circuitry of the power amplifier is direct-coupled, using a full complementary output stage. This configuration eliminates the non-linearities which are inherent in amplifiers using a quasi-complementary output configuration. The driver/output transistor connection is a complementary Darlington compound arrangement, extremely tolerant of transistor variations and resulting in a virtual emitter-follower, which is direct-coupled to the load.

One aspect which is often overlooked in amplifier construction is the need for heat sinks for the output transistors. The amplifier built by the author has what is believed to be a fairly rational approach to heat sinking. Massive finned aluminum heat sinks are really necessary only when the amplifier is designed to deliver high levels of power over a relatively long period of time. The author's approach is based on the fact that this amplifier is not built for laboratory use (although it's certainly good enough) but for the reproduction of music, in which the crest factor is high but the average power level is low.

Using this rationale, output transistors $Q6$ and $Q7$ of the 60-W channels are mounted on *Thermalloy* 6403 anodized heat sinks using Thermacote compound as an interface. The sinks are mounted with the fins vertical for greatest effectiveness. As an alternative, the *Wakefield* NC 403A is an excellent choice. In addition, *Wakefield* Type 111 mounting brackets make for a neat and simple installation.

Fig. 3. Resistance of crossover network reduces damping.



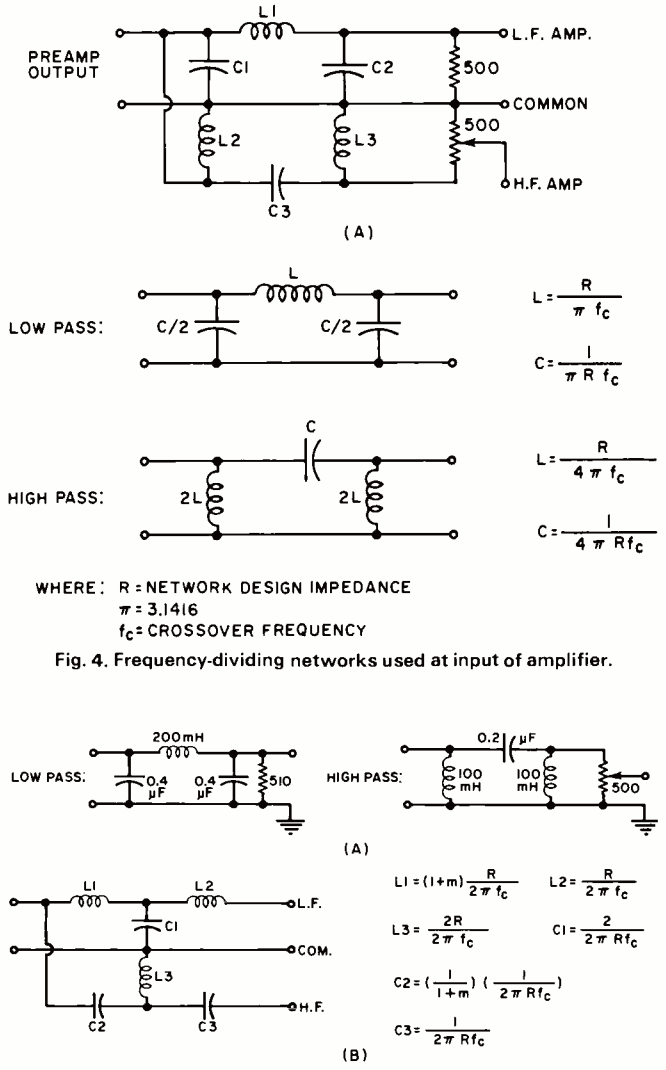


Fig. 4. Frequency-dividing networks used at input of amplifier.

Fig. 5. (A) Values used by author. (B) M-derived filter networks.

For 30-W channels, the output transistors are mounted directly to the chassis using appropriate isolating washers and hardware. In the event the Thermacote interface compound is not available, *Dow Corning* #340 is the same, or *Dow Corning* #4 silicone grease—although not as good thermally—will be adequate. The basic idea is to fill any gaps or spaces which may exist between the mounting surface of the power transistor and the heat sink in order to improve power (heat) transfer.

The power supply, shown schematically in Fig. 2, is simple and requires no voltage regulating circuitry due to the inherent regulation (VA capacity) of the power transformers. In the event better regulation is desired—with a minimum of changes—in the high-power supply, a high-current choke such as the *Triad* C-48Y can be installed between the bridge and the filter capacitors. Two of them, however, are required and the resulting weight of two chokes and two power transformers may prove to be a burden to all but the fittest. Due to the use of balanced (plus and minus) supplies, the improvement provided by the chokes is minimal as far as practical use of the amplifier is concerned, and their absence will never be noticed except when lifting the quad amplifier array.

Wiring is not particularly critical, but good lead dress and proper grounding techniques should be used in order to obtain the 90-dB signal-to-noise ratio of the amplifiers. Each supply output is diode-isolated and decoupled, providing better than 70-dB separation between channels.

The so-called, and often highly touted, damping factor of an amplifier is the ratio of the load impedance to the internal impedance of the amplifier. For example, if the load is 8 ohms, and the amplifier's internal impedance is 0.08 ohm, the damping factor is then 8/.08 or 100. In the case of the amplifier described here, the impedance (looking back into the amplifier output) is on the order of 0.02 ohm, indicating a damping factor of 400 with an 8-ohm load. Now, here's where the tricks begin. In order to use this low impedance to damp the loudspeaker (woofer) against overshoot or ringing, it would require that the loudspeaker be connected directly *at the amplifier.* This, of course, is totally impractical.

Let's say that the loudspeaker has an 8-ohm impedance and is 10 feet from the amplifier. The most popular and economical speaker wire is "zip cord" or common 18-gauge, 2-conductor lamp cord. Standard 18-gauge stranded copper wire has a resistance of 6.636 ohms per 1000 feet. Since the speaker is 10 feet from the amplifier, then the wire is 20 feet long (there are two conductors) for a resistance of 0.132 ohm. Admittedly, this isn't a great deal of resistance, but let's see what has happened to our damping factor of 400.

The internal impedance of the amplifier is 0.02 ohm and the speaker wire is 0.132 ohm, for a total of 0.152 ohm. Our damping factor is now 52.6 *at the speaker,* which is, of course, where it counts. This figure is certainly more than adequate, since anything above 10 or 15 has been shown to have little effect. When using a standard speaker system, in which the crossover network is interposed between the amplifier and transducer, an additional resistance is introduced. This is shown in Fig. 3 and illustrates a simple constant-*k* 12-dB-per-octave crossover network of the type in common use. If the resistance of the l.f. choke is 0.1 ohm, the *actual* damping factor for the woofer is now 31.7, a relatively distant removal from our original 400 figure but, nevertheless, still adequate.

Frequency Division

The amplifier described has an input impedance of 10,000 ohms. The use of the frequency-dividing networks at the input greatly simplifies the construction, since large value (and expensive) components are unnecessary, the design not having to be done for an impedance of 8 ohms or so. The network is shown in the diagram of Fig. 4A.

Since the output impedance of many high-quality preamplifiers is on the order of 600 ohms, this dividing network was designed for an impedance of 500 ohms, a close enough match, and it allows the use of a 500-ohm level control at the input of the h.f. amplifier channel. This is needed since nearly all crossover networks at the speakers contain some sort of h.f. level control, in the form of step attenuators or rotary pads. The 500-ohm terminating resistors are necessary to balance the network. The basic configuration of the networks and the formulas used are shown in Fig. 4B.

The networks used by the author were designed for a crossover of 800 Hz, and are shown in Fig. 5A. The schematic for these networks can be redrawn by inverting one side and using a common ground. In the network shown in Fig. 5B this technique is used. This network is of the *m*-derived type, in contrast to the constant-*k* type illustrated in the previous discussion. The basic difference in the types of networks used is that it is impractical to obtain an attenuation slope greater than 12-dB/octave using a network of the constant-*k* variety, but nearly any desired multiple of 6-dB/octave can be obtained using the *m*-derived configuration. For most cases, particularly in speaker crossovers, an *m* of 0.6 should be used in the formulas shown with the figure.

There is, of course, another approach which can be taken relative to the dividing network; with active filters, using integrated-circuit operational amplifiers. The *Q* multiplication obtainable in the configuration is the product of the basic *Q* of the circuit and the closed-loop gain selected. This produces very sharp selectivity, but is really not necessary in this case, and from some aspects is undesirable. ▲

Weather forecasting—yesterday and today—contrasted. (Top) Weathermen watching kite carrying weather instruments aloft in early 1900's from field near what is today Washington National Airport. (Bottom) Hurricane Beulah (Brownsville, Texas, 1967) seen on radar.

What's the weather going to be?

By ARTHUR H. SEIDMAN/Contributing Editor

This year marks centennial of U.S. Weather Service. Weather predicting, although dominated today by equipment such as computers and radar, still as in days of old, depends heavily on human element.

THROUGHOUT the ages man has had a propensity for predicting the future. Invariably he has failed in his prognostications because they were generally based, not on fact, but on superstition, folklore, and myth. One notable exception has been the prediction of weather. The reasons for his success in this field may be attributed to an expanding knowledge of weather conditions, improved instrumentation, and the contributions of technology, especially radar and the computer.

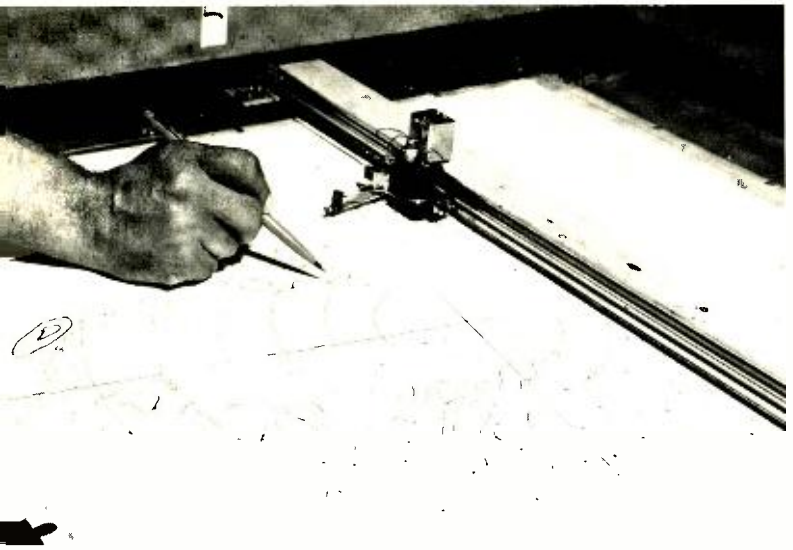
Early man was strongly preoccupied with weather control. He depended on various rituals and incantations to bring rain when it was needed or cause storms to abate. The early Greeks related weather to their gods; lightning, for example, was the work of Zeus, the father of gods. Aristotle attempted to explain all phases of the weather in his book "Meteorologica." Although his book was considered authoritative for nearly 2000 years, most of his conclusions were wrong

Some of the early observations and rules were often put into verse. A famous quatrain, having some validity, is: "Red sky in the morning/Sailor take warning;/Red sky at night/Sailor's delight."

Despite the keen interest in weather evinced by many of our founding fathers, including Washington, Franklin, and Jefferson, it was the year 1870 that marks the establishment of an official weather service in this country. On February 9, 1870, President Ulysses S. Grant signed a bill creating a national weather service. It was referred to as the "Division of Telegrams and Reports for the Benefit of Commerce."

Under the auspices of the Army Signal Service, which later became the U.S. Signal Corps, weather observations emanated from 24 scattered stations. Since time is a vital element, the Signal Service was an excellent choice for the job of issuing weather observations. They had the facilities for transmitting by telegraph their observations, taken by "observer-sergeants," to Washington, D.C. It is interesting to note that before World War I, the Weather Bureau was the first government agency to use wireless telegraphy for communications.

By 1873, flood warnings began to be issued and in 1886 there were 290 locations equipped to forecast cold waves. On October 1, 1890 President Benjamin Harrison signed a law transferring the job of weather forecasting from the Signal Corps to the Department of Agriculture. At this point in history, the agency was called the Weather Bureau. In 1940 it was taken over by the Department of Commerce



A computer-driven automatic weather chart plotter.

B-57 from Environmental Science Service Administration's (ESSA) Research Flight Facility gathers data in a hurricane. These on-the-spot observations are reported to the National Center in Miami, then analyzed and evaluated by ESSA's National Hurricane Research Laboratory, also located in Miami.

and in 1965 it became part of the Environmental Science Services Administration (ESSA).

In the 1880's a visitor to the Weather Service would have been impressed by the activity in the indications room where weather forecasts were prepared. Such a visitor was the British meteorologist, Ralph Abercomby, who came to Washington in 1888. Some of his observations recorded in his book "Seas and Skies in Many Latitudes," provide an intimate glimpse of the operations of the Weather Service.

"Three times a day, seventy-five men in all parts of the Union simultaneously read their barometers and thermometers, besides noting the direction and force of the wind, with the appearance of the sky and motion of the clouds." The data was telegraphed to Washington where one man read the various figures from each station while a second man recorded the numbers. A third man, however, had a more difficult task to perform.

"He has before him a large outline map of the United States, and as the observations are read out for each station, he writes them down in the proper place on the map. For instance, suppose he heard called out—New York, 30.0 inches, 79°, S.W. 30, he would mark the barometric height of 30.0 inches in one coloured ink, the temperature of 79° in another colour. An arrow flying from south-west with a little 30 beside it, to denote the number of miles an hour the wind was flowing, all as near as possible to where New York would be on the map. This he does for every station. . . ."

When the recording of data was completed, six subsidiary charts were constructed. A fourth man ". . . has two blank maps of the United States on his desk before him; but instead of writing down on them what the barometer actually is at each place, he marks on one map how much the mercury has risen or fallen in the last eight hours, and on the other the amount of change in the last twenty-four hours. From these he draws, as it were, a picture of how changes of pressure are travelling across the country, or of the formation of new storms."

A fifth man ". . . has also two maps before him, and draws on them lines of equal changes of temperature, exactly as number four has done for pressure. By means of his charts it becomes easy to trace the progress of what are called hot or cold waves across the Union."

Two more maps are prepared by a sixth man. ". . . one he marks at every station the kind of cloud, and the direction of its motion—which may be very different from that of the wind on the surface of the ground—and sometimes the colour of the sunset. On the other he notes the temperature of the dew point, and some deductions from that, which enable him to chart out the position of damp or dry areas of country."

This work took the six men 2 hours to complete. The last and most exacting task was the interpretation of the recorded data and preparation of a weather forecast, which was issued three times daily. This called for the services of a highly trained and experienced individual—the indications officer.

He first examined the chart on which has ". . . written down the readings of the barometer and thermometer, and draws with his own hand lines, called isobars, through all places where the barometer was at the same height, say 30.0 inches, 30.1 inches, and so on; and also another set of lines with a red pencil through all places where temperature is the same, say 60°, 70°, and so on; and then he walks round the room and looks at the five other charts which are all ready for his inspection.

"He is then ready to issue his indications—but why, and how? All forecasting depends principally on the lines we have called 'isobars.' These map out to a trained eye not only the whereabouts of good or bad weather, but also indicate the future course of wind or rain or thunderstorms. The map which the indications officer drew himself is the primary source of this forecast; the other five charts are only refined and elaborate adjuncts to assist in the formation of his judgement. No calculation is possible; everything depends on the skill and experience of the forecaster.

"And now, some two hours and twenty minutes after the observations were taken, the indications are ready to be telegraphed to every city in the Union. . . ." This is how it was done some 100 years ago.

How It is Done Today

In 1970 the Weather Bureau still collects data on barometric pressure, temperature, wind velocity, and dew point. The information is still plotted on charts and forecasts transmitted to cities throughout the country. But some significant changes have occurred since Abercomby's time. Automatic weather stations, radar, satellites, computers, and thousand-word-a-minute teletypewriter circuits—are some of the technological innovations assisting today's meteorologist.

In 1934 an air mass analysis section was established in the Weather Bureau. Air mass analysis is concerned with the interactions, occurring along their frontal boundaries, of parcels of air having different temperatures and moisture content, and their effect on the weather. Forecasts of greater reliability are obtained with this approach and it proved to be a milestone in the history of weather forecasting.

The Weather Bureau's National Meteorological Center (NMC) at Suitland, Maryland, is the focal point for the reception, processing, and dissemination of weather information. Here millions of bits of information, gathered from hundreds of locations, are collected, analyzed, and developed into a weather forecast. For a complete view of the atmosphere, thousands of individuals must, just as was done

in Abercomby's time, simultaneously observe its state by taking "snapshots" at given times over a global area.

Some forty teletypewriters feed weather data to an *IBM* 360/30 computer where it is recorded on discs, each of which can store about 10,000 observations. The information is transferred onto tape and processed by an *IBM* 7094. This computer identifies, checks, and sorts the data, finally generating lists of error-free information for checking, analyzing, plotting, and filing purposes. The results are interpreted by both computers and meteorologists. Although the computer plays a major role, humans are still required for interpretation.

Greenwich Mean Time (GMT) is used for observations and two cycles of analysis are run daily. Observations are made in the Northern Hemisphere at 0000 and 1200 hours GMT. Each cycle begins with a preliminary analysis, made after 90 minutes of data collected from near the surface to 18,000 feet. During this period, data was obtained from radarscopes, satellite photographs fed into automatic picture transmission (APT) circuits, and satellite infrared radiometer systems (SIRS).

The computers are programmed in terms of a mathematical model of the atmosphere which is based on established physical laws. The atmosphere is divided horizontally into 3021 grid points and vertically into seven layers. At 10-minute intervals, new readings of temperature, humidity, pressure, and wind velocity are introduced for each grid point and layer. The computer is thereby kept up-to-date with changing weather patterns.

With approximately 70 percent of the data in and analyzed, an operational computer analysis is undertaken. Ten levels of atmosphere over the Northern Hemisphere from near the surface to 53,000 feet are analyzed. The analysis takes the computer 30 minutes and is completed before the measurements are four hours old. Using paper and pencil, it would take five men eight hours to do the same job.

As a check on the computer solution, manual analyses are made for the surface, 18,000-, and 30,000-feet elevations. A final computer analysis is run on the *CDC* 6600, covering the Northern Hemisphere from near the surface to an elevation of 53,000 feet. After some five million computer operations, it takes 90 minutes to complete a 48-hour forecast.

The forecasts are transferred to smaller computers and put on tape for use by the curve follower for plotting charts, for coded Teletype transmissions, and for direct input to civilian and military flight-planning computers. Whereas surface forecasts are modified to show areas of weather and cloudiness, and also to check and improve on the computer forecast, all upper-air forecasts are distributed without modification.

Besides long-range forecasts for 3-, 5-, and 30-day reports, 12-, 24-, 36-, and 48-hour surface forecasts are issued daily. NMC transmits some 450 facsimile charts and 200 teletypewriter messages and distributes more than 2500 weather maps each day. The transmission facilities include the 40 teletypewriters mentioned earlier and a dozen facsimile circuits. International cable and radio links are used for transmitting weather information to ships at sea and to other nations.

The local weatherman interprets the information received from NMC in terms of his area of responsibility. Using his own measurements, charts, experience, and intuition, in conjunction with the NMC report, he issues a weather forecast for his vicinity. Although the computer and other technological aids play a vital role, weather forecasting is, as in Abercomby's day, still somewhat of an art.

The Next Hundred Years

Today's weather forecasts are touched by "human hands" and experience plays a part in the meteorologist's predictions. The model of the atmosphere stored in the computer is not detailed enough to insure a complete and precise computer generation of weather forecasts without human intervention. Just as air mass analysis was a milestone in its day, it is a good bet that in the next hundred years another breakthrough will appear to help provide more accurate and longer range forecasts.

View of flooded Beaumont, Texas (1923). Weather predicting is more accurate today but, depending on the ferocity of the storm, scene doesn't change except for car styles.

Weather satellites with improved and sophisticated sensors for probing every mile of our global atmosphere will become more prevalent. Improved sensors and greater coverage of the atmosphere with supersonic craft will result in more complete data for the computers. This should make weather forecasting less of an art with the realization of "untouched by human hands" weather forecasts.

Before the end of the next century it is likely that each household will be equipped with a computer terminal. It will not be too surprising to find the Weather Bureau piping into each home the answer to the perennial question "What is the weather going to be?"

The author wishes to thank Tom Morgan, Principal Assistant of the Weather Bureau Office in New York City, for helping in the preparation of this article and verifying some facts and figures quoted. ▲

First picture ever taken of a tornado (shot about 1880). Photography still plays an important role in recording and understanding the behavior of these killer funnels.

Understanding Random-Access Memories

By JAMES E. McALISTER

A simple explanation of operation of a RAM which "remembers" a logic sequence, stores it for any length of time, and then allows it to be withdrawn for processing.

AS pointed out by Dale Mrazek in his article "IC Memories—Growth and Future," ELECTRONICS WORLD, March and April 1970 issues, solid-state memory units are finding many applications in industry. Because of this, some knowledge of the actual operation of the memory units themselves may be desirable.

As its name implies, the random-access memory (RAM) is simply a solid-state device which "remembers" a logic sequence applied to its input terminals. This sequence can be stored for any length of time and can then be withdrawn for processing.

In order to explain the operation of the RAM, it will be broken down into its basic components.

Flip-Flop–Basic Memory Unit

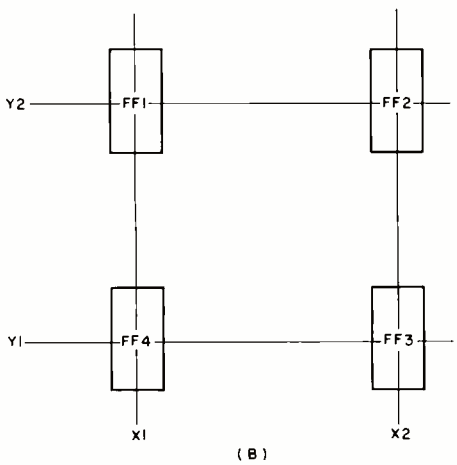
The simplest type of memory unit is the set-reset flip-flop. As shown in Fig. 1A, the FF may be "set" by applying a "1" to its S terminal and a "0" to its R terminal. Reversal of these inputs "resets" the FF. In the set state, the Q output of the FF is a "1", and this "1" remains (consider it to be "remembered") until the FF is reset (Q output goes to "0"). If both R and S are "0", the FF output does not change, but simply continues to store (remember) its last value ("0" or "1"). With this particular type of FF, it is assumed that both R and S are not simultaneously "1".

S	R	Q
0	0	*
0	1	0
1	0	1
1	1	—

* — NO AFFECT ON PREVIOUS OUTPUT

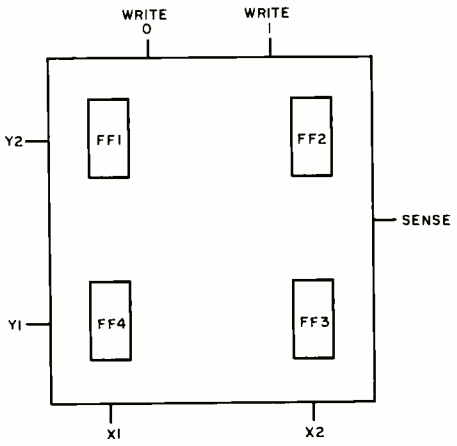
(A)

Fig. 1. (A) Logic symbol of set-reset flip-flop and its truth table and (B) a conventional 4-element flip-flop.



(B)

Fig. 2. Random-access memory showing the write and sense control lines.



It has been shown that a single FF can store a "0" or "1". However, for large-memory operation, many FF's are needed, therefore making it convenient to arrange them in symmetrical fashion. Fig. 1B shows four FF's in a conventional 2 x 2 matrix configuration. Statements about this small matrix can be directly applied to a matrix of any size.

Also shown in Fig. 1B are four control lines—X1, X2, Y1, and Y2. By selecting an X line and a Y line and finding their intersection, a particular FF can be singled out of the matrix. FF1, for example, can be selected or addressed by X1-Y2. Because the FF's are arranged in this matrix fashion, any FF in any size matrix can be randomly addressed by using only two control leads.

The Write-Sense Process

In order for the FF matrix to be useful, it must be possible to not only set and reset the FF's, but also to determine or sense their output states when necessary.

Fig. 2 shows the 2 x 2 FF matrix with more control lines added. By addressing a single FF, the "write" lines and the "sense" line are electrically connected (from inside the memory unit) to that FF. The Write-1 line can then be considered to be the S terminal for that FF and the Write-0 line the R terminal. The addressed FF alone can then be set or reset in the normal manner. Note that operations performed on addressed FF's in no way affect the states of the other FF's in the matrix.

In order to determine whether a "1" or "0" is stored in a certain FF, it is first addressed, but neither Write line is excited (both are "0"). The FF's output will then appear on the Sense line.

Since the Write-Sense process may be performed for any FF in the matrix in a random fashion, this type of memory unit is called a random-access memory. The sensing operation is usually "nondestructive." This simply means that an FF's output may be sensed more than once; that is, the state of the FF is not destroyed or disturbed by the sensing operation.

The statements presented here apply specifically to RAM's (bipolar) produced by *Texas Instruments*. The theory should, in general, hold true for units from other manufacturers. Application of this theory to a particular manufacturer's device should give some helpful insight into its operation. ▲

GRAPHIC COMPUTER TERMINALS

Part 2

By DAVID L. HEISERMAN

Special circuits and tie-in with a central processing unit make graphic video terminal a versatile "tool" for engineers, scientists, and draftsmen. Opens up whole new vista for graphic data manipulation that's limited only by expense and the imagination of man.

The operator is shown using light-pen device to draw geometric figure on graphic display terminal screen. Light pen can also be used by operator to wipe out any line it touches by using in "erase" mode.

PART 1 of this article described the basic alphanumeric type of raster-scan video display terminal and a random-point display system that requires one full 21-bit word for every dot-increment plotted on the screen. In this concluding article, we will describe a third type of video display terminal—the stroke generator display system—and some sophisticated circuits used to improve the operation of the random-point display system.

Adding a Dot-Vector Generator

The random-point display system described last month requires 100 separate 21-bit word commands from the display buffer to plot a vector or straight line 100 dots long. At 40 microseconds per dot, this one line occupies about 10% of the terminal's flicker-free display capacity.

Since vectors are among the most common video display configurations, an RPD controller might be connected to a special circuit that translates a single-word command into coordinate information for a straight line of any length and in any direction. With such a "black box" in operation, the RPD controller could plot out any vector in about the same time as it takes to plot a single point—about 40 microseconds.

The circuit that can do this job for the RPD system is a dot-vector generator. The simplest kind of dot-vector generator consists of a digital comparator and an up/down binary counter—two identical sets of control circuits, one for the X-axis and the other for the Y-axis (Fig. 1). Upon receiving a 1-word command from the display buffer, the counters run up or down a predetermined number of counts. This counting process moves the dot, one increment at a time, from its last resting place to an endpoint specified by the 1-word command.

The only thing that limits the plotting time of this vector drawing system is the counting rate of the up/down counters. Since up/down counters can run a whole order of magnitude faster than present-day memories can call up data, a dot-vector generator decreases the RPD controller's vector plotting time by at least a factor of 10.

A typical vector command word contains 23 bits. Eleven of these bits go to the X-axis portion of the vector generator, and 11 to the Y-axis section. Ten of these 11 bits in each section go to the digital comparator and tell the counters the endpoint of their count. The remaining bit in each section tells the counters whether they should count up or down.

This analysis accounts for 22 of the 23 bits in a dot-vector command. The last bit tells the digital unblanking system to either blank or unblank the vector image on the CRT screen. If the operator wants to draw a visible vector, for example, the unblanking bit unblanks the CRT beam at every incremental point along its path. If, on the other hand, the operator simply wants to move the beam to a new starting point on the screen, the 23rd bit in the dot-vector word keeps the CRT beam turned off.

The most economical dot-vector generators have up/down counters that run from the same digital clock. This means that the counters run at exactly the same rate and the only vectors the system can plot are those that are horizontal, vertical, or multiples of 45°. Such a dot-vector generator can draw one-word lines in only eight different directions. Although this seems to be a serious limitation, practical experience shows that the system can closely approximate just about any kind of curve or vector with a series of short 45° segments and dots.

More sophisticated dot-vector generators use a slightly different approach to approximating vectors that are not multiples of 45°. The display buffer sends a single-word command to the generator. This one word specifies the endpoint of the vector. The vector generator computes the

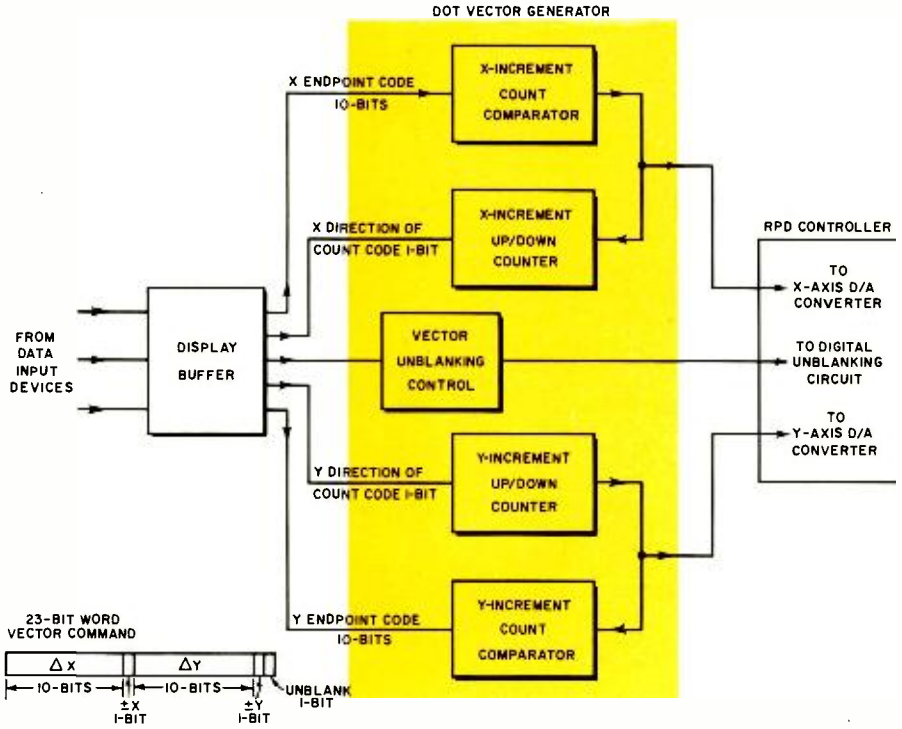


Fig. 1. Block diagram of dot-vector generator used with random-point display controller to permit vectors to be plotted in same time it takes to plot single point. As shown in illustration, typical vector-command word contains 23 bits.

coordinates for a series of incremental points that "bracket in" the desired vector.

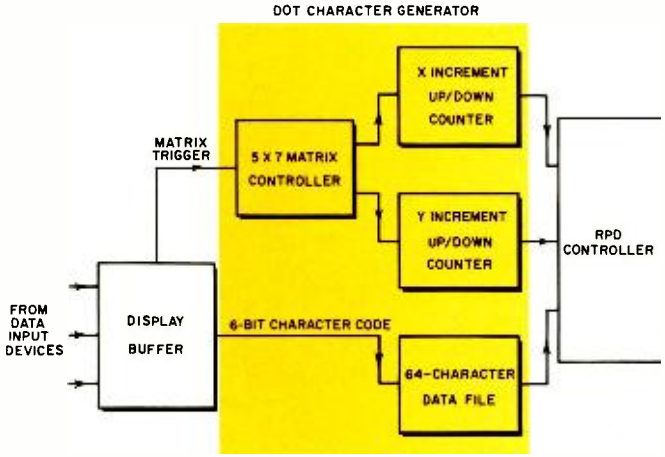
This last dot-vector technique further decreases the plotting time for most kinds of vectors and curves. The generator, however, must have computational abilities that the simple vector generator does not. In this case, the user has to be willing to trade higher generator costs for decreased vector and curve plotting times.

Adding a Dot-Character Generator

Graphic terminals have to display alphanumeric characters perhaps more often than line drawings. It is possible to use the simple RPD controller to write out the characters but, again, the flicker-free display capacity is limited to about 1000 points.

As in the case of the dot-vector generator, a dot-character generator (Fig. 2) can plot out an entire character in about the same time it takes the system to plot a random point. A dot-character generator translates a 1-word command from the display buffer into signals the controller can use to plot out a character.

Fig. 2. Block diagram of dot-character generator used with random-point display controller to permit an entire character to be plotted in the time it takes to plot a random point.



In the dot-character generator mode, the X- and Y-axis up/down counters automatically scan out a 5×7 dot matrix. When they complete the scan of one of these matrices, the counters move the beam to the next character position where they can scan through another matrix.

The digital unblanking circuit does most of the work in the dot-character generator mode. As the X-Y counters scan out their matrices, the unblanking circuit unblanks the CRT at the appropriate points to display a given character.

Most graphic display terminals have a character file of 64 letters, numbers, punctuation marks, and special symbols. A binary character command requires only 6 bits in order to call up one of these 64 characters. The point-display system discussed earlier used 21-bit words for random points, and 23-bit words for vectors. Since a character command word requires only 6 bits, most terminal manufacturers lump three 6-bit character commands into one 18-bit word. This nearly triples the character writing speed without having to increase the capacity of the digital circuits beyond 23 bits.

Graphic Display Interaction

Programming an alphanumeric text on a graphic display terminal can be much like plotting text on a raster-scan system. A cursor generator circuit generates signals to mark the point on the CRT screen for the next character. The operator types out the character on a keyboard and the display buffer codes, stores, and displays the character during the next refresh cycle.

The operator can use a set of levers on the keyboard to position the cursor if he wishes. He can delete single characters or entire lines of text pressing the appropriate "Erase" key.

Most graphic display systems can be equipped with a light pen device (see lead photograph). Although this device is intended primarily for use in the graphic or vector drawing mode, it can be useful in the character mode as well. A light pen is a hand-held photosensitive device. Whenever the operator places the pen against a character on the CRT face, the light from the phosphor activates a photosensitive trigger circuit. The resulting signal interrupts the refresh buffer at that particular coordinate point on the CRT screen. Any commands from the keyboard that call for a change in the text under the light pen appear on the screen during the next refresh cycle.

Thus, in the character-plotting mode, a light pen is simply a convenient replacement for a lever-operated cursor. In the graphic-drawing mode, however, the light pen takes on a more dynamic function.

Operators can program a graphic display by typing a coordinate language program into the display buffer. Most graphic displays are so complicated, though, that such programs have to be computer-generated. Using a light pen in conjunction with an interactive graphic-display system bypasses the need for separate coordinate language programs.

In the graphic-plotting mode, the display buffer generates a cursor mark. This mark generally takes the form of an "X" or an asterisk. When the operator places the light pen over the cursor, the resulting signal enables a light-pen tracking circuit. As the operator moves the light pen across the face of the CRT, the tracking circuit moves the cursor

so that it is always positioned directly under the light pen.

The display buffer keeps track of the cursor's coordinates as the pen moves it across the face of the CRT. At every permissible plotting point in the 1024 × 1024 plotting matrix, the buffer accepts and stores the cursor's coordinates. During each refresh cycle the buffer tells the RPD controller to unblank the beam at all points the cursor has covered. As far as the operator is concerned, he is "writing with light" on the face of the CRT.

The operator can also place the light pen into an erase mode. In this mode, the light pen acts as an eraser to wipe out any lines it touches. In the "blank" mode, the operator can use the light pen to move the cursor around the screen without plotting or erasing any lines.

There are several other kinds of CRT pointing devices such as "joy-sticks," or tracking-ball controllers, and Rand tablets. These electromechanical devices are more expensive and complicated than the light pen and, consequently, are not in common use. These alternate pointing or drawing devices, however, do most of their own coordinate encoding. This eliminates much of the logic circuitry associated with light-pen display buffers.

Once the operator has completed his writing on the CRT, he can unload all the coordinate data into a processor memory or store it permanently on magnetic tape just like a conventional computer program.

The price tag on complete interactive graphic systems ranges from $10,000 to $50,000 for most models. The price depends largely on the size of the refresh memory, the type and amount of special generator hardware, and the flicker-free display capacity of the system.

Stroke-Generator Display Systems

A third major technique for developing video displays is accomplished by using a stroke-generator display system. This technique builds up graphic or alphanumeric displays from a series of short line strokes.

Rather than using counters and A/D converters to move the CRT beam from one incremental point to the next, the stroke generator develops smooth analog strokes in response to one-word commands from the display buffer.

It is possible to plot a perfectly smooth line of any slope or curvature by generating horizontal and vertical ramp signals having different amplitude ratios. One part of a stroke generator plot command, then, contains Y:X amplitude ratio information. To plot a vector with a slope of 2, for instance, the buffer sends digital commands to the analog ramp generators, telling them to produce a Y-ramp voltage that has twice the amplitude of the X-ramp voltage.

Getting the proper slope or curvature is only part of the stroke generator's problem—it must also generate continuous strokes of any desired length. There are two common ways of establishing the length of the strokes: the fixed-time method and the constant-rate method.

Using the constant-rate method, the beam travels along its stroke path at a fairly constant rate. A typical plotting rate for such a system is about 8 microseconds per inch. Part of the plot command word, then, contains bits that set the time a pair of X and Y ramp analog gates open to let the deflection signals through to the CRT.

The constant-rate method, unfortunately, makes the framing time and total flicker-free display capacity largely dependent on the length of the longest stroke in the display. Precise calibration of the hybrid (digital and analog) timing circuits also becomes a serious problem for terminal manufacturers trying to "economize" their products.

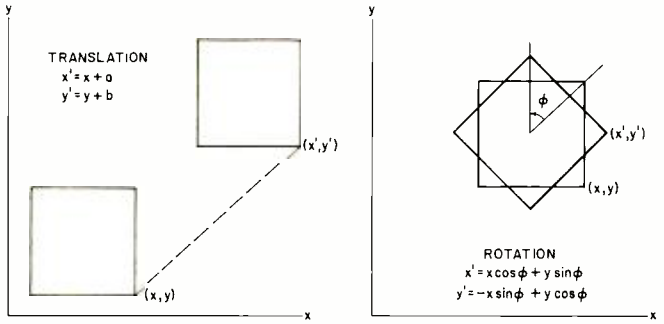


Fig. 3. Examples of kinds of (left) translations and (right) rotations made possible with graphic terminal/CPU system.

To make the system's display capacity less dependent upon stroke length, and then get around the problems of timing precision, many terminal manufacturers use the so-called fixed-time stroke generator. Such stroke generators still determine stroke angle or curvature by varying the ratio of the Y-ramp and X-ramp amplitudes. Instead of varying the time base of the ramps to get different stroke lengths, however, the fixed-time generator multiplies both ramp signals by a constant. The ratio of voltage is unchanged, but the plotting time changes to conform to the allowable writing time interval. Typical plotting times are in the neighborhood of 40 microseconds for all strokes.

Just as in the RPD systems, a new stroke always begins at the endpoint of the last stroke. The operator can move the starting point around simply by blanking the CRT beam and feeding in the appropriate stroke commands.

Stroke-generator systems also have special "add-on" circuitry to automatically generate patterns for alphanumeric characters. The characters in a stroke-generator system have a much smoother appearance than those in an RPD system. Stroke-generator systems are almost an order of magnitude faster than the typical RPD or digital system. This also means a tenfold increase in the flicker-free display capacity.

The main disadvantage of the stroke or analog graphic display terminals is the complexity of the analog circuitry. The biggest headache is maintaining the precise ramp phase relationships between the X and Y deflection systems. Any slight phase errors appear as distortions and "kinks" in the graphic displays.

As in any kind of present-day analog system, stability is possible only by using stabilizing circuits which rival the actual operational circuits in expense and complexity. Us-

(Continued on page 72)

The most critical specs for any kind of video display system are capacity of the refresher memory, maximum number of points per frame, number of characters per frame, and number of 1/2" lines or strokes the system can display without noticeable flicker. This table contains specs for a few of the graphic video terminals on the market. Ratio of display capacity figures to core size approximates design efficiency.

			FLICKER-FREE CAPACITY		
MFGR.	MODEL	REFRESH MEMORY SIZE (bits)	POINTS PER FRAME	CHARACTERS PER FRAME	½" LINES PER FRAME
Bunker-Ramo	DR-90	8K	888	6060	1777
Control Data	250	4-8K	13,333	6000	5797
Digital Equip.	338/339	4-32K	2222	666	235
ITT	OPSC	4K	4166	2720	4166
Philco-Ford	512	1-16K	2564	5555	1282
Raytheon	DIDS1500	4K	1365	4096	1360
RCA	6320	2-8K	555	3333	1111

SURVIVAL RADIO for APOLLO

By WILLIAM L. BLAIR / Project Manager, Cubic Corp., San Diego, Calif.

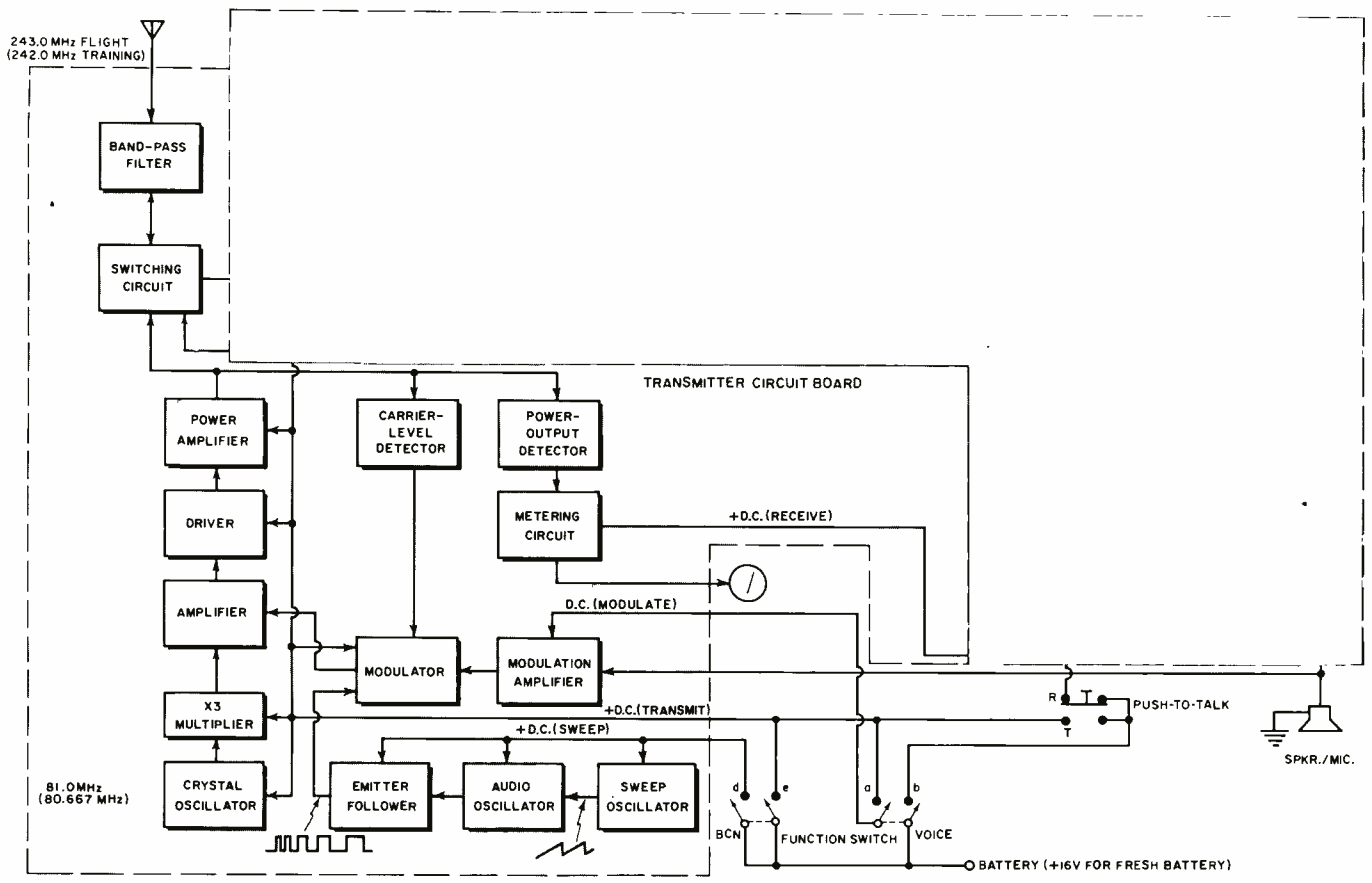
Description of life-raft voice and beacon transceiver with 1-watt output for 24-hour operation that is designed specifically for emergency communications.

Photograph of the highly reliable beacon/transceiver which is part of the Apollo astronauts' survival kit.

WHEN Apollo 12 lifted off from Cape Kennedy on its epic voyage to the Moon, the astronauts carried with them a new electronics package for which everyone hoped they would have no use. On this and all subsequent flights, the survival kit contains a new small, lightweight, highly reliable beacon/transceiver which would be used only in the event of mishap during the landing of the capsule upon its return to earth.

If the prime communications equipment within the spacecraft should be damaged or become inoperative, or if the crew were forced to abandon the command module in a life raft, this transceiver would be their only means of communication with the recovery team. It was designed to operate either with its own flexible quarter-wave whip antenna or through the spacecraft antenna system. The small hand-held unit has a self-contained battery sufficient to permit continuous beacon transmit operation at a minimum output of one watt for a period considerably in excess of 24

Fig. 1. Functional block diagram of the Apollo survival radio discussed in the article. Note that both the receiver and transmitter sections of this unit are enclosed in dotted boxes. Controls and the speaker are shown outside of boxed areas.



hours. Normal operation as a voice transceiver provides an even longer operating time. In the beacon mode, the output is square-wave modulated (50% duty cycle) by a swept frequency audio tone. It is easily recognized on the air by search aircraft using direction-finding equipment out to a distance of 100–125 nautical miles (radio line-of-sight). In the voice mode, two-way AM communication is available through a common speaker/microphone and Push-to-Talk switch control. The receiver delivers an output signal-to-noise ratio of +10 dB or better for inputs as low as 3 microvolts, thereby again affording good quality performance out to the radio line-of-sight.

Operation

The complete functional block diagram is shown in Fig. 1. The antenna circuit is matched for a 50-ohm load and a single two-pole band-pass filter is shared by both transmitter and receiver. A diode switching network isolates the receiver from the antenna when transmitting and *vice versa* when receiving. Fig. 2 is a schematic of the antenna coupling network.

Any signal on the 243-MHz emergency frequency is amplified by about 27 dB in three cascaded r.f. amplifier stages before conversion to the 15-MHz i.f. frequency in the active mixer. A crystal-controlled oscillator, followed by a frequency tripler, provides the local-oscillator signal.

The receiver passband shape factor is controlled by the four-pole i.f. band-pass filter immediately following the mixer. It is characterized by a 200-kHz 6-dB bandwidth and a 2-MHz 60-dB bandwidth. Three i.f. amplifiers, having a total of about 75 dB of gain, boost the received signal to a level appropriate for detection in a conventional diode circuit. A filter/amplifier network utilizes the d.c. components from the detector to provide a.g.c. to the second and third r.f. stages and the second i.f. amplifier stage. The a.g.c. action holds the output level essentially constant for inputs from threshold to more than 3000 μV.

The detected audio component is amplified to a 6-V peak-to-peak signal in a single audio-amplifier stage and is used to drive a 4000-ohm miniature speaker. When receiving a signal with 30% AM, an output sound level of 118 dB above 0.0002 dyne/cm^2 is produced. The audio 3-dB passband is in excess of 300 to 3000 Hz.

A single battery, which is made up of a series of twelve wound-anode mercury cells, is used to provide all the power required to operate the complete transceiver. The battery was selected because of its high energy-to-weight ratio, its low internal impedance, its relatively flat voltage characteristic, and its improved low-temperature performance. A fresh battery has a no-load output of about 16 volts and the end point, considered as battery exhaustion, is 11 volts. In the receive mode, a series-pass type regulator is used to hold the voltage applied to the receiver circuits constant so that performance characteristics are maintained throughout the battery lifetime. Since much higher currents are drawn from the battery in the transmit mode, a series regulator would be highly dissipative and is not used. Rather, an automatic level control (a.l.c.) circuit is used to stabilize transmitter performance over the range of applied voltage.

A miniature ruggedized meter is used to indicate battery status when the transceiver is in the receive mode. The circuit is designed to produce full meter deflection for a fresh battery (16 V) and zero for an expended battery (12 V in the receive mode). In the voice-transmit mode this meter indicates carrier power output and the operation of the voice modulator, while in the beacon-transmit mode it indicates peak power output and modulation presence. Since a sample of the r.f. signal is detected directly at the transmitter output, meter deflection is an indication that all transmitter circuits are operative.

The transmitter consists of five transistorized stages. A fifth overtone crystal-controlled oscillator operates at 81

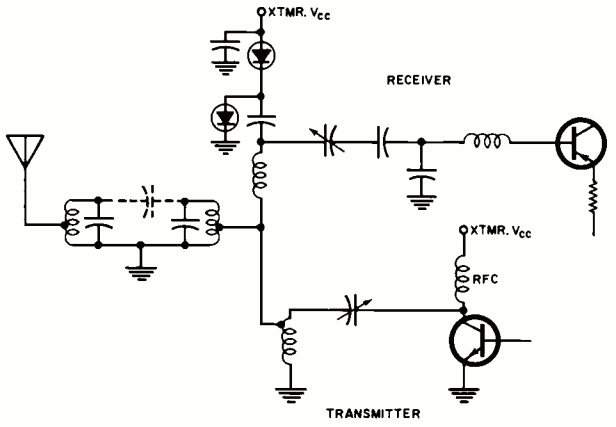


Fig. 2. Schematic diagram of the antenna coupling network.

MHz and drives a frequency tripler to an output at 243 MHz. The amplifier following the tripler is collector modulated by either the beacon or voice signal. The driver and final stages are operated as class-C amplifiers to a peak power output capability in excess of 3 watts.

In the beacon mode of operation the detected r.f. sample from the tank circuit of the final power-amplifier stage is fed back and amplified in the modulator, together with the adjustable square-wave voltage level to reduce the peak output level to about 1.25 watts with a fresh battery. The loop gain is sufficient to hold this output level constant until the battery voltage drops well below 13 volts. At the battery-exhaustion voltage (11 V), the peak output power is still at least 1 watt.

In the voice-transmit mode, the unmodulated level is held at 0.5 watt by the automatic level-control signal and an adjustable d.c. bias voltage. The sum of the d.c. bias voltage and the automatic level-control signal is used to adjust the base bias voltage of the modulator transistor. This stage, in turn, varies the collector voltage of the modulated transmitter stage to provide a constant carrier output power. When the transmitter is voice-modulated, the negative feedback also compensates for the distortion which would be experienced in the class-C driver and output stages. The 3-watt peak-power capability allows 100% upward and

Fig. 3. Simplified schematic diagram showing the functional relationship of transmitter modulation and a.l.c. circuits.

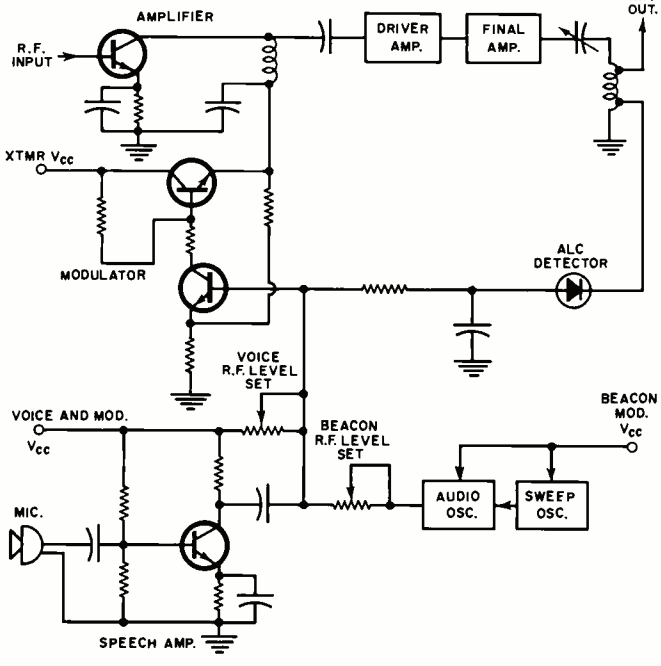


Fig. 4. Transceiver with covers removed. Battery pack shown on right is contained in the cylindrical compartment and retained by the screw-on cap shown. The electronics package, containing the receiver and transmitter circuit boards, becomes accessible when the flat cover is removed. The flexible quarter-wave whip antenna can be seen in the foreground.

downward modulation. A single audio-amplifier stage raises the relatively high output from the microphone to a level sufficient to produce over 90% modulation of the output carrier when speaking in a normal voice a few inches from the microphone.

The square-wave beacon modulation signal is generated by a multivibrator circuit. The frequency of the multivibrator is dependent upon bias voltage on the transistor bases, which in this case is supplied by the output of a sawtooth waveform generator. The sawtooth frequency is about 2.5 Hz and sweeps the square-wave frequency from 1000 Hz to 300 Hz linearly, returning instantaneously to 1000 Hz where the cycle is repeated. The output of the multivibrator is coupled through an emitter-follower to the same modulator stage used for voice transmission. Fig. 3 is a simplified schematic showing how the modulation and a.l.c. circuits are interconnected.

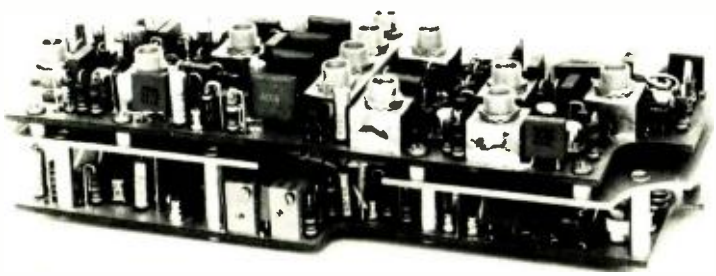
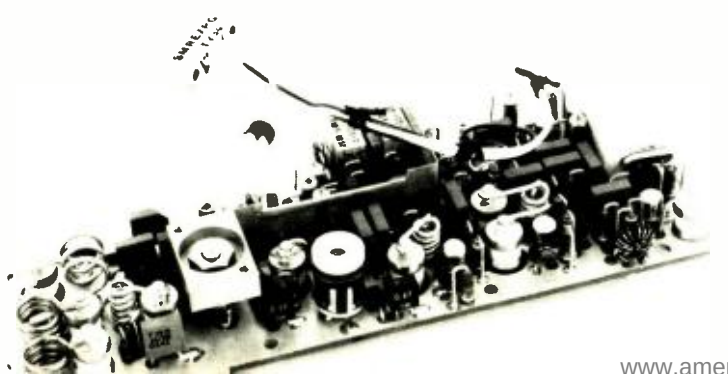


Fig. 5. Electronics package showing receiver circuit board mounted on top and the transmitter circuit board on bottom.

Fig. 6. Voice and beacon modulators and transmitter board.



Operating Controls

Only two controls are required to operate the radio. A function switch places the unit in "Off," "Voice," or "BCN" (beacon) modes. This switch contains a magnet imbedded in one side of the round thumb-operated knob. As the magnet is moved into each position it activates reed switches inside the case without the need for a mechanical linkage to pass through the side of the housing. The second control is a Push-to-Talk switch, which is used to change from receive to transmit when operating in voice mode.

Packaging

Mechanical packaging was a challenging design task because of size and weight limitations and rather severe environmental requirements. The requirements of 80 cubic inches and 64 ounces were achieved (actual volume, 50 cubic inches) and the equipment successfully passed qualification which included:

1. Specified performance at +140°F after storage for seven hours at +160°F, followed by five minutes at 200°F.
2. Specified performance at +32°F after storage for four hours at –60°F.
3. Survival and subsequent operation after 20-G acceleration, 78-G shock, and 0.06 G^2 - Hz random vibration over the band of 80 to 2000 Hz.
4. Specified performance and proof of water-tight integrity following exposure to 10 cycles from 0° to +160°F at a pressure of 10^{-8} PSIA and subsequent immediate immersion under 15 feet of seawater for a one-hour period.

Fig. 4 shows the transceiver with covers removed. The housing is an aluminum casting with separate sealed compartments for battery and electronics. The battery constitutes almost one-half the weight and size of the transceiver. It is contained within a cylindrical compartment on one side of the casting and is retained by a screw-on cap which uses an "O"-ring seal. A coaxial connector permits rapid replacement of an expended battery and the separate compartment avoids the possibility of water entering the electronics compartment in case of battery replacement in heavy seas.

Access to the electronics compartment is achieved by removal of a flat cover having a molded butyl-rubber seal. There are only four other openings in the walls of the electronics compartment. The speaker/microphone is sealed into its mounting hole by a rapid curing epoxy, while the sealed meter and Push-to-Talk switch are sealed in their mounting holes by using RTV (silicone rubber adhesive/sealant). The fourth hole is used to mount the antenna jack and is sealed by an "O"-ring. The function switch does not require a sealed rotary joint since it uses magnetic switching as described previously.

The electronics package is shown in Fig. 5. It consists of an aluminum support plate to which two printed-circuit boards and a d.c. connector are attached. All case-mounted elements, including battery and function switch, are connected to the circuitry through this plug. The antenna is connected through a short length of cable in a microminiature coaxial plug to a mating jack on the transmitter board.

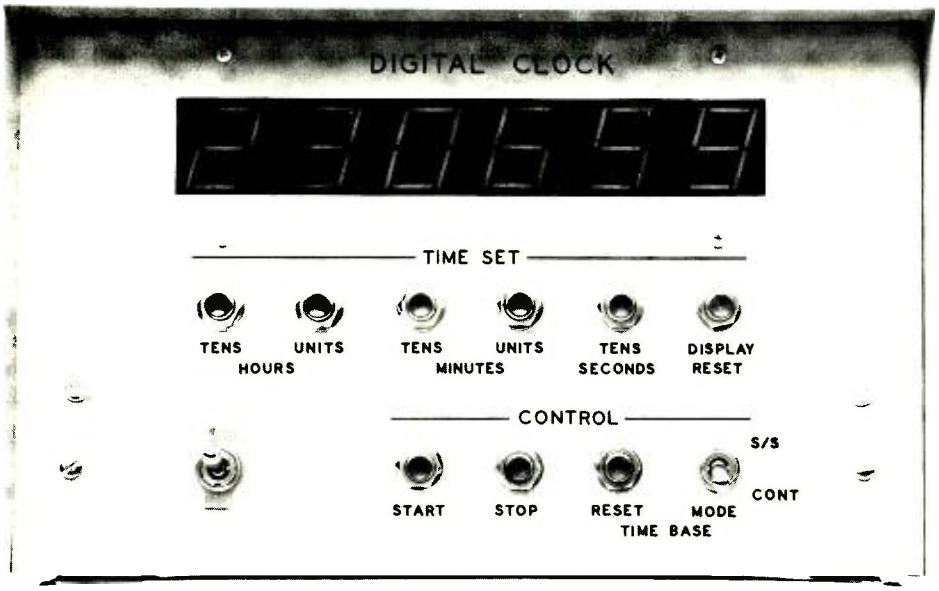
The top board in Fig. 5 contains the receiver circuitry. This board is mounted conventionally to short threaded stand-offs with the parts side up. The four variable capacitors which tune the four-pole i.f. filter may be seen running across the short dimension of the board at its approximate midpoint. Space conservation in the tuned circuits of the r.f. stages is achieved by winding the inductors directly around the bodies of the piston-type variable capacitors, which serve as coil forms.

High density is obtained by mounting most parts, includ-

(Continued on page 59)

Digital Instruments

Part 4—24-Hour Digital Clock



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

Design details on a 24-hour digital clock that displays time in an hours, minutes, seconds format. Contains circuits that allow for setting or updating displayed time and for both starting and stopping clock without upsetting time-base synchronization.

Front-panel view of digital clock showing arrangement of controls that are described in the article

THE simplest form of 24-hour digital clock is shown in Fig.1. It counts 1-pps pulses from a time-base generator and displays, in an hours: minutes: seconds format, the number of pulses counted. The first two stages (÷10 and ÷6) count to 60, providing an output to the next two stages (the minutes counter) every 60 seconds. The minutes counter also counts to 60 and every 3600 seconds (or 60 minutes) it provides an output to the hours counter. The hours counter counts to 24 and every 24 hours (or 86,400 seconds) the entire counting cycle repeats.

The decoders monitor the states of the counters, and their outputs cause the appropriate numerals to appear on the visual display. The digital clock does nothing more than count the 1-pps time-base input signal, hence the accuracy of the clock is identical to that of the time-base input pulse timing.

As with all digital instruments, the readout resolution of the digital clock implies a degree of accuracy that may not, in fact, exist. If the time-base is derived from the local 60-Hz power-distribution system, the indicated *vs* actual time may wander around several seconds during a day, yet the effect of these variations cancels, yielding excellent long-term stability. A crystal-oscillator time-base, on the other hand, may exhibit variations in period of only a few microseconds during the course of a day, but initial frequency offset and

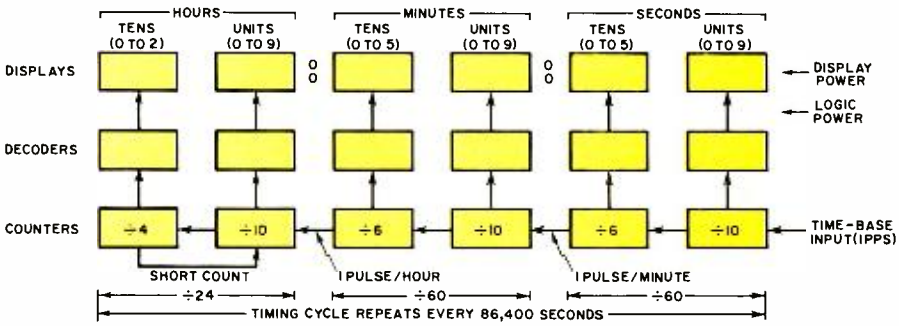
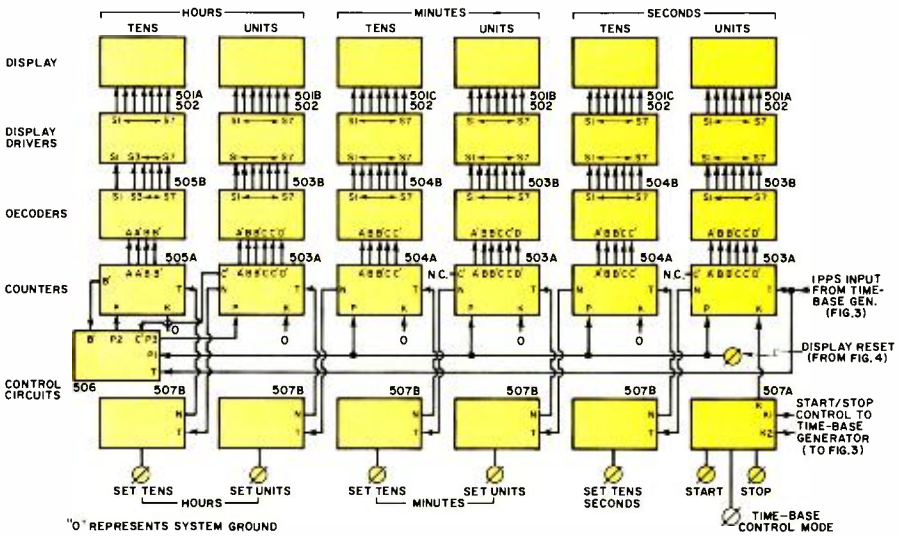


Fig. 1. Simple 24-hour digital clock that counts 1 pps from time-base generator and displays in an hours, minutes, seconds format number of pulses.

Fig. 2. Detailed block diagram of the 24-hour digital clock described in article. See Table 1 for logic diagram reference for each of indicated modules.



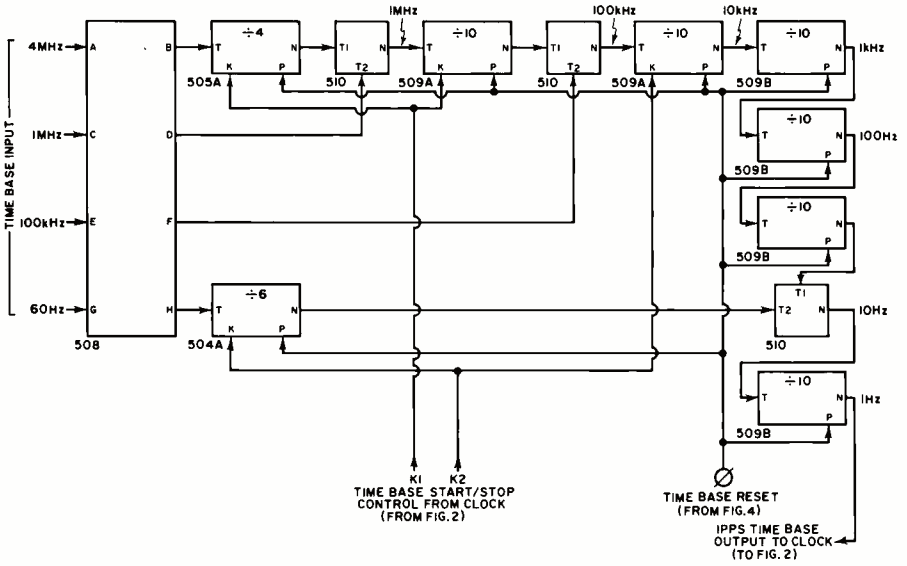


Fig. 3. Block diagram of time-base generator that accepts either 60-Hz, 100-kHz, 1-MHz, or 4-MHz input frequencies and develops a 1 pps time-base output. Refer to Table 1 for cross-references to the logic diagrams for the indicated modules.

drift due to crystal aging produce a cumulative long-term timing error that must be corrected occasionally.

The simple clock in Fig. 1 does not provide for setting or updating the displayed time or for starting and stopping the clock without upsetting the time-base synchronization. When these additional circuits are added, the block diagram of the 24-hour clock described in this article evolves (Fig. 2.) The companion time-base generator appears in Fig. 3, and the power supply in Fig. 4. Each of the blocks in the diagrams of Figs. 2 and 3 represents a major functional subsystem made up of one or more IC's and/or discrete components. The 500-series numbers adjacent to each of the blocks (modules) identify the associated logic diagram or schematic diagram from which that module is constructed, as cross-referenced in Table 1.

Design Comments

The complete design of the digital clock and the time-base generator reflects the author's initial design objectives which include:

1. All internal counting is in the BCD (binary coded decimal) format (so that the clock can readily interface with other elements of a larger digital system).

2. The decoded display output information is in a 7-line code, providing a ground-circuit completion capable of switching 40 V d.c. at 25 mA d.c. or 25 V d.c. at 50 mA d.c. (capable of switching low-voltage incandescent loads directly; ideally suited for operation of a remote display; directly compatible with seven-segment display, removing any limitation on physical size of display).

3. All operating power is derived from a single 12-V d.c. input (allows a 12-V storage battery to function as a standby power supply).

4. RTL (Resistor-Transistor Logic) IC's are used throughout, and the number of functions in any one package is limited (reduces IC costs and limits system repair cost in the event of a single logic element failure in an IC package, while retaining +15° C to +55° C operating temperature range with option to extend IC temperature to 0° C to +75° C).

5. The time-base generator accepts input frequencies of 60 Hz, 100 kHz, 1 MHz, and 4 MHz (accommodates 60-Hz line frequency, 100-kHz and 1-MHz conventional standard frequencies, and 4 MHz from a commercially available high-performance yet inexpensive crystal oscillator).

6. The time-base generator 1-pps output may be readily synchronized to WWV timing ticks. The displayed time may be changed (*e.g.*, from GMT to local time) without upsetting the time-base generator synchronization.

At the risk of offending the purists, the author has taken the liberty of defining midnight as 24:00:00 rather than 00:00:00. The last two stages of the counting chain (the hours counters) are a modulo-10 counter (503A) followed by a modulo-4 counter (505A) capable of counting to 40 but forced to reset one second after a count of 24 is reached. This approach represents a considerable simplification over the other alternatives of (1) combining the last two stages into a composite modulo-24 counter and decoding the resultant 24 counter states to drive two seven-segment dis-

Fig. 4. Simplified schematic of power supply and 4-MHz crystal oscillator used with the digital clock shown in Fig. 2.

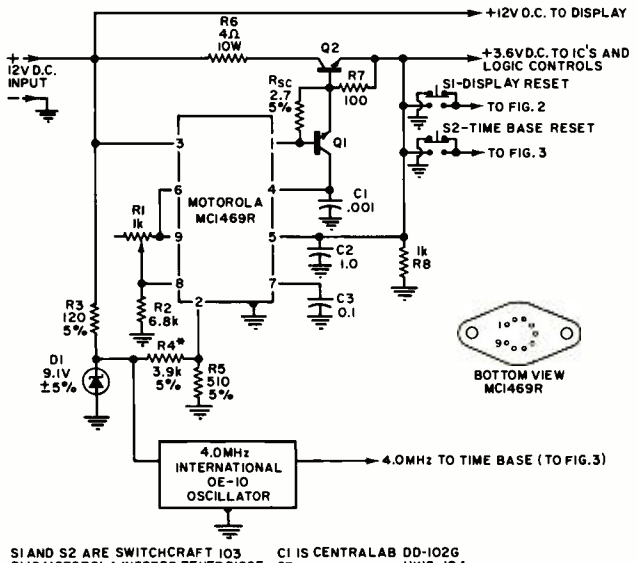
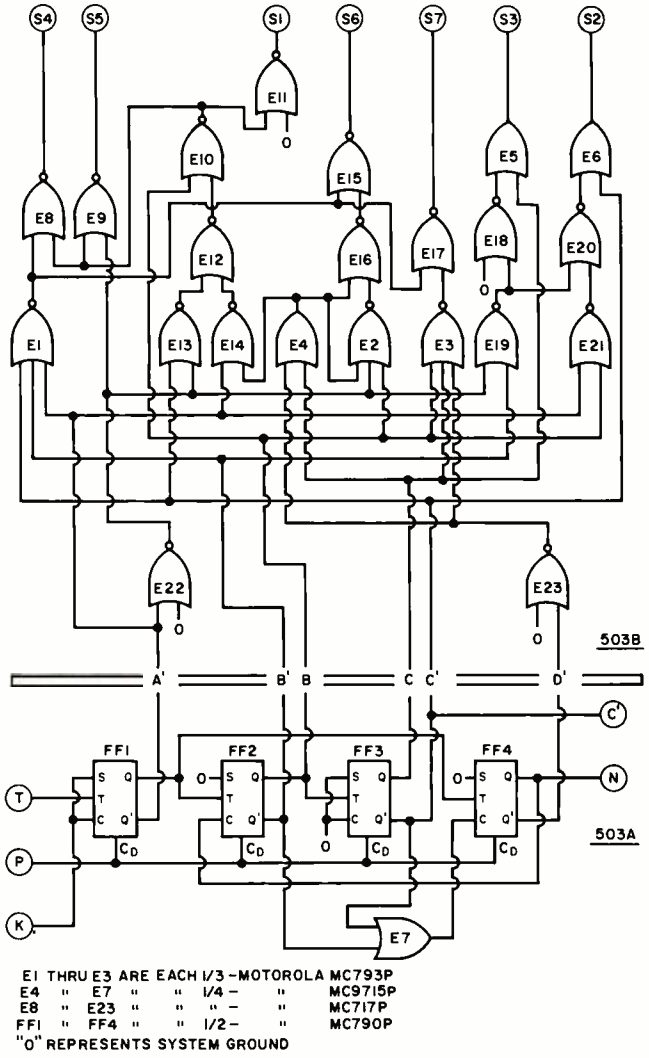


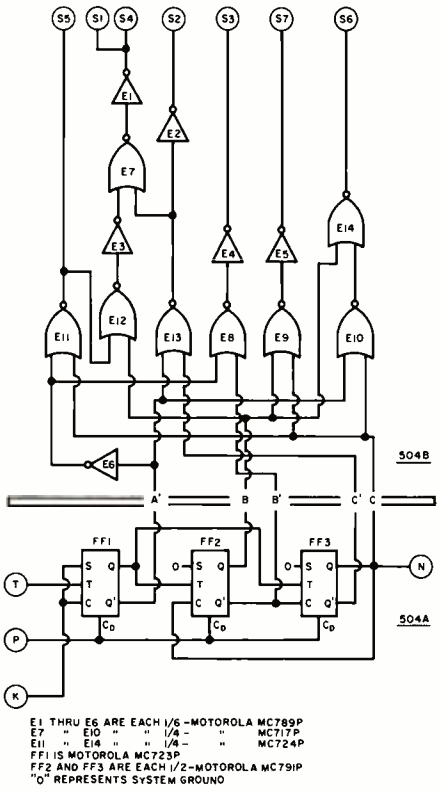
Table 1. Listing of function and logic figure cross-references for each of the modules used in constructing 24-hour clock.

MODULE	FUNCTION	FIG. REF.
1. 501A, 501B, 501C	Dialight seven-segment digital readouts	8B
2. 502	Display drivers	8A
3. 503A, 503B	Modulo-10 binary counter and BCD-to-seven segment decoder (0 through 9)	5
4. 504A, 504B	Modulo-6 binary counter and BCD-to-seven segment decoder (0 through 5)	6
5. 505A, 505B	Modulo-4 binary counter and BCD-to-seven segment decoder (0 through 2)	7
6. 506	Twenty-fourth hour detector and hours reset generator	10
7. 507A 507B	Start/Stop control circuit Time-set circuit	9A 9B
8. 508	Time-base input circuit	11
9. 509A	Minimum-hardware modulo-10 counter	12
10. 509B 510	Decade divider Selector gate	13A 13B



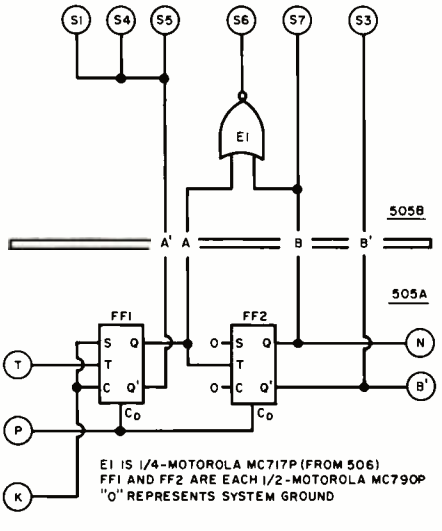
E1 THRU E3 ARE EACH 1/3 -MOTOROLA MC793P
E4 " E7 " " 1/4 - " MC9715P
E8 " E23 " " " - " MC717P
FF1 " FF4 " " 1/2- " MC790P
"0" REPRESENTS SYSTEM GROUND

Fig. 5. Logic diagram of modulo-10 binary counter and BCD-to-seven segment decoder used with drivers and readouts of Fig. 8.



E1 THRU E6 ARE EACH 1/6 -MOTOROLA MC789P
E7 " E10 " " 1/4 - " MC717P
E11 " E14 " " 1/4 - " MC724P
FF1 IS MOTOROLA MC723P
FF2 AND FF3 ARE EACH 1/2-MOTOROLA MC791P
"0" REPRESENTS SYSTEM GROUND

Fig. 6. Logic diagram of modulo-6 binary counter and BCD-to-seven segment decoder used with drivers and readouts of Fig. 8.



E1 IS 1/4-MOTOROLA MC717P (FROM 506)
FF1 AND FF2 ARE EACH 1/2-MOTOROLA MC790P
"0" REPRESENTS SYSTEM GROUND

Fig. 7. Logic diagram of modulo-4 binary counter and BCD-to-seven segment decoder used with drivers and readouts of Fig. 8.

plays, or (2) sensing a system time of 23:59:59 to generate an hours-reset signal when the last four digits display :00:00 for the 24th time. A 12-hour clock would probably utilize a modulo-12 hours counter since the time displayed must advance from 12:59:59 to 01:00:00.

The capability of presetting each digit of the clock to any arbitrary number within its counting range allows the clock to be corrected and synchronized at any time. The less elegant methods of resetting the clock to 00:00:00 or simply stopping it for a period of time are not attractive since a waiting period of up to 24 hours could conceivably be required before the clock could be synchronized. The idea of advancing the time at an accelerated rate was discarded because of the considerable time that would still be required to set the clock and the lack of complete control over each digit. Gating the 1-pps clock pulse input directly into each counter appeared to have possibilities, but analysis showed a high probability of an additional clock pulse being generated during the gating process. Finally, the most desirable approach of presetting the desired time *via* switches and gating that information into the counters at the required instant was discarded because the additional complexity to accomplish such a menial task was unwarranted. The approach finally chosen, that of resetting the clock display to 00:00:00 and advancing each digit by one each time its associated push-button is depressed and released, has proven to be a most satisfactory compromise between operational convenience and circuit complexity.

The 503A, 504A, and 505A modules (Fig. 2.) are modulo-10 (Fig. 5), modulo-6 (Fig. 6), and modulo-4 (Fig. 7) binary counters, respectively. Terminal T is the clock-pulse input to the counter, N is the output to the next stage, and P is used to preset all counter flip-flops to the "0" state. Input K serves as a counter disable control; the first FF in the counters cannot toggle unless K is "0."

The data outputs of the counters are connected to companion BCD-to-seven-segment decoders. The decoders (503B and 504B) for the first five counters are exactly as described in the second article of this series (August issue). The decoder (505B) for the hours-tens counter includes only those elements necessary to identify the first three states (0,1, and 2) of the hours-tens counter, since the associated displayed digit never exceeds 2.

The display driver (502 modules) transistors (Fig. 8A) conduct whenever a logic "1" level is present at the input side of the base resistors. The transistor and resistor associated with segment S2 of the hours-tens display is not required, since it is not necessary to open the return path associated with that segment. Either *Motorola* MPS5172 or MPSA20 transistors may be used in the display drivers. The MPS5172 is suitable for circuits carrying up to 25 V d.c. and

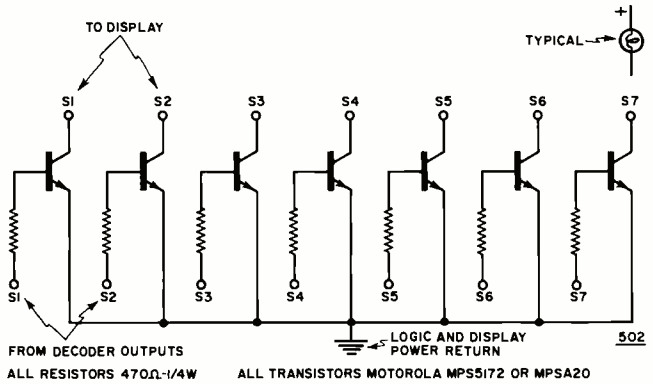


Fig. 8. (A) Schematics of display drivers and (B) layout and terminal arrangement of Dialight 7-segment digital readouts.

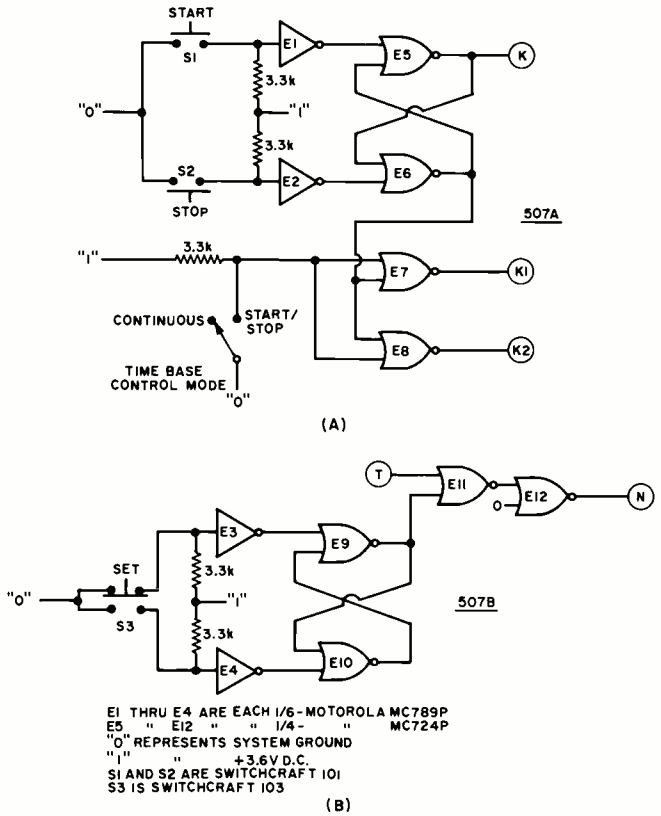


Fig. 9. Logic diagrams of the (A) Start/Stop control circuit (507A) shown in Fig. 2 and of the (B) Time-Set circuit shown in Fig. 2.

50 mA; the MPSA20 is a lower *beta*, higher voltage device suitable for circuits carrying up to 40 V d.c. and 25 mA. The base drive to each transistor is 640 μA minimum.

The seven-segment displays (501 modules), Fig. 8B, are *Dialight* 710 Series described in the first article of this series (July issue). When equipped with #344 bulbs (10 V at 14 mA, 15 V at 18 mA), they are compatible with either the MPS5172 or MPSA20 transistors, and provide excellent brightness when operating from 12 volts d.c.

The 507A module (Fig. 9A) generates the start and stop control signals for the clock and the time-base generator. The two 2-input *nor* gates, E5 and E6, are connected as an RS flip-flop whose inputs are supplied by inverters E1 and E2. When the "Start" switch is depressed (closed) the input to E1 is grounded and its output is at the "1" level, driving terminal K to "0." Since both inputs to E6 are "0," its output is "1," and that output applied to the other input of E5 holds E5's output at "0" even when the "Start" switch is released. The RS FF latches in the opposite state (K="1") when the "Stop" switch is closed momentarily. When the "Time Base Control Mode" switch is in the "Start/Stop" position, gates E7 and E8 function as inverters and the level at K appears at K1 and K2, supplying the start and stop signals to the dividers in the time-base generator (Fig. 3). When the "Time Base Control Mode" switch is in the "Continuous" position, K1 and K2 remain at "0" regardless of the level on K. The seconds-units clock counter (Fig. 2) is inoperative when K is "1;" four of the dividers in the time-base generator (Fig. 3) are inoperative whenever K1 and K2 are "1."

The Time-Set (507B) module (Fig. 9B) also uses an RS FF circuit, but for its "noiseless-switch" properties rather than its latching action. The output of gate E9 is normally "0," and clock pulses pass uninverted through gates E11 and E12 from one counter stage to the next. If the clock is stopped, and the level on input T is "0" (assured if the "Display Reset" switch, Fig. 4, is momentarily closed), depressing and releasing the "Set" switch causes a "0"-to-"1"-to-"0" transition at output N. The "1"-to-"0" transition is interpreted as a clock pulse by the next counter stage and it advances one count. Note that the time-setting activity must begin with the hours-tens counter in order that the output of the preceding counter be "0." The seconds-units digit is advanced by starting the clock and stopping it when the desired seconds-units digit appears.

The twenty-fourth hour detector and hours-reset generator (506) module (Fig. 10) is made up of a JK FF and five *nor* gates, three of which are connected simply as inverters. If the "Display Reset" switch is momentarily depressed at least once after application of power to the clock circuits, FF1 will be in the "0" state, and P2 and P3 will be "0". The B' and C' inputs to gate E1 (Fig. 10) are both "0" for the first time when the hours display indicates 24:. At all other times, either B' or C' is "1" and C of FF1 is "1." Thus, FF1 remains in the "0" state in spite of the clock pulses that occur once each second at T. When the displayed time advances from 23:59:59 to 24:00:00 the level at C of FF1 steps from "1" to "0." When the next clock pulse arrives at T of FF1, it toggles to the "1" state and the levels of P2 and P3 step from "0" to "1," resetting both hours counters; the displayed time is now 00:00:01. At the same time, C of FF1 steps from "0" to "1." One second later FF1 toggles back to the "0" state and P2 and P3 step from "1" to "0," removing the reset signal from the hours counter.

The time-base input (508) module (Fig. 11) conditions the 60-Hz, 100-kHz, 1-MHz, and 4-MHz input signals so that their levels and fall times are compatible with the requirements of the JK FF's in the time-base generator divider circuits. The coupling capacitors (Fig. 11) may be eliminated if the peak input signal excursions are less than ±4 V with respect to ground *and* the input signal passes through 0.75 V and 1.4 V once each cycle. A sinusoidal input signal of about 500 mV r.m.s. is required if the capacitors are used. The 508 module diagram assumes that only one input signal will be electrically connected to the time-base generator at any given time; if this is not the case, then the three Schmitt triggers not associated with the desired input signal must be disabled. This may be accomplished by connecting

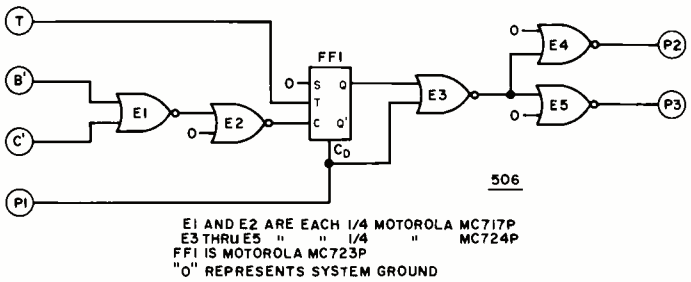


Fig. 10. Logic diagram of the twenty-fourth hour detector and hours reset generator circuit (506) shown in Fig. 2.

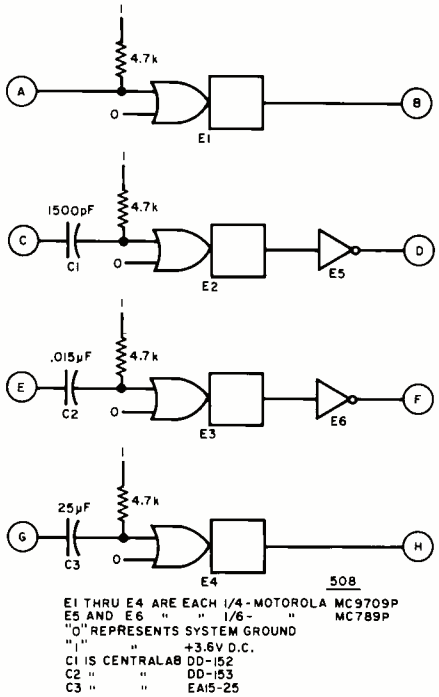


Fig. 11. Logic diagram of time-base input circuit shown in Fig. 3.

the second input of each Schmitt trigger (presently shown at the "0" level) to +3.6 V d.c. through a 3.3k resistor. The desired input signal is then selected by grounding the second input of that Schmitt trigger through a toggle switch. Inverters E5 and E6 follow the Schmitt triggers E2 and E3 so that outputs D and F are "0" when E2 and E3 are disabled or when their input signals are disconnected.

The 4-MHz and 60-Hz signals are divided by 4 and 6, respectively, so that they may be gated into the decade divider (509A and 509B) chain, Figs. 12 and 13A, respectively, along with the 1-MHz and 100-kHz signals (Fig. 3). Gating (510) is accomplished with a *nor* gate, E1, and inverter, E2, connected as an *or* gate (Fig. 13B). The "Time Base Reset" switch (Fig. 4) must be closed momentarily when a new input signal is selected, to assure that inactive gate inputs are at the "0" level.

The 4-MHz crystal oscillator (see Fig. 4) is an *International Crystal* OE-10. These oscillators are available at any frequency from 3 MHz to 20 MHz and remain within 0.0005% of the specified frequency over a range of −10° C to +60° C. A zero-adjust trimmer is provided and frequency *vs* temperature data is supplied with each unit. The oscillator output is fed directly to Schmitt trigger input.

Power requirements of clock and generator are:

1. OE-10 Oscillator	4.5 mA
2. Time-base generator	3.6 V d.c. at 650 mA continuous 3.6 V d.c. at 800 mA during reset
3. Clock	3.6 V d.c. at 860 mA continuous 3.6 V d.c. at 950 mA during reset
4. Display	12 V d.c. at 260 mA with 16 bulbs illuminated (11:11:11) 12 V d.c. at 670 mA with 43 bulbs illuminated (08:08:08)

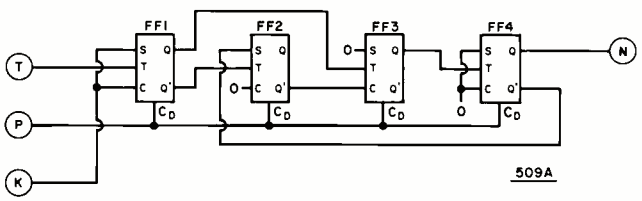
The display is powered directly from the 12-V d.c. source, the OE-10 oscillator supply voltage is developed across the 9.1-volt zener diode, and a *Motorola* MC1469R positive power-supply voltage regulator IC derives the 3.6-volts for the RTL IC's. Resistor $R1$ allows the 3.6-V output to be set anywhere from 3.5 to 4.0 volts. Transistors $Q1$ and resistor R_{SC} limit the MC1469R output current to approximately 220 mA in the event of an open in $Q2$'s collector circuit (or an emitter-base short in $Q2$). The voltage developed across $R5$ will cause the MC1469R to shut down if the chip temperature reaches a nominal 95° C. Resistor $R6$ reduces $Q2$'s power dissipation from 12.6 watts with a 1.5-A load (without $R6$) to 4.4 watts maximum under any load condition, and limits the collector current of $Q2$ to 3 A under short-circuit conditions.

Assembly

The package pin connections of the IC's used in the clock and time-base generator may be obtained free of charge by writing to *Motorola Semiconductor Products Inc.*, 5005 East McDowell Road, Phoenix, Arizona 85008 for the data sheets and brochures on the specific IC and semiconductor type numbers. In addition, copies of "The Semiconductor Data Book" and "The Micro Electronic Data Book" may be purchased from *Motorola* or many of the larger electronics parts distributors. These books contain complete specifications on all *Motorola* semiconductors and integrated circuits. This information, together with the module diagrams (Figs. 5-13) may be used to assemble each module or group of modules. The modules are interconnected as shown in Figs. 2 and 3. Although not shown on the module diagrams, pin 11 of every IC is connected to +3.6 volts d.c. and pin 4 of every IC is grounded. The clock and time base require a total of 60 IC's, 41 transistors, and 58 resistors.

"P" pattern "Micro-Vectorbord" (*Vector Electronic Company*) is ideally suited for this type of construction, eliminating the task of drilling well over 1000 holes. The $6\frac{1}{2}$" × $4\frac{1}{2}$" × $\frac{1}{16}$" size accommodates all of the circuitry required

(*Continued on page 73*)

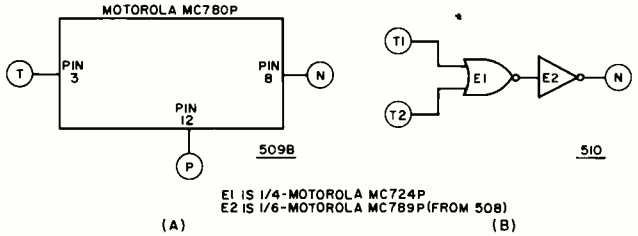


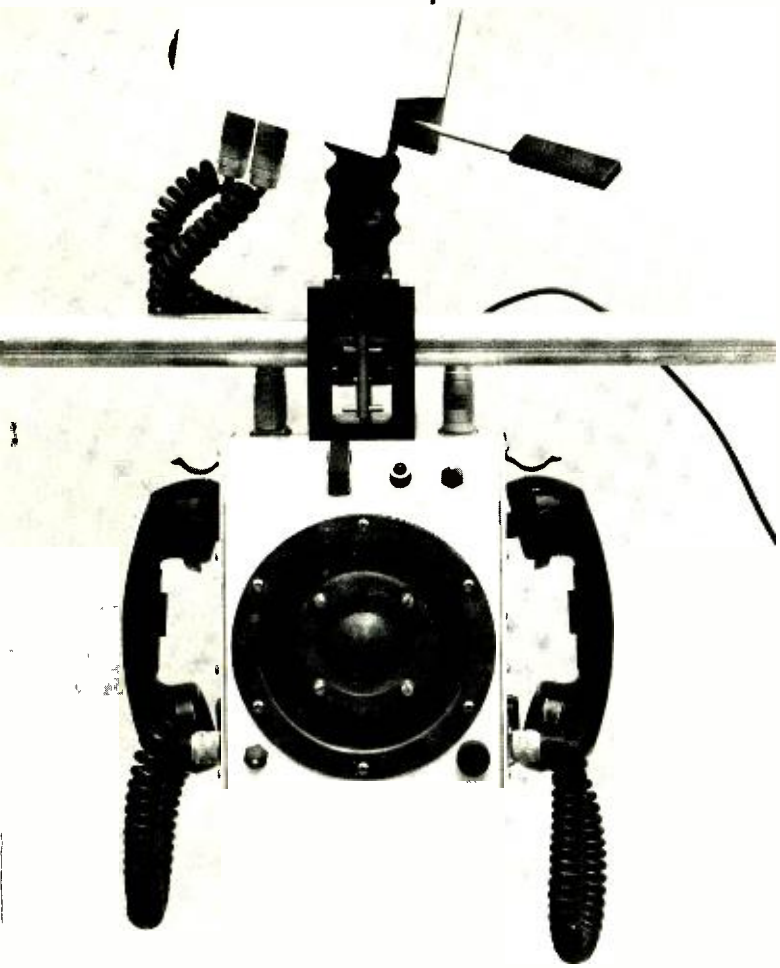
	INTERNAL LEVELS											
AFTER	S1	C1	Q1	S2	C2	Q2	S3	C3	Q3	S4	C4	Q4
CLEAR	0	0	0	1	0	0	0	1	0	0	0	0
CP1	0	0	1	1	0	1	0	0	0	0	0	0
CP2	0	0	0	1	0	1	0	0	1	0	0	0
CP3	0	0	1	1	0	1	0	0	1	0	0	0
CP4	0	0	0	0	0	1	0	0	0	0	0	1
CP5	0	0	1	0	0	0	0	1	0	0	0	1
CP6	0	0	0	0	0	0	0	1	0	0	0	1
CP7	0	0	1	0	0	1	0	0	0	0	0	1
CP8	0	0	0	0	0	1	0	0	1	0	0	1
CP9	0	0	1	0	0	0	0	1	1	0	0	1
CP10		0			0			0			0	

FF1 THRU FF4 ARE EACH 1/2-MOTOROLA MC790P
"0" REPRESENTS SYSTEM GROUND

Fig. 12. Logic diagram and the state table for the minimum-hardware modulo-10 counter circuit (509A) shown in Fig. 3.

Fig. 13. Diagrams of the (A) decade divider circuit (509B) and of the (B) selector gate circuit (510) shown in Fig. 3.





Laser-Beam Communicator

By JULIUS LEVINE
Director, Electronics Div., Holobeam, Inc.

High-quality voice riding on laser beam is used in Navy ship-to-ship communications system.

Fig. 1. Fixed version of optical communications system. Unit is attached to ship's personnel rail and is equipped with 15-W public-address system in addition to push-to-talk handset.

THE portable laser optical communications system (OCS) provides a secure audio link in the presence of electrical, optical, and audio disturbances. The gallium arsenide *(GaAs)* laser beam is invisible since the emitted light is in the infrared region (9050 Å at room temperature); is completely safe for the human eye (peak energy density is 0.7 $\times 10^{-7}$ joule/cm^2); has a potential line-of-sight range of about 10 miles; audio information quality transmitted by the beam is independent of laser output power variations; and a variety of coding schemes can be incorporated to increase the security of the information transmitted.

The system was developed and manufactured by *Holobeam, Inc.* for U.S. Navy ship-to-ship communications during refueling operations on the high seas. Among the major reasons for the Navy to seek such a system was poor reliability of their radiotelephones and the anticipated need to refuel ships under conditions of radio silence.

Two OCS configurations have been produced and delivered to date; a fixed system (Fig. 1) and a portable unit (Fig. 2). The fixed transceiver is attached to a ship's personnel rail. In addition to a push-to-talk handset, the fixed transceiver is also equipped with a 15-watt public-address system. The fixed OCS is unidirectional since each transceiver uses only one laser diode for transmission and one silicon photodiode for reception.

The portable OCS (Fig. 2) consists of a transceiver optics system mounted on top of the helmet, an electronic pack, and a battery pack (not shown). Three additional receiver photodiodes are mounted on the helmet—one on each earpiece and one on the back. Consequently, moving the head does not affect the reception quality and, in this sense, the portable OCS is omnidirectional.

Both the fixed and portable OCS's in this application are designed to provide voice communications over 250 feet, which is only a small part of their potential maximum range. The main reason for setting the laser helmet optics for such a short range is that when this particular system is in operation, the ships being refueled are in close proximity. Another reason is the wide laser beam divergence possible at this short distance. Thus, both units provide beams 75 feet in diameter at 250 feet. Such a wide beam divergence eliminates any need for accurate laser aiming and assures reliable communications even while the ship being refueled pitches, rolls, and yaws.

The successful field performance of the OCS can be attributed to two major design innovations: the pulse position modulation (PPM) technique whereby audio (analog) information is converted at the transmitter (Fig. 3) directly into pulse position in time and reconstructed at the receiver (Fig. 4) directly without the commonly used A/D and D/A converters; and the design of a low-voltage (40-volt d.c.) pulsed laser power supply capable of producing fast (80-ns) high-current (40-amp) pulses at a 8-kHz repetition rate. The PPM insures clear reception independent of wide variations in the laser output power. The successful design of a low-voltage power supply in place of a conventional high-voltage unit resulted in a smaller and lighter power-supply package—a major consideration in portable equipment.

Pulse Position Modulation

One reason for devising the PPM technique used in this OCS is that it is extremely difficult, if not impossible, to keep the *GaAs* laser light power output at some constant level. Thus, any kind of amplitude-modulation scheme depending on a constant laser power output would be very complex and unreliable.

In general, the operation of a gallium-arsenide laser depends on the amplitude, width, and repetition rate of current pulses applied to it. Making the pulse width sufficiently narrow and the repetition rate sufficiently low, the laser output power will then depend solely on the magnitude of the applied current.

Selection of a value (or values) for this current must be made on the basis of current *versus* temperature for the particular laser diode type. Characteristically, no single current value can be chosen if the laser is to operate over a relatively narrow temperature range. For example, if the laser input current is kept constant over a temperature range of –15° to +55° C, no output will be obtained at approximately 40° C with the maximum output power obtained at approximately –15° C rather than at room temperature.

	DFS		OCS	
	Infantry	Large Gun	Fixed	Portable
Range	500 meters	3000 meters	250 feet	250 feet
Beam Divergence	1, 5, or 10 mradians	1, 5, or 10 mradians	300 mradians	300 mradians
Detector Number	8	13	1	4
Detection	Omnidirect.	Omnidirect.	Unidirect.	Omnidirect.
Pulse Width (in ns)	200	200	80	80
Peak Energy Density (in joules/cm^2)	0.3×10^{-7}	0.2×10^{-7}	0.7×10^{-7}	0.7×10^{-7}

Table 1. Comparisons between the OCS and the DFS laser systems.

Thus, to operate the laser diode near its maximum power output over a reasonable temperature range, a thermal control network is incorporated into the OCS. This control network consists of a thermistor, a voltage regulator, and a pulsed current supply with the output proportional to the regulator voltage. The subminiature thermistor with a very small thermal time constant (2 seconds) is mounted directly on the laser diode which, in turn, is mounted on a 3" × 3" heat sink. In this way the thermistor signal adjusts the output voltage of the regulator which then determines the amount of current applied to the laser diode during each pulse.

However, due to the inherent *GaAs* laser diode thermal operating characteristic, the output power cannot be maintained constant even with temperature compensation if maximum power output is desired at all temperatures. This is due to the narrowing of the available laser operating region for both lower and elevated temperatures. Consequently, while the OCS thermal control network maintains the laser input current near its maximum allowable value, the output laser power varies. As a result, in the OCS developed for the Navy, maximum power is obtained at approximately room temperature and thermal half-power points occur at –15° and +55° C.

Modulator Design

Since the operation of the laser diode in this system depends entirely on its input current, the modulator (pulsed current supply) design can be rated next in importance only to the modulation technique itself. Furthermore, modulator design freedom was severely limited by the portability requirement of this optical communications system.

The most suitable technique for generating high-level (40-amp), short-duration (80-ns) current pulses is the conventional capacitor discharge through a fast electronic switch. Since the rise and fall times of the current pulse, as well as the d.c. supply voltage charging the capacitor, are determined by this switch characteristic, its selection and design play an important part. In fact, the switch requirements—ability to turn on fast while switching high current—are mutually exclusive for most semiconductor switches.

Most electronic switches designed for this purpose use SCR's as the final switching elements, since SCR's can pass very high peak currents. However, their turn-on and turn-off times are relatively slow unless very high voltages are used. But high voltages could not be used in a portable unit such as the OCS.

To avoid the need for a high-voltage supply, a modulator was developed that uses three high-speed transistors as the current switch. Not only is it fast, but it permits the use of a 40-volt power source to charge the capacitor that provides the laser input current.

As was mentioned earlier, both the fixed and the portable OCS models have a range of 250 feet with a beam divergence at that distance of 75 feet. These beam parameters are due entirely to the Naval system specifications that called for a reliable, effectively omnidirectional, short-range voice link for ship-to-ship communications.

Narrow Beam Extended Range

Before starting work on the OCS for the Navy, a Direct Fire Simulation (DFS) laser system was designed and deliv-

Fig. 2. Portable version of the optical communications system showing laser and optics located on top of helmet. Omnidirectional reception is achieved by mounting three photodiodes on the helmet—one on each of the earpieces and one on the back.

"But once the organization is actually in operation, we shall have facts. You can be sure the Federal Trade Commission will be keeping a close watch on *RSA* and its parent company for any infraction of the anti-monopoly laws, and the FTC recently has been given a new set of teeth—or at least encouragement to use the teeth it has—by Congressional criticism spurred on by the aroused consumer. *RCA* will be walking very carefully to avoid any triple-damage suits.

"While *RCA* has lots of experience in servicing its own products, servicing all makes of receivers is a different ball game altogether—as we well know. Servicing one brand of receiver when you are back-stopped by the factory and copious field notes is a lot different than catch-as-catch-can wrestling with dozens of different makes and hundreds of variations in mechanical layout, circuitry, and service procedures. Technicians can be factory-trained to service one brand but not to service all brands. To be able to service all makes rapidly and efficiently, a technician must have very sound knowledge of fundamental theory plus a lot of practical experience in general servicing plus a willingness to study almost continuously. This kind of technician is hard to come by and difficult to keep. He is usually much happier working for himself than for someone else.

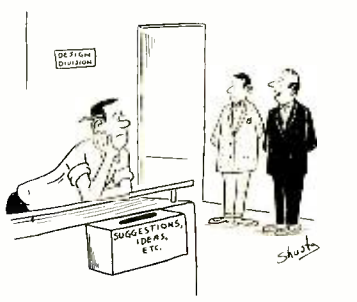
"*RCA* is gambling the resentment aroused among independents by *RSA* will soon die out and be forgotten. If it doesn't, the company is too smart to continue antagonizing thousands of independent service dealers, especially now these independents seem finally on the road to forgetting their differences and established a powerful nation-wide organization. *RSA* may well be the agglutinating agent, as a common enemy, that clumps the separate organizations together like butter forming in a churn. Such an organization could keep alive the bitterness and resentment for years to come. No manufacturer, not even one as large as *RCA*, can afford to have literally thousands of enemies. If *RSA* tarnishes the *RCA* image, it will be jettisoned."

"Other manufacturers are quick to take advantage of the situation," Barney added. "Some are already running ads in service magazines pointing out their long friendship with the independent service dealers, stating *they* have never been in the service business, and announcing their dedication to independent service."

"There's consolation in the knowledge no other nation-wide major repair service organization has succeeded," Mac said. "While we have chain groceries, drugstores, restaurants, and motels, we don't have a chain of automobile repair shops, appliance repair shops, or camera repair shops. We do, of course, have muffler and transmission shops, but we don't have chain garages that can repair the entire car. When you consider the billions of dollars spent for car repair, there must be a good reason why we don't have chains of repair garages. Repair service does not lend itself to big-scale organization, and I think I know why."

"I think I do, too," Barney interrupted. "The big executives can sit at their mahogany desks and make plans and earmark millions of dollars to launch an organization, production engineers can fiddle with their slide rules, and the advertising boys can buy radio and TV time and newspaper and magazine space; but you still end up with a guy standing at a bench fixing something. The buck stops with him. If he doesn't have the knowledge and the experience and the motivation to do a good job of repairing the set, all the grandiose plans crumble to nothing. There are some things that do not yield to massive effort. When a NASA official was being urged to use a crash program to overcome the missile gap, he observed rather sadly, 'In some instances, a crash program is like trying to get a baby in one month by getting nine women pregnant.'"

Grinning appreciatively, Mac fished in his pocket for a tip. "He's right," he said with a chuckle. "You might tell the boys I finally stroked my long gray beard and commented that I have lived through many threats to the independent service shops and independent service dealers. There were the cheap a.c.-d.c. cracker-box receivers that were going to destroy us, the superheterodyne circuit no ordinary man could ever understand, the TV sets no radio man could ever service, color sets too complicated for a B&W technician to master, printed circuits that would never need service, transistor sets that would last forever, drugstore tube testers, do-it-yourself repair books, plug-in module sets, etc., etc., etc. But they still need us. Tell the fellows to keep their cool and hang in there. If you can stand one more old saw, quote the proverb a wise Arab says when anything good or bad appears: 'This, too, will pass.'" ▲



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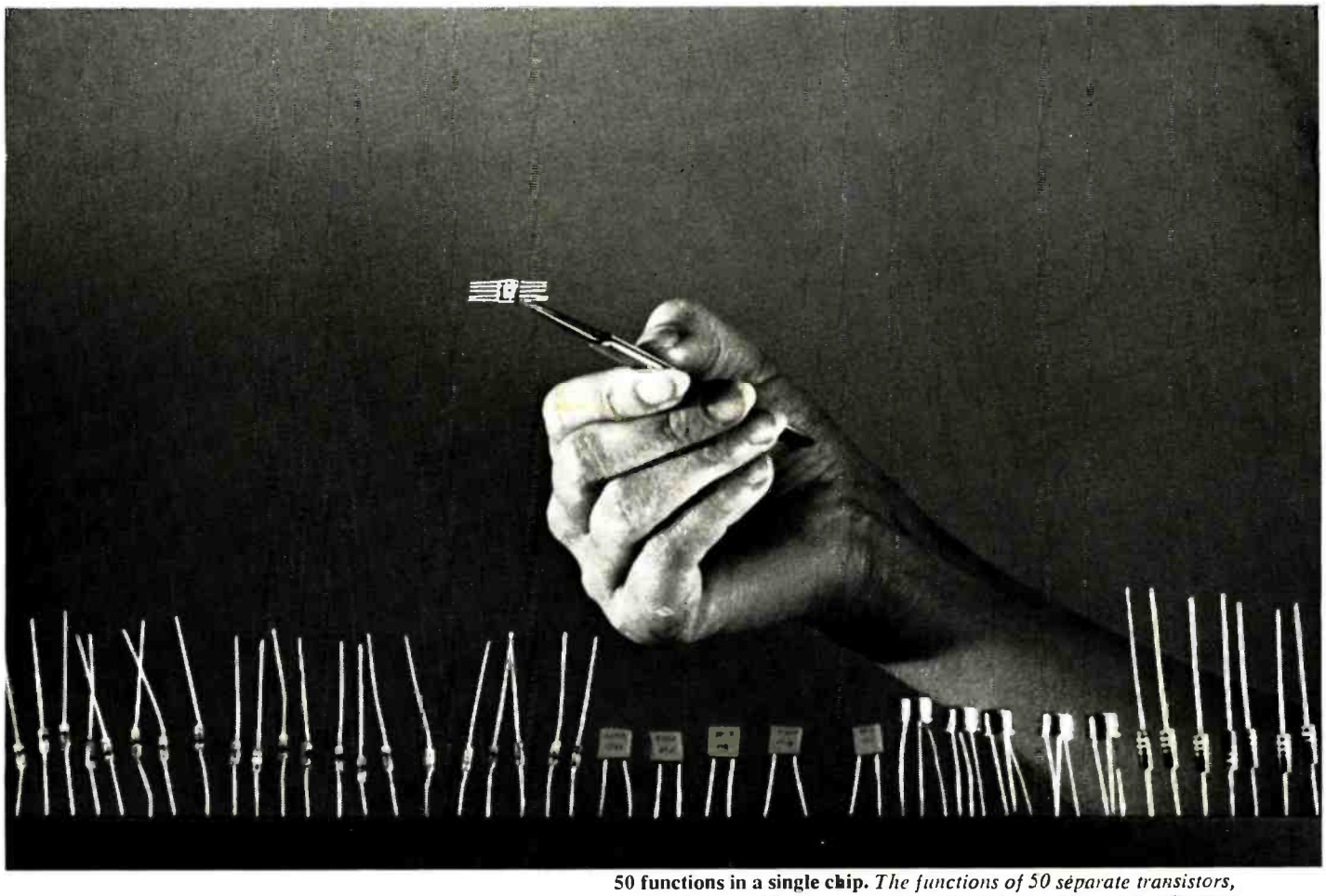


50 functions in a single chip. *The functions of 50 separate transistors, diodes, resistors and capacitors can now be performed by the tiny dot in the center of the integrated circuit held by the tweezers.*

The "Chip" ...will it make or break your future job?

THE DEVELOPMENT OF INTEGRATED CIRCUITRY is the dawn of a new age of electronic miracles. It means that many of today's job skills soon will be no longer needed. At the same time it opens the door to thousands of exciting new job opportunities for technicians solidly grounded in electronics fundamentals. Read here what you need to know to cash in on the gigantic coming boom, and how you can learn it right at home.

TINY ELECTRONIC "CHIPS," each no bigger than the head of a pin, are bringing about a fantastic new Industrial Revolution. The time is near at hand when "chips" may save your life, balance your checkbook, and land a man on the moon.

Chips may also put you out of a job... or into a better one.

"One thing is certain," said *The New York Times* recently. "Chips will unalterably change our lives and the lives of our children probably far beyond recognition."

A single chip or miniature integrated circuit can perform the function of 20 transistors, 18 resistors, and 2 capacitors. Yet it is so small that a thimbleful can hold enough circuitry for a dozen computers or a thousand radios.

Miniature Miracles of Today and Tomorrow

Already, as a result, a two-way radio can now be fitted inside a signet ring. A complete hearing aid can be worn entirely inside the ear. There is a new desk-top computer, no bigger than a typewriter yet capable of 166,000 operations per second. And it is almost possible to put the entire circuitry of a color television set inside a man's wristwatch case.

And this is only the beginning!

Soon kitchen computers may keep the housewife's refrigerator stocked, her menus planned, and her calories counted.

Money may become obsolete. Instead you will simply carry an electronic charge account card. Your employer will credit your account after each week's work and merchants will charge each of your purchases against it.

When your telephone rings and nobody's home, your call will automatically be switched to the phone where you can be reached.

Doctors will be able to examine you internally by watching a TV screen while a pill-size camera passes through your digestive tract.

New Opportunities for Trained Men

What does all this mean to someone working in Electronics who never went beyond high school? It means the opportunity of a lifetime—if you take advantage of it.

It's true that the "chip" may make a lot of manual skills no longer necessary.

But at the same time the booming sales of articles and equipment using integrated circuitry has created a tremendous demand for trained electronics personnel to help design, manufacture, test, operate, and service all these marvels.

There simply aren't enough college-trained engineers to go around. So men with a high school education who have mastered the fundamentals of electronics theory are being begged to accept really interesting, high-pay jobs as engineering aides, junior engineers, and field engineers.

How To Get the Training You Need

You can get the up-to-date training in electronics fundamentals that you need through a carefully chosen home study course. In fact, some authorities feel that a home study course is the best way. "By its very nature," stated one electronics publication recently, "home study develops your ability to analyze and extract information as well as to strengthen your sense of responsibility and initiative." These are qualities every employer is always looking for.

If you do decide to advance your career through spare-time study at home, it makes sense to pick an electronics school that specializes in the home study method. Electronics is complicated enough without trying to learn it from lessons designed for the classroom instead of correspondence training.

The Cleveland Institute of Electronics has everything you're looking for. We teach only Electronics—no other subjects. And our courses are designed especially for home study. We have spent over 30 years perfecting techniques that make learning Electronics at home easy, even for those who previously had trouble studying.

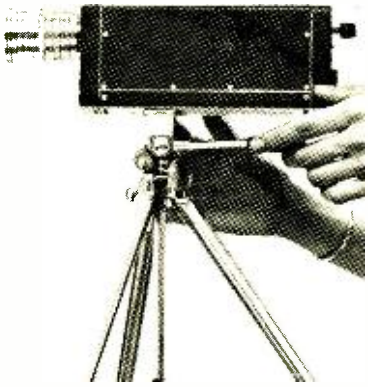
Your instructor gives your assignments his undivided personal attention. He not only grades your work, he analyzes it. And he mails back his corrections and comments the same day he gets your lessons, so you read his notations while everything is still fresh in your mind.

Always Up-to-Date

Because of rapid developments in Electronics, CIE courses are constantly being revised. Students receive the most recent revised material as they progress through their courses. This year, for example, CIE students are receiving exclusive up-to-the-minute lessons in Microminiaturization, Logical Troubleshooting, Laser Theory and Application, Single Sideband Techniques, Pulse Theory and Application, and Boolean Algebra. For this reason CIE courses are invaluable not only to newcomers in Electronics but also for "old timers" who need a refresher course in current developments.

ENROLL UNDER NEW G.I. BILL

All CIE courses are available under the new G.I. Bill. If you served on active duty since January 31, 1955, or are in service now, check box on reply card for G.I. Bill information.



Tiny TV camera *for space and military use is one of the miracles of integrated circuitry. This one weighs 27 ounces, uses a one-inch vidicon camera tube, and requires only four watts of power.*

Get FCC License or Money Back

No matter what kind of job you want in Electronics, you ought to have your Government FCC License. It's accepted everywhere as proof of your education in Electronics. And no wonder—the Government licensing exam is tough. So tough, in fact, that without CIE training, two out of every three men who take the exam fail.

But better than 9 out of every 10 CIE graduates who take the exam pass it.

This has made it possible to back our FCC License courses with this famous Warranty: you *must* pass your FCC exam upon completion of the course or your tuition is refunded in full.

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Want to know more? The postpaid reply card bound in here will bring you a FREE copy of our school catalog describing today's opportunities in Electronics, our teaching methods, and our courses, together with our special booklet on how to get a commercial FCC License. If card is missing, use the coupon below.

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COLLEGE-LEVEL COURSE IN ELECTRONICS ENGINEERING

for men with prior experience in Electronics. Covers steady-state and transient network theory, solid state physics and circuitry pulse techniques, computer logic and mathematics through calculus. A college-level course for men already working in Electronics.

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Please send me without cost or obligation:

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2. Your book on "How To Get A Commercial FCC License."

I am especially interested in:

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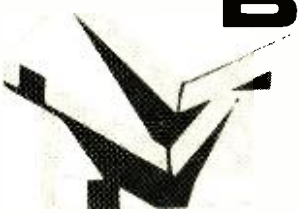
BOOKS



"UNIFIED CONCEPTS OF ELECTRONICS" by Clyde N. Herrick. Published by *Prentice-Hall, Inc.*, Englewood Cliffs, N.J. 07632. 662 pages. Price $13.50.

This text, by an instructor at San Jose City College, is designed as a classroom aid for courses at the technical school or junior-college level.

It is the author's contention that although modern electronics covers vast areas, there is a common denominator of basic laws and principles that binds these diverse areas together so that the student with an understanding of these unifying factors can cope with the circuits, devices, and systems he will encounter in any specialized field.

The text is divided into 28 chapters, four appendices, and a glossary. The treatment is mathematical and the author specifies as prerequisite courses in arithmetic, algebra, geometry, and trigonometry plus an elementary understanding of analytic geometry.

Since the material is clearly and carefully presented, anyone with the requisite background could use this text as a home-study or self-instruction book. Each chapter carries a summary, a series of multiple-choice questions, and a group of problems to be worked for checking purposes. The text is lavishly illustrated and the appendices carry supplementary material to be used with the text.

* * *

"ELECTRONIC FLASH, STROBE" by Harold E. Edgerton. Published by *McGraw-Hill Book Company*, New York, N.Y. 347 pages. Price $22.50.

This volume, by the "father" of the modern stroboscope, should provide the "last word" for anyone who needs to learn about electronic flash for his research, hobby, or profession. Dr. Edgerton, who is Institute Professor Emeritus at MIT, provides both theoretical and practical information on the field. He has even provided a number of experiments for the reader to try out—as a learning process as well as a mind-extending experience.

The twelve chapters making up the text include an introduction to the technique, the theory of the electronic flash lamp, spectral output of flash lamps, circuits for electronic flash equipment, lighting requirements for photography, single-flash equipment, equipment of short exposure time, equipment for nature photography, the stroboscope, exposure calculations and special photography, techniques of light measurement, and specialized applications.

While the text is lavishly illustrated, one can only regret that Dr. Edgerton's obvious modesty deprives us of more glimpses of his justly renowned flash pictures for those who missed them the first time around. The writing is clear and at a level which can be understood by photography hobbyists and/or electronics buffs, or both.

* * *

"CB RADIO" by Leo G. Sands. Published by *A.S. Barnes and Co., Inc.*, Cranbury, N.J. 141 pages. Price $6.95.

This is a revised and updated edition of the author's 1960 volume. In addition to explaining what CB radio is and is not, how the service got its start, how it can be used, the author covers transmitting and receiving equipment, provides information on simple installation and maintenance techniques, and outlines for service technicians the business potential represented by the market for CB gear.

There are photographs of equipment, line drawings, partial schematics, tables, listings of CB equipment makers, the "10 Code," a glossary of radiotelephone terms, and other useful data for CB users or potential users of the service.

* * *

"INTRODUCTION TO ELECTRIC CIRCUITS" by Herbert W. Jackson. Published by *Prentice-Hall, Inc.*, Englewood Cliffs, N.J. 07632. 710 pages. Price $13.50.

This Third Edition of a popular elementary text has been extensively revised to reflect the new standards recommended by the International Electrotechnical Commission so that when the North American standards organizations eventually put the standards into effect, the student and technician will be prepared for the new concepts and terminology. In addition, in anticipation of the adoption of the metric system, the author has started easing his students into this way of thinking.

One especially valuable innovation is the printing of important statements in blue—which should facilitate reviewing the text material prior to examinations and serve as memory joggers for the student.

The text is divided into two main parts covering electricity and magnetism and circuit analysis techniques. The first part deals with an introduction; current and voltage; insulators, semiconductors; and sources of e.m.f.; resistance; work and power; series and parallel resistances; capacitance; magnetic circuits; inductance; alternating current; reactance; vector algebra; impedance; power in a.c. circuits; and electrical measurements. The second part covers equivalent circuits, resistance networks, series and parallel impedances; impedance networks; resonance; transformer action; coupled circuits; three-phase systems; and harmonics. Five appendices cover determinants, natural sine, cosine, and tangent trig function tables, and a table of exponentials.

Since the author's approach is almost conversational and his material is presented in clear and easily understood form, there is no reason why this book couldn't be used as a home-study text as well as in the classroom.

* * *

"MODERN ELECTRONIC MAINTENANCE PRINCIPLES" by D.J. Garland & F.W. Stainer. Published by *Pergamon Press Ltd.*, Elmsford, N.Y. 10523. 82 pages. Price $2.70 soft cover.

This volume was prepared on behalf of the Society of Electronic and Radio Technicians (S.E.R.T.) and is designed for practical training programs involving maintenance technicians in both electronic and other disciplines.

The authors, both of whom have been associated with the Technical Training Command of the R.A.F., have divided the text into twelve chapters outlining the need for maintenance principles, reliability, components and reliability, factors affecting maintenance, preventive and corrective maintenance, the half-split method, aids to maintenance, functional diagrams, fault-finding guides, test equipment, training for maintenance, and work underway in maintenance research.

Although the terminology and circuit diagram symbols used in the text are British, U.S. technicians should have no difficulty making any necessary transitions.

While many of the circuits selected to demonstrate the various maintenance techniques involve military gear and, specifically R.A.F. equipment, the procedures outlined by the authors are equally applicable to commercial equipment of varying degrees of complexity.

The writing is clear and concise, the text is well illustrated, and the double-column format and the handbook-size presentation makes this manual as easy to use on the service bench as it is as a reference work for home- or classroom study of the why's and wherefore's of electronic equipment maintenance. ▲

Survival Radio for Apollo

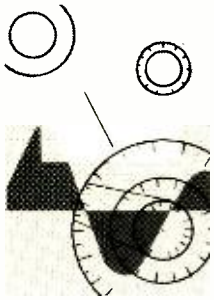
(*Continued from page* 40)

ing resistors, vertically. A novel technique was used to secure parts against the vigorous mechanical environment without adversely affecting the electrical performance. A thin sheet of clear acetate was softened by heat and then pulled down into close contact with the parts by means of a vacuum applied beneath the printed-circuit board. The softened acetate flows around each part, giving the appearance of a conformal-like coating, but does not flow under the part where the change in dielectric constant would disturb the tuning and Q of critical circuits. The acetate has a very low thermal capacity and consequently cools immediately after forming without thermal shock to the parts. Only very minor tuning adjustments have been required following application of the acetate which, essentially, bonds every part to every other part for excellent mechanical rigidity. Individual parts can be replaced after covering by using a small knife to remove the acetate around the part and later securing the new part with RTV.

The voice and beacon modulators and the transmitter are located on the second printed-circuit board. It is mounted on long threaded stand-offs in an inverted position. This makes it convenient to attach heat sinks for the transmitter driver and final amplifier stages directly to the aluminum support plate which itself acts as a heat sink. This has proved to be very effective and these devices experience only a nominal 3–5°C rise above ambient under continuous transmit conditions. Fig. 6 shows the transmitter board removed from the mounting plate so the various component parts are more readily visible.

While, hopefully, the survival radio will never be called upon to perform its intended function, it must always be ready. Great effort is made to achieve the highest possible reliability of the equipment. All parts selected for use were of the established reliability (ER) or testing extra (JANTX) type, or were subjected to rigorous 100% screening tests. In addition, the equipment is assembled under clean-room conditions with microscopic inspection at each step and subjected to thorough acceptance testing before delivery.

The author wishes to acknowledge the contributions of Peter J. Hooyen, Jess C. Wright, E. Samuel Levy, William C. Cockerell, Jr., Wolfgang Schmidt, and George Metz in developing the Apollo Survival Radio. The work was performed under contract with NASA's Manned Spacecraft Center in Houston, Texas. ▲



TEST EQUIPMENT

Product Report

Triplett Model 602 Solid-State V.O.M.

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

AT first glance, the new *Triplett* Model 602 looks like a conventional solid-state v.o.m. But if you look carefully at the row of push-buttons at the left, you find, in addition to the usual "+", "–", and "AC" functions, one push-button marked "AP." This activates the unique auto-polarity feature. Now you don't have to reverse leads or push in the other polarity button when your meter pointer reads backwards because you didn't know the polarity of the d.c. voltage or current you were measuring. With this meter, the pointer reads up-scale regardless of the polarity.

This little trick is accomplished fairly simply. The input is first applied through a voltage divider to a field-effect transistor. Output of the FET goes to another transistor which operates as the meter-circuit driver. There are two oppositely wired crystal diodes connected to opposite sides of the meter movement. When the input polarity is positive, one of these conducts; when the input polarity is negative, the other conducts. Because of the way these diodes are connected to the meter, it reads up-scale in either case. If you really want to know the polarity of the voltage you are measuring, then you simply disable one of these diodes by pressing the "+" or "–" button. Now, the meter will read up-scale only when the marking on the button matches the polarity of the voltage being measured.

Two more transistors, connected in a Darlington configuration, are in the feedback loop from the meter circuit back to the FET input stage. These transistors stabilize the gain of the circuit and make the output linear regardless of the series diodes. The feedback circuit also compensates for changes in the resistance of the coil of the movement with temperature.

The tester has high input impedance, thanks to the FET used, on both d.c. (13 megohms)and a.c. (10 megohms) on all ranges. Lowest full-scale range for d.c. and a.c. is 0.3 V.

Readily available batteries are used to power the v.o.m. These are a "D" cell for the ohmmeter scales and two 9-volt transistor-radio batteries for the transistor meter amplifier. Price of the Model 602 is $100. ▲

Victoreen 499 "Vic-Chek" X-Ray Survey Meter

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

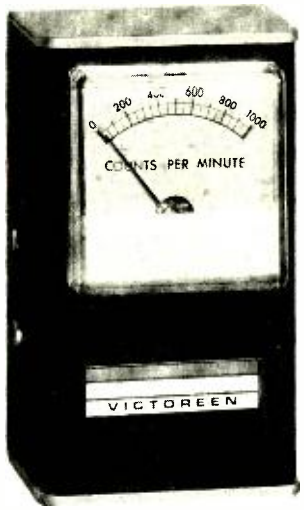
WITH the continuing excitement about x-radiation from color-TV sets, service technicians have been looking for a simple, inexpensive instrument they could use to check a color set for such radiation. The new Model 499 "Vic-Chek" from *Victoreen Instrument Div.* has been designed to fill this need. However, when we saw the survey meter, we were somewhat disappointed in that the calibrations are in terms of counts per minute rather than milliroentgens per hour, which are the units specified by the government standard (x-radiation not to exceed 0.5 mR/hr at a distance of 5 cm). Evidently, the type of Geiger-Mueller counter tube used, the design of the radiation window, and the simple circuitry used do not permit the kind of accuracy needed to check radiation in units defined by the standard. *Victoreen* produces such instruments, but at prices far above the Model 499.

The meter is still useful, however, to indicate *relative* radiation. The techni-

cian, for example, can check the amount of radiation produced when he substitutes a shunt regulator tube for an older type that may have been producing some x-radiation. He can also determine the relative amount of radiation before and after making a high-voltage adjustment on a color set.

The full-scale reading on the meter is 1000 counts/minute. The background count indicated by the meter was around 25 to 50 counts/minute in our location, and when we moved the meter all around the outside of our color-TV set, the reading went up another 25 to 50 counts at most. On the other hand, when we put a couple of luminous-dial wristwatches on the window of the meter, the meter pointer was pinned full-scale in some cases. Of course, this radiation drops off sharply with distance and there was little or no radiation from the backs of the watches. Even the amount of radiation at full-scale is quite a bit below the standard, however. As near as we were able to determine, the full-scale reading of 1000 counts/min is roughly equivalent to only 0.2 mR/hr at a distance of 5 cm.

Although designed primarily for TV technicians, the Model 499 is also useful where a quick and sensitive x-ray and *gamma*-radiation survey meter is needed. Applications include prospecting, geology, radio-chemistry, and general table-top surveys.



The detector tube, a Geiger-Mueller counter, is housed inside the compact unit behind a 10-cm² radiation window of aluminized Mylar. The meter circuits are solid-state for low power consumption and reliability. Power is supplied by a 9-volt transistor-radio battery.

The 1-lb instrument easily fits within an operator's hand; size is 3 in by 5 in by 2½ in deep. Price is $79.50. ▲

Ohmite Models 3405-3410 Resistance Decade Boxes

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

RESEARCH and development labs frequently make use of precision resistance decade boxes in some of their measuring and testing setups. Such boxes are also useful for some production-line tests where exact resistance values are needed. Service technicians also use decade boxes to make component substitutions although this application requires higher power and much lower accuracy resistors than the ones used in the new *Ohmite* "Determ-Ohm" decade boxes.

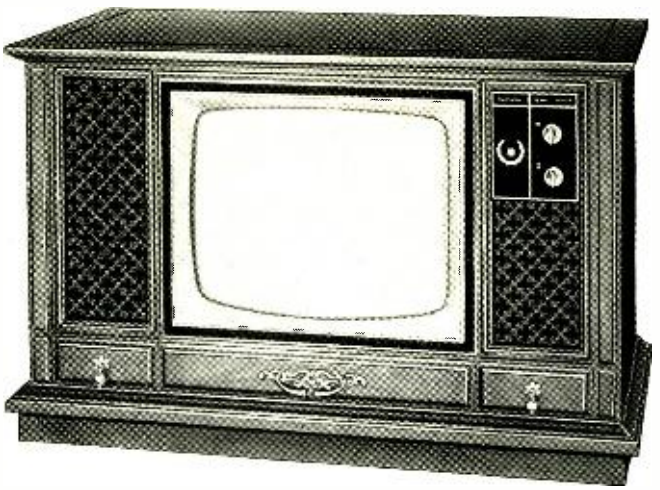
The company has four models available. These are the Models 3405, 3406, and 3407, which are four-decade boxes with maximum resistances of 9.999, 99.99, and 999.9 kilohms at 1, 10, and 100 ohms per step, respectively; the Model 3410, a six-decade box with maximum resistance of 999.999 kilohms at 1 ohm per step. Accuracy of all the boxes is within 0.1 percent with no more than 0.01 ohm added for contact and circuit resistance per decade. The precision resistors used are all quarter-watt units.

We were quite impressed with the rocker-type thumbwheel switches used to select the various resistors. The resistance setting is indicated by the in-line numeric readout displayed by these switches to 4 or 6 significant figures, depending on the model. Pushing the lower part of the rocker advances the number and corresponding resistance value; pushing the upper portion of the rocker decreases the number. With this kind of readout, it's just about impossible to set the resistance values incorrectly. Unlike some such switches, you can go back and forth from 9 through 0 to 1 without having to switch back through all the other values. The switches are rated in excess of 50,000 operations.

The housing is 5-in wide by about 4-in high and about 4-in deep. Prices are $85 for Models 3405, 3406; $90 for Model 3407; and $125 for the 3410 ▲

New from Heath...in time

New Heathkit® solid-state modular color TV

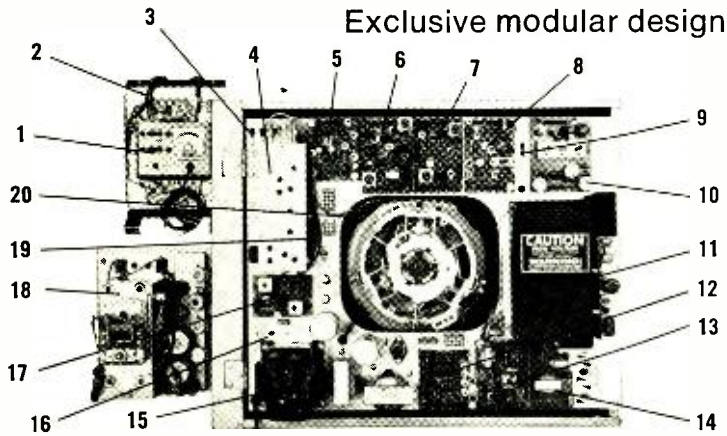


The result of over five years in research and development, these sets represent one of today's greatest color TV values. Here's why: a total of 45 transistors, 55 diodes, 2 silicon controlled rectifiers, 4 IC's containing another 46 transistors and 21 diodes plus 2 tubes (picture and high voltage rectifier) combine to deliver performance and reliability unequalled by any conventional tube set. Other features include: MOSFET VHF tuner; high-gain 3-stage solid-state IF; emitter-follower output; automatic fine tuning; VHF power tuning; built-in degaussing plus manual degaussing coil; automatic chroma control; adjustable noise limiting and gated AGC; "instant-on"... sound instantly, picture in seconds; bonded-face, etched glass picture tubes; adjustable tone control; exclusive hi-fi outputs; and 48-hour factory service facility for modules. The sets are designed to be owner-serviced ... the only sets on the market with this exclusive feature. A built-in dot generator, volt-ohm meter, and modular snap-out epoxy circuit boards make routine adjustments and service a snap ... virtually eliminating service calls and offering significant savings over the life of the set. It all adds up to the color TV buy of a lifetime in the GR-270 and GR-370 ... ready now for Christmas giving!

Kit **GR-270,** 227" 20V tube, 114 lbs. **$489.95***
Kit **GR-370,** 295" 23V tube, 127 lbs. **$559.95***
Kit **GR-370MX, GR-370** with RCA matrix tube, 127 lbs. **$569.95***

- Modular plug-in circuit board construction
- MOSFET VHF tuner and 3-stage IF
- Pushbutton channel advance
- Hi-fi sound outputs — for amplifier
- Designed for owner-servicing

Exclusive modular design



1 Exclusive check-out meter
2 Tilt-out convergence/secondary control panel
3 Gun shorting switches
4 3-stage IF assembly
5 Plug-in AGC/Sync circuit board
6 Plug-in 3.58 MHz oscillator circuit board
7 Plug-in Chroma circuit board
8 Plug-in Luminance circuit board
9 Service and Dots switches
10 Plug-in Video Output circuit board
11 High voltage power supply
12 Plug-in Vertical Oscillator circuit board
13 Plug-in Horizontal Oscillator circuit board
14 Plug-in Pincushion circuit board
15 Conservatively-rated power supply components
16 Circuit breaker protection
17 Plug-in Sound circuit board
18 Master control panel
19 Hi-fi sound output
20 Plug-in wiring harnesses and connectors for faster assembly

Choice of factory-assembled cabinets

3 models in 295 sq. in.

Luxurious Mediterranean Cabinet...factory assembled of fine furniture grade hardwoods and finished in a flawless Mediterranean pecan. Statuary bronze trim handle. 30-1/32" H x 47" W x 17¾" D.
Assembled GRA-304-23, 78 lbs. **$129.95***

Deluxe Early American Cabinet...factory assembled of hardwoods & veneers and finished in classic Salem Maple. 29 21/32" H x 37¼" W x 19¾" D.
Assembled GRA-303-23, 73 lbs. **$114.95***

Contemporary Walnut Cabinet...factory assembled of fine veneers & solids with an oil-rubbed walnut finish. 29 17/32" H x 35 13/16" W x 19⅞" D.
Assembled GRA-301-23, 60 lbs. **$74.95***

3 models in 227 sq. in.

Exciting Mediterranean Cabinet...assembled using fine furniture techniques and finished in stylish Mediterranean pecan. Accented with statuary bronze handle. 27 21/32" H x 41⅞" W x 19¾" D.
Assembled GRA-202-20, 85 lbs. **$114.95***

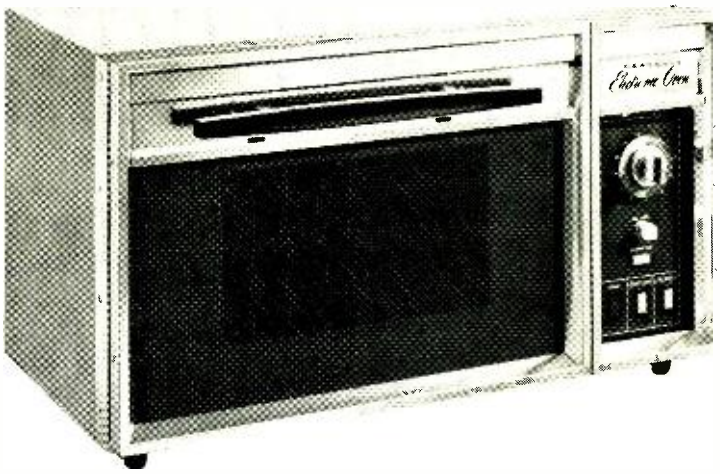
Contemporary Walnut Cabinet and Base Combination. Handsome walnut finished cabinet sits on a matching walnut base. Cabinet dimensions 20 31/32" H x 31 1/16" W x 18⅝" D. Base dimensions 7¾" H x 27¾" W x 18⅝" D.
Assembled GRA-203-20 Cabinet, 46 lbs. **$49.95***
GRS-203-6 above cab. w/matching base, 59 lbs. **$59.95***

Handy Roll-Around Cart and Cabinet Combination. Features the GRA-203-20 walnut cabinet plus a walnut-trimmed wheeled cart with storage shelf.
Assembled GRA-203-20 Cabinet, 46 lbs. **$49.95***
GRA-204-20 Roll-Around Cart, 19 lbs. ..**$19.95***
GRS-203-5 Cart & Cabinet Combo, 65 lbs. **$59.95***

for Christmas giving

New Heathkit Electronic Oven

...only $399.95*



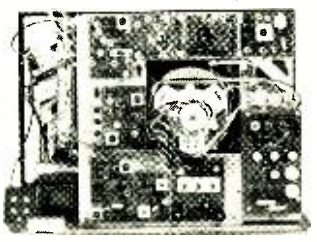
Now, through the miracle of microwave energy, a cooking revolution that frees you from conventional kitchen drudgery forever!

Imagine a baked potato in 4 minutes; baked beans in a little over 6 minutes; a five-pound roast in 45 minutes. This is the miracle of microwave cooking. And now Heath brings you this modern miracle for the first time in money-saving, easy-to-assemble kit form. For busy families on the go, meal preparation is a matter of minutes. You can cook on china, glass, or even paper dishes since only the food becomes hot. Your cooking dish can be your serving dish. Frozen foods can be defrosted in minutes for quick spur-of-the-moment frozen meals cooked right in their own containers. And there is not the slightest cause for concern about the safety of your Heathkit electronic oven. Exclusive door design prevents microwave leakage from the oven cavity. And with a SAFETY INTERLOCK SYSTEM UNIQUE IN THE INDUSTRY, not only does the oven stop cooking if the door is opened, but the door can't be opened unless the interlock is operating properly. A second independent door interlock is also provided for maximum protection. And all interlock mechanisms are tamperproof. Assembled in accordance with the manual, the GD-29 meets all the new federal standards for safety and radio interference. No special precautions are required when operating. The Heathkit electronic oven is as safe as your conventional oven! Quality components are used throughout: magnetron tube by Litton, the uncontested leader in the field; avalanche diode circuitry for longer tube life; simplified wiring harness with push-on quick-connectors for reliability and ease of assembly. GD-29 prototypes endured grueling "life-tests" equivalent to over 60 years of continuous service... further assurance of uncompromised reliability. Another feature is portability: the Heathkit electronic oven operates on regular household current. Plug it in anywhere... on a countertop, a wheeled cart, in the kitchen, on the patio, at the cottage... anyplace a grounded 120V AC power outlet is available. Make this a Christmas to remember by putting a Heathkit electronic oven under the tree. It's a gift your wife will thrill to... and a present the whole family will enjoy... meal after meal after meal.

Kit **GD-29,** 80 lbs. **$399.95***

New Heathkit portable solid-state color TV

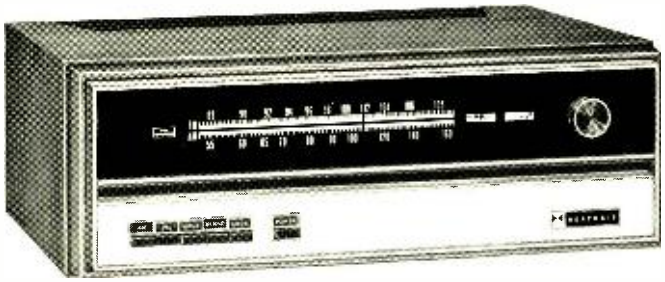
- Big set performance, portable convenience
- MOSFET VHF tuner & 3-stage IF
- Modular, self-service design
- 102", 14 V picture tube



What do you do for an encore after you've created the solid-state GR-270 and GR-370 big-screen sets? Simple. Make them portable. That's virtually what's been done in the new Heathkit GR-169 solid-state portable color TV. Heath engineers took the same cool-running solid-state circuitry from the large screen chassis and packaged it in an easy-to-assemble compact chassis... with the same nine plug-in glass epoxy circuit board modules used in the big sets. In fact the only difference is the smaller preassembled horizontal deflection and high voltage power supply. The same MOSFET tuner and high gain 3-stage IF found in the big sets offer superlative color performance. And, as in the larger sets, complete owner-service features are provided by inclusion of built-in dot generator and degaussing along with an exclusive volt-ohm check-out meter. 48-hour factory service facilities for modules are also provided with the GR-169. Other features include: built-in antennas and connections for external antennas; instant picture and sound; complete secondary controls available behind the hinged door on the front panel; high resolution circuitry for sharp, crisp pictures; adjustable noise limiting to keep external interference to a minimum. If you're looking for big set color fidelity and performance with portable convenience... put the new Heathkit GR-169 on your Christmas shopping list now!

Kit **GR-169,** 48 lbs. **$349.95***

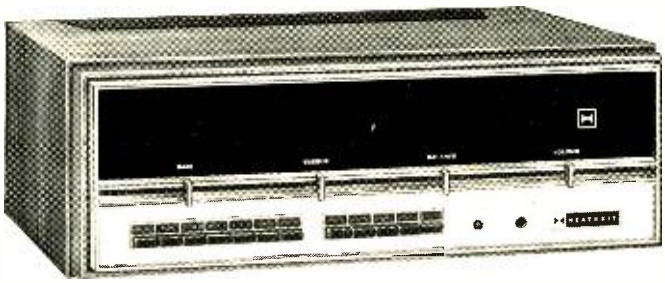
New Heath-gift ideas... for



New Heathkit® AJ-29 AM-FM-FM stereo tuner

This is the feature-packed tuner section of the famous Heathkit AR-29 stereo receiver . . . now available as a stereo "separate." The pre-assembled, factory-aligned FM tuner boasts 1.8 uV sensitivity for whopping station pulling power using FET design for superior overload characteristics. Three IC's in the IF section offer superior AM rejection, hard limiting, temperature stability, and outstanding reliability. Other features include a computer-designed 9-pole L-C filter for greater than 70 dB selectivity; new "blend" and "mute" functions; and a built-in AM rod antenna that swivels for best reception.

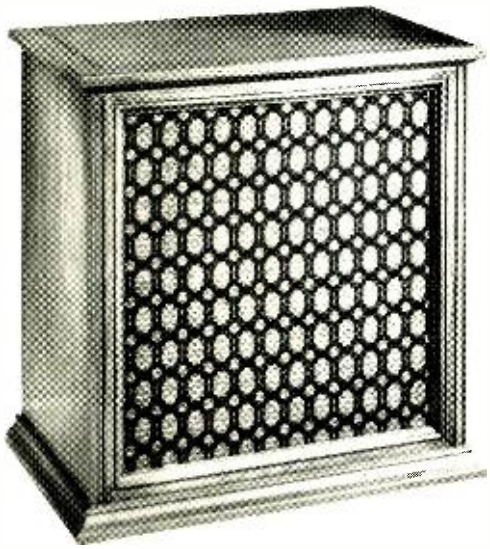
Kit **AJ-29,** 19 lbs., less cabinet **$169.95***
Assembled **AE-19,** oiled pecan cab., 9 lbs. **$19.95***



New Heathkit® AA-29 100-watt stereo amplifier

Power-packed amplifier section of the Heathkit AR-29, the AA-29 stereo "separate" marks another milestone in superior Heathkit amplifier design. Its 70-watts of continuous power is more than enough to drive even the most inefficient speaker systems. A massive, fully-regulated and filtered power supply, 4 conservatively heat sinked output transistors and the best IM and harmonic distortion specifications in the industry add up to sound fidelity you never expected to hear outside the theater. Modular plug-in circuit boards make assembly easier . . . snap out in seconds for future servicing.

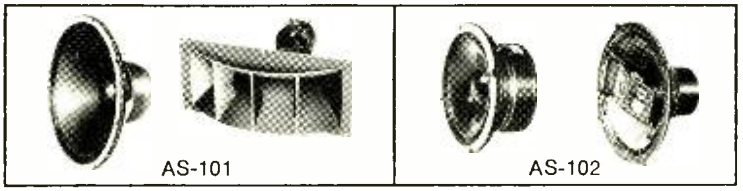
Kit **AA-29,** 27 lbs., less cabinet **$149.95***
Assembled **AE-19,** oiled pecan cab., 9 lbs. **$19.95***



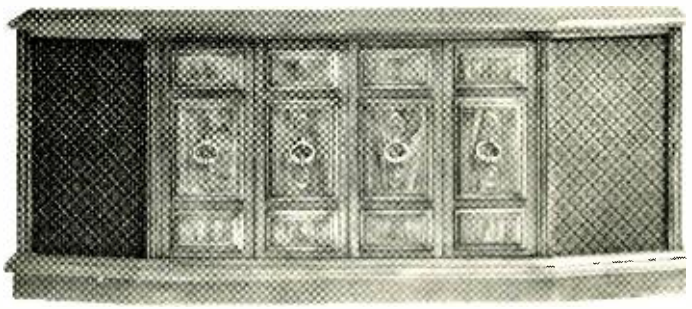
New Heathkit® floor model speaker systems

In the new Heathkit AS-101 and AS-102 speaker systems, Heath engineers have combined the best of both worlds of sound and beauty. The AS-101 Heath/Altec-Lansing 2-way system features a 15" woofer and sectoral horn delivering from 35 to 22,000 Hz with uncompromising accuracy. The AS-102 Heath/Bozak 3-way system uses a 12" woofer, 6" mid-range, and two 2½" tweeters in an infinite baffle design to produce clean natural reproduction from 40 to 20,000 Hz. Both systems are housed in assembled Mediterranean pecan cabinets, 29⅝" H x 27¾" W x 19⅞" D.

Kit **AS-101,** 53 lbs. **$259.95***
Kit **AS-102,** 39 lbs. **$259.95***



New Heath stereo equipment credenza



Romantic Mediterranean styling in wife-pleasing one-piece console design . . . yet with plenty of room for your favorite separate stereo components. Six-and-a-half feet of solid craftsmanship executed in North American Hickory veneers and solid oak trim, finished in oiled pecan. Completely assembled and finished, ready for installation of Heath or other components. Speaker enclosures are ducted port reflex design, pre-cut for 12" speakers. An adjustable shelf has room for stereo receiver, cartridge or cassette tape player or separate tuner and amplifier. Below the shelf is room for your turntable and record storage. Accessory matching drawers on ball bearing slides are available for turntable and tape player.

Model **AE-101,** 90 lbs. **$189.95***

home, shop and ham shack

New Heathkit® IC 15 MHz frequency counter...199.95*

A highly accurate, low cost frequency meter for anyone requiring accurate frequency measurements. Compare these features to counters selling for over twice this low price: accurate counting, 1 Hz to over 15 MHz; integrated circuitry; automatic trigger level for wide range input without adjustment; five digit readout with Hz/kHz ranges and overrange indicators for eight digit capability; high input impedance; storage circuitry for non-blinking, no-count-up readout; computer-type circuitry, no divider chain adjustment; temperature-compensated crystal time base oscillator; BNC input with cable; double-sided, plated-thru circuit board with sockets; three-wire, removable line cord; heavy-duty aluminum case handle/tilt stand and die cast zinc front panel; no special instruments required for accurate calibration.

Kit **IB-101,** 7 lbs. **$199.95***

IB-101 SPECIFICATIONS: Frequency Range: 1 Hz to greater than 15 MHz. **Accuracy:** ±1 count ± time base stability. **Gate Times:** 1 millisecond or 1 second with automatic reset. **Input Characteristics: Sensitivity:** 1 Hz to 1 MHz, less than 100 mV rms. 1 MHz to 15 MHz, less than 250 mV rms. After 30 minutes warmup. **Trigger Level:** Automatic. **Impedance:** 1 Meg ohm shunted by less than 20 pf. **Maximum Input:** 200 V rms, DC–1 kHz. Derate at 48 V per frequency decade. **TIME BASE: Frequency:** 1 MHz, crystal controlled. **Aging Rate:** Less than 1 PPM/month after 30 days. **Temperature:** Less than ±2 parts in 10^7/degree C. 20 to 35 degrees C after 30 minutes warmup. ±.002% from 0 to 50 degrees C. **GENERAL: Readout:** 5 digits plus overrange. **Temperature Range:** Storage; −55 to 80 degrees C. Operating; 0 to 50 degrees C. **Power Requirements:** 105-125 or 210-250 VAC, 50/60 Hz, 8 watts. **Cabinet Dimensions:** 8¼" W x 3⅛" H x 9" D not including handle. **Net Weight:** 4½ lbs.

See these and 300 other Heath-gift suggestions at one of the following Heathkit Electronic Centers:

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Fair Lawn, N. J. 07410
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Houston, Texas 77027
3705 Westheimer

Los Angeles, Calif. 90007
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35 W. 45th Street

Philadelphia, Pa. 19149
6318 Roosevelt Blvd.

Pittsburgh, Pa. 15235
3482 William Penn Highway

St. Louis, Mo. 63123
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LaMesa, Calif. 92041
8363 Center Drive

San Francisco Area
Redwood City, Calif. 94063
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During 1971, consult Heathkit Catalog Supplements and local newspapers for announcements of new Heathkit Electronic Centers opening in these places:

Long Island Area
Westbury, New York

Miami, Florida

San Francisco Area
El Cerrito, California

Cincinnati, Ohio

Los Angeles Area
Woodland Hills, California

Atlanta, Georgia

Prices listed are factory mail order. Retail prices are slightly higher.

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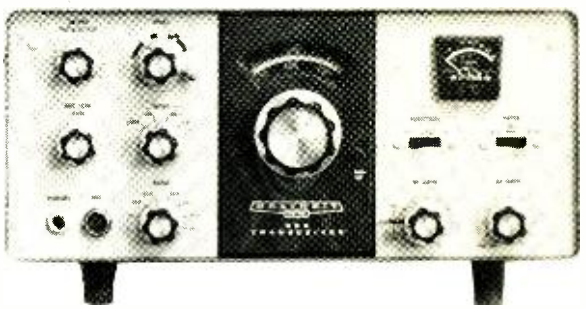

New Heathkit® HW-101 SSB transceiver

The Hams at Heath have done it again . . . with an uprated version of the Heathkit HW-100, one of the most popular pieces of ham gear on the market! The HW-101 features improved receiver circuitry resulting in better than 0.35 uV sensitivity for 10 dB S+N/N. Image and IF rejection are better than 50 dB. Other improvements are a new 36-to-1 ball-bearing dial drive; new selectable SSB or CW filters and attractive new front-panel styling.

Kit **HW-101,** 23 lbs. **$249.95***

New Heathkit wattmeter/SWR bridge

Two switch-selected ranges allow measurement of RF output from 10-200 W and 100-2000 W. Built-in calibrator permits 10% accuracy throughout the 80-10 M ham bands.

Kit **HM-102,** 3 lbs. **$29.95***

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NBS Reveals Plans

New Facilities for WWVH to be Activated in 1971

New equipment, a new location, and the addition of one more broadcast frequency is expected to offer service of utmost reliability for cities as far away as Hong Kong, Saigon, Calcutta.

NEXT year, WWVH, the National Bureau of Standards' time and frequency station in the Pacific, will be broadcasting from a new site on Kauai in the Hawaiian Islands with an additional carrier frequency, increased power, and a revised format. As a result, far-eastern parts of the world will have time and frequency broadcast service of unprecedented reliability. The new facility is now under construction on the west coast of Kauai and broadcasts are expected to start during the spring of 1971.

Obsolescence, propagation barriers, and a vanishing site are the reasons NBS is abandoning the Maui Island site from which WWVH has been broadcasting since 1948. Part of the site was a man-made peninsula which has been eaten away by the erosive action of the sea. Mountains on both sides of the station interfere with transmission to the north and east where signals are urgently needed, and the equipment is old, obsolete, and in constant need of repairs.

The Choice

The site on Kauai was chosen for its smooth, level, unobstructed characteristics. It also offered commercially available water and power supplies, accessibility by improved roads, and an airport. In addition, the area is free from electromagnetic interference and there is room on the 35-acre site to space antenna arrays which are harmonically related so they will not interfere with each other.

Each array consists of two vertical masts spaced one-fourth wavelength apart and phased at 90 degrees. The antenna arrays will be located approximately 300 feet from the breaking surf and a radial ground screen around each array will extend over the beach to the ocean, thereby furnishing an infinite ground plane. The standby antennas and the building will be located inland approximately 350 feet from the center line of the operational antennas. In contrast to the old site at Kihei on Maui, this one has an established natural beachline which is not affected by the erosive action of the sea. The building will be built on three-foot piers as a precaution against possible inundation by tidal waves.

Very-low-frequency signals (20 kHz) from WWVL at Fort Collins, Colorado, will control the master clock at the station. The Fort Collins clock, in turn, is controlled by the Bureau's atomic clock at the Boulder Laboratories.

The Changes

Power at the new station will be increased from 2 kW to 10 kW and three technicians will be added to the staff so the facility can be manned around the clock. Present broadcast frequencies of 2.5, 5, 10, and 15 MHz will be supplemented with a new 20-MHz frequency to give additional coverage of the serviced area.

The directional antennas of the station will project a cardioid pattern of radio illumination which will cover Alaska to the north, New Zealand to the south, and some major cities in the Orient (Saigon, Singapore, Hong Kong, and Calcutta). The Bureau's research on the new site included a computer study which shows that the new WWVH facility will give these key points in the Far East a reception reliability of from 90-99% during the hours between 0600 and 1600 GMT, and only slightly less reliability during other hours.

Those desiring additional information on this new facility can write to the Program Information Office, National Bureau of Standards, Boulder, Colorado 80302 for details. ▲

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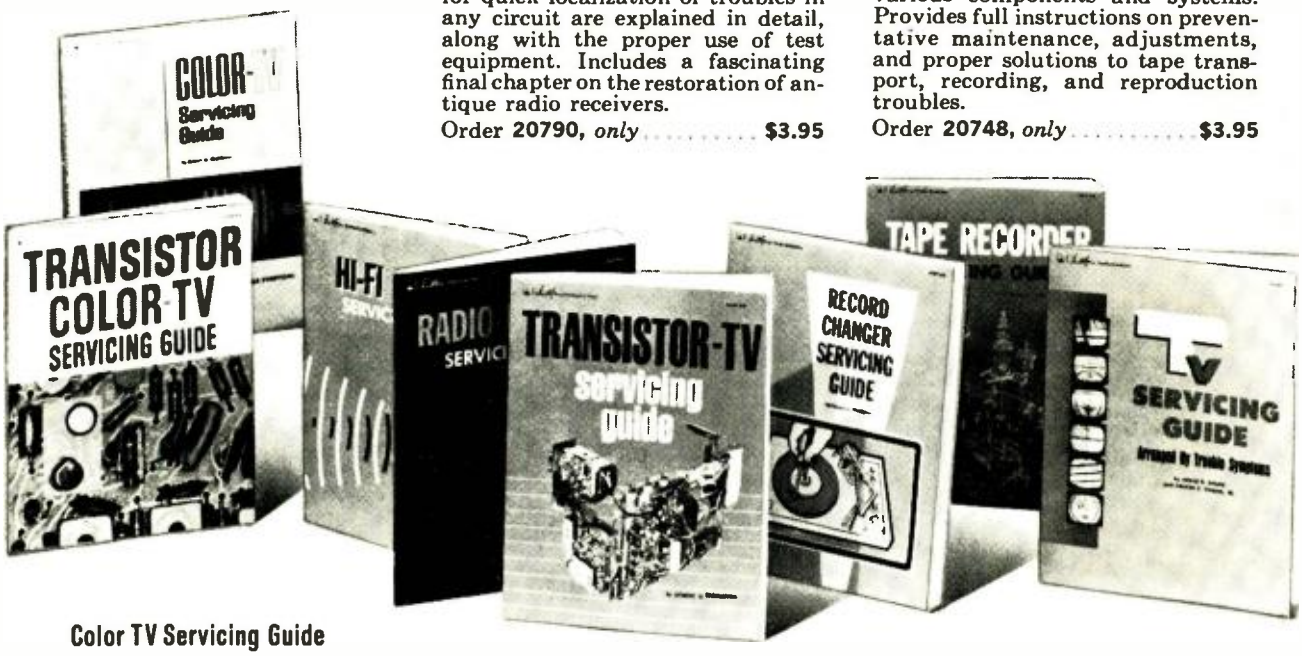

Hi-Fi Stereo Servicing Guide

by ROBERT G. MIDDLETON. A complete guide to effective servicing of a-m tuners, fm tuners, stereo-multiplex units, and audio amplifiers (all components, except record players and tape recorders). Includes hi-fi speaker system installations, trouble localization, and overall system evaluation. Also gives testing methods for verifying performance.

Order **20785**, *only* **$3.95**

Radio Receiver Servicing Guide

by ROBERT G. MIDDLETON. Presents the professional technician's approach. Covers troubleshooting and repair of a-m radio receivers, both solid-state and tube type. Methods for quick localization of troubles in any circuit are explained in detail, along with the proper use of test equipment. Includes a fascinating final chapter on the restoration of antique radio receivers.

Order **20790**, *only* **$3.95**

Record Changer Servicing Guide

by ROBERT G. MIDDLETON. Presents the general principles of record changer design, followed by a detailed analysis of the working parts of changer mechanisms. Explains adjustment and lubrication procedures, diagnostic techniques for operating troubles, and the corrective measures required to remedy them. This is a thoroughly practical guide.

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Tape Recorder Servicing Guide

by ROBERT G. MIDDLETON. Tells how to repair tape recorders profitably. Thoroughly explains the principles and characteristics of magnetic recorder circuitry, describing the various components and systems. Provides full instructions on preventative maintenance, adjustments, and proper solutions to tape transport, recording, and reproduction troubles.

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Color TV Servicing Guide

by ROBERT G. MIDDLETON. Shows how to apply fast troubleshooting techniques to color-TV repair using the famous Middleton system based on analysis of trouble symptoms illustrated by actual full-color picture tube photos. Clearly-written text explains possible trouble causes and diagnostic procedures. Final chapter explains in detail how to use color-bar generator.

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Transistor Color-TV Servicing Guide

by ROBERT G. MIDDLETON. Clearly explains the basics of the various circuits used in transistor color-TV receivers, including the most recent developments. Shows how to apply proper troubleshooting procedures based on analysis of trouble symptoms. Includes a wealth of circuit diagrams, charts, and picture tube and waveform photographs.

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Transistor-TV Servicing Guide

by ROBERT G. MIDDLETON. Second edition. Updated to provide full information on latest circuitry and many additional new test procedures. Clearly explains general transistor circuitry and servicing techniques and then proceeds through the receiver, section by section, describing various picture and or sound trouble symptoms and their remedies.

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by LESLIE D. DEANE and CALVIN C. YOUNG, JR. This is the famous guide used by more than 100,000 service technicians. Shows you how to apply quick troubleshooting procedures based on analysis of trouble symptoms illustrated by picture tube photos. Fully explains possible causes for each trouble symptom and then details proper diagnostic and repair procedures.

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C.E.T. Test, Section #10

Transistors and Semiconductors

By DICK GLASS*

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

This is the tenth 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 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 83.

1. In a common-emitter transistor-amplifier circuit, the emitter terminal is common to:

(a) the base only
(b) the collector only
(c) the input circuit
(d) the input and output circuits

2. Which set of positive terminal voltages would be typical of a class-A audio amplifier using an "n-p-n" silicon transistor?

(a) E=.5 V, B=1.2 V, C=10.0 V
(b) E=1.2 V, B=5 V, C=10.0 V
(c) E=10.0 V, B=9.8 V, C=0.0 V
(d) E=10.0 V, B=.4 V, C= .1 V

3. Your v.o.m. leads connected directly across a milliammeter produces an 80 mA reading on the milliammeter when the v.o.m. is on R X 1 range. For resistance checking common transistor circuits you should:

(a) not use the R X 10k range
(b) not use R X 1000 or 10k range
(c) use only the R X 1 range
(d) not use the R X 1 range

4. A forward-biased diode has anode positive and the cathode negative.

(a) true
(b) false
(c) depends on material diode is made of
(d) transistors are biased, two-element diodes are not

5. Comparing a FET (field-effect transistor) with an ordinary bipolar transistor, which of the following statements is correct?

(a) a FET has low input impedance, is either "n" or "p" type
(b) a FET has high input impedance, is either "n" or "p" type
(c) a FET has terminals called emitter, gate, and drain
(d) a FET is biased oppositely, has low input capacitance, greater power capacity

6. Which one of the following pairs of terms are correctly matched?

(a) transistor/pinch off
(b) FET/"n-p-n-p"
(c) tunnel diode/negative resistance
(d) diode/amplification

7. A unijunction transistor has:

(a) 2 emitters, 1 base
(b) 2 emitters, 1 collector
(c) 2 bases, 1 emitter
(d) little use in triggering circuits

8. To properly check a transistor with an ohmmeter:

(a) measure between E-B, B-C, C-E
(b) measure between C-E, then reverse leads
(c) measure between B-E, C-E, B-C, reversing meter leads on each
(d) measure between B-E, C-E, reversing meter leads on each

9. Leads are unmarked on a transistor. Using your ohmmeter, the lowest forward resistance reading will usually be obtained between:

(a) emitter and collector
(b) base and collector
(c) emitter and base
(d) it is not possible to identify leads this way

10. With an ohmmeter's positive voltage lead on the base of an unknown transistor, it can be determined whether it is "p-n-p" or "n-p-n" because:

(a) a "p-n-p" will have low resistance to only one other lead
(b) a "p-n-p" will have low resistance to both of the other leads
(c) an "n-p-n" will have low resistance to only one other lead
(d) an "n-p-n" will have low resistance to both of the other leads

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

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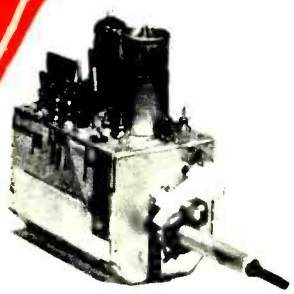

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Graphic Computer Terminals

(*Continued from page 37*).

ers, then, may pay dearly for smooth and fast stroke displays.

Applications of Interactive Graphics

The only applications of graphic video terminals hinted at so far have been rather trivial—drawing pictures on a CRT screen and, perhaps, storing them in a memory for future reproduction.

The real dynamic nature of interactive graphics comes into play when the user connects the terminal to a general-purpose central processing unit (CPU). Fitting a CPU into the interactive graphics control loop makes possible a new world of data manipulation only dreamed of ten years ago.

One common graphic manipulation is that of geometric translation. For instance, an operator can use a light pen to draw a simple 2" × 2" square in the center of the CRT. After sending the figure's coordinates to a CPU, he can instruct the computer to move the square to any other point on the screen. The CPU uses the coordinate information from the display buffer to compute the coordinates for the new position. On the next refresh cycle, the CPU unloads the new coordinates into the buffer, and the square appears in its new position—in the upper right-hand corner of the screen.

Another common graphic manipulation is that of figure rotation (Fig. 3). The operator can draw a square that has its sides lined up with the X and Y axes and instruct the CPU to rotate the figure through any angle. The CPU performs the necessary mathematics and replaces the original coordinate information in the display buffer with the new information that reflects the rotation. A feature sometimes built into character generators is a circuit that permits a 90° rotation of characters without entering their plotting data into a central processing unit.

Another interesting possibility is that of multiplying the number of identical figures in the display. An operator can draw a single figure on the CRT with a light pen. By giving the CPU appropriate instructions, any number of identical figures will appear on the screen in any desired position and orientation (Fig. 4).

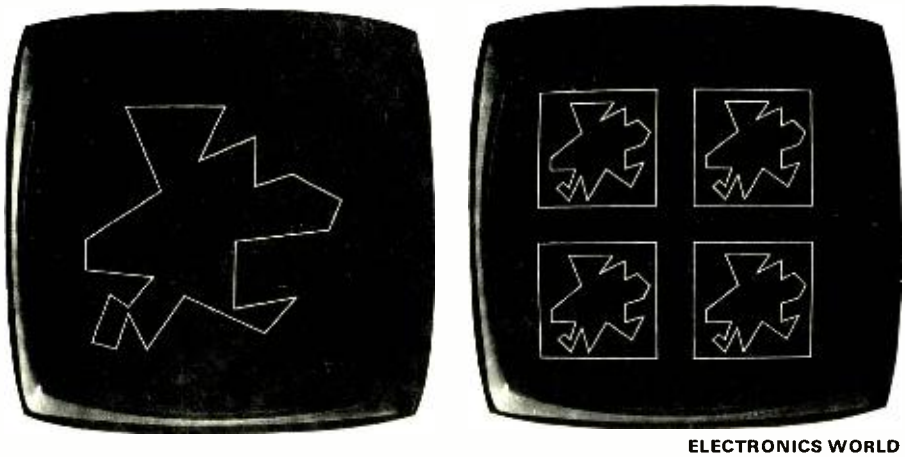
Perhaps the most incredible application of video terminal/CPU interactive graphics involves making 2-dimensional projective drawings of 3-dimensional objects. Draftsmen have always had problems drawing axonometric pictorials of complicated 3-dimensional objects. An interactive graphics system can draw axonometric pictorials in any orientation within a few milliseconds.

As incredible as this system may seem, it is much more than an electronic draftsman. Engineers and scientists can add physical data to parts of the drawing and simulate an almost endless variety of physical effects if this is desired.

An engineer, for example, can use the light pen to sketch the framework for a bridge. He can also assign stress coefficients to all the lines. After this, he can simulate loads crossing the bridge and find, quite dramatically, maximum allowable stresses. If the bridge happens to "collapse," the engineer can draw in more supports, assign stress values, and run the problem again.

Scientists and engineers have been running simulations such as these on traditional teletypewriter computer schemes for years. The graphic system, however, adds a whole new dimension to the ease and speed of information analysis—rather than having to wade through reams of typed figures, the operator can actually visualize what is going on at every instant. The savings in data analysis time can often pay the extra costs of a graphic terminal in a short time. ▲

Fig. 4. All types of graphic manipulations are possible by connecting a video display terminal to general-purpose center processing unit (CPU). One aspect of this is that a CPU connected to a graphic terminal can, when given the appropriate instructions, take a (left) single figure drawn on CRT with light pen and (right) change its size and/or multiply the number of identical figures and position them anywhere on the screen.



Digital Instruments

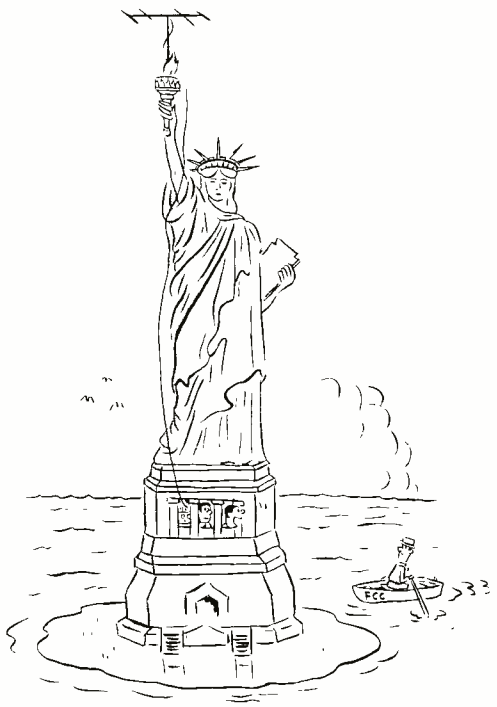
(*Continued from page* 45)

for the hours, minutes, or seconds sections of the clock, or the entire time-base generator including the oscillator. Plain (64P44-062EP) or copper-clad (64P44-062EPC2) material may be used. Other hardware items that will be found useful are: *Vector* T42-1 terminals, FA2 retainer clips, and R714-1 or *Texas Instruments* C7519 14-pin D.I.P. IC sockets. The use of pre-punched board and IC sockets facilitates construction, modification, and troubleshooting.

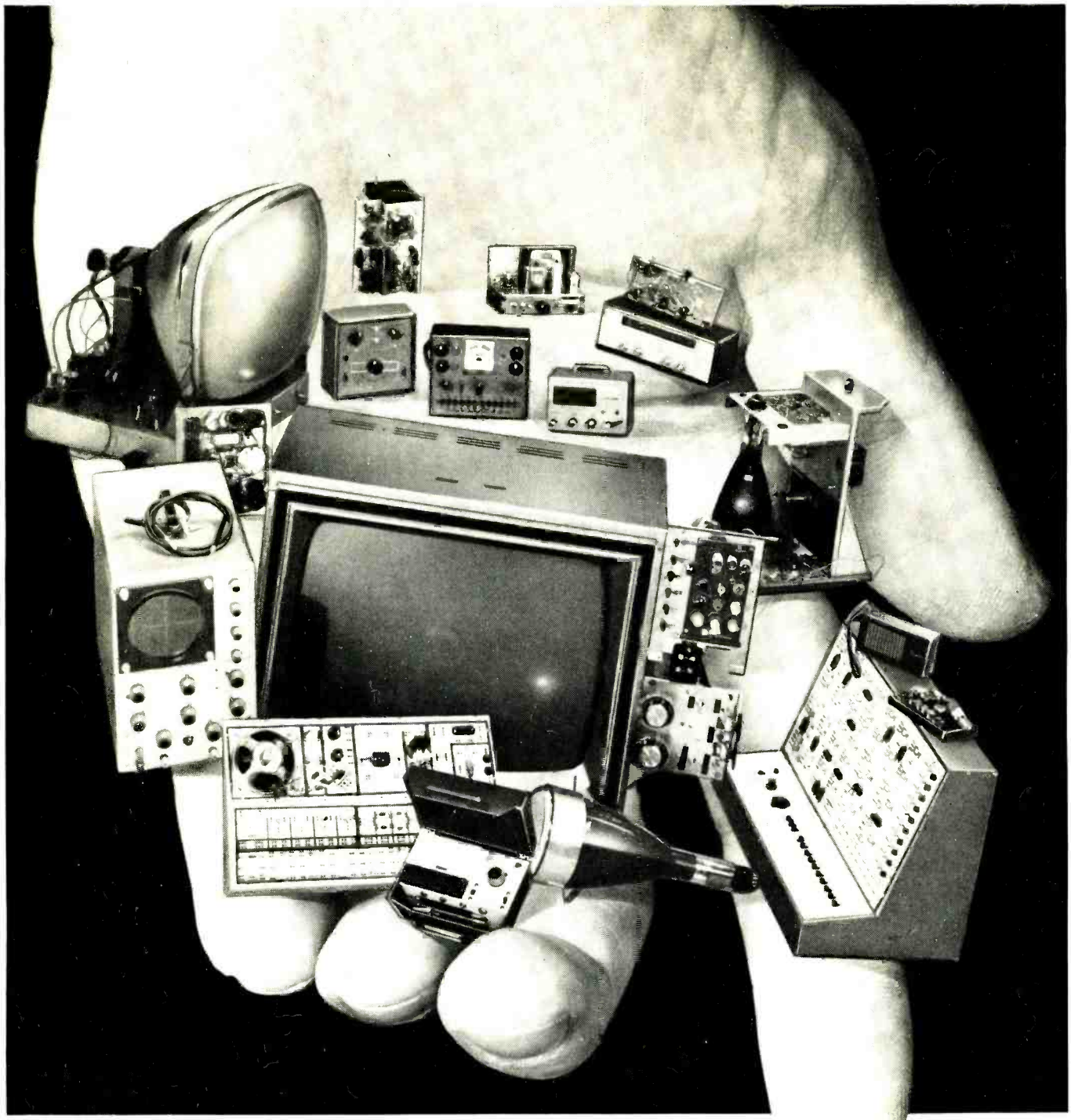
Terminals *a* through *g* (segments S1 through S7) of each *Dialight* display module (Fig. 8B) *except* pin 6 of the hours-tens display are connected directly to the collector of the appropriate display driver transistor. Pin 6 (segment 2) of the hours-tens display and the decimal and colon pins of the 501B and 501C modules are grounded; the common (Com) pin of each module is connected to 12 volts d.c. A red plastic window (*Dialight* #712-0103-006) and module mounting bars (#713-0100-006) finish off the display.

Our next article will discuss a simple three-mode (frequency, period, and total events) electronic counter designed around Resistor-Transistor Logic (RTL) IC's and using the 60-Hz commercial power-line frequency as the timing reference. General electronic counter design considerations will also be covered.

(*Continued in January issue*)



"What'd I tell you? Here he comes!"



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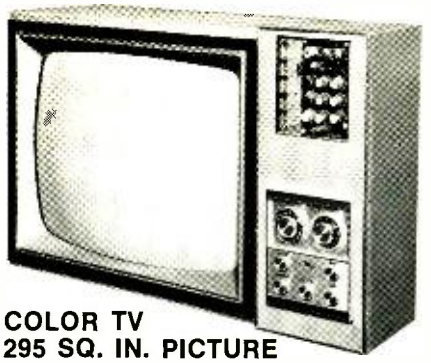

COLOR TV
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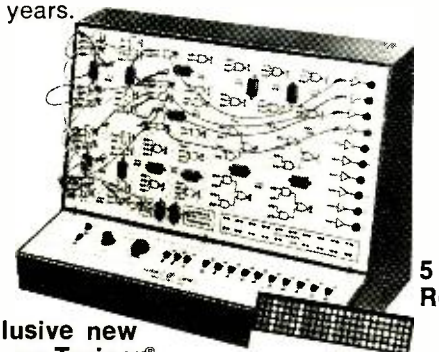

Exclusive new Compu-Trainer®

NTS offers a solid grounding in computer operation, wiring, data processing and programming. One of the 10 important kits included is our exclusive Compu-Trainer®. It's a fully operational computer logic trainer — loaded with integrated circuits — the first ever offered in home study. It introduces you quickly to how, what, when and why of computers . . . from theory to practical servicing techniques. This unit is capable of performing 50,000 operations per second.

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Choose from two exciting courses to get into the big-paying fields of transmitting and receiving equipment: (1) The FCC License Course. (2) The Master Course in Electronic Communications (more comprehensive, with Citizens' Band Two-Way-Radio). Either Communications program qualifies you for your FCC First Class Commercial Radio-Telephone License — *NTS assures you will pass this FCC exam within six months after successfully completing your course or your tuition is refunded.* Kits include an Amateur-Phone 6 Meter VHF Transceiver — NTS exclusive, 6 transistor Solid-State Radio, Volt-Ohmmeter (fully transistorized).

5 Watt AM Transmitter/ Receiver

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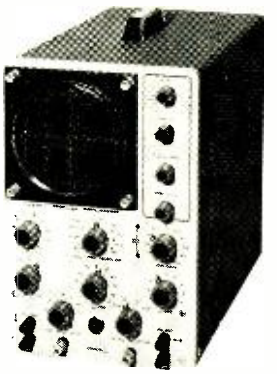

5" Oscilloscope

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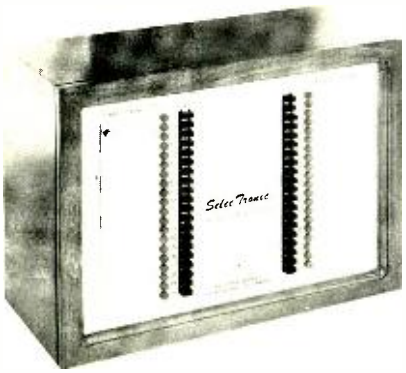
COMPONENTS • TOOLS • TEST EQUIPMENT • HI-FI • AUDIO • CB • COMMUNICATIONS

AUDIO DEMONSTRATOR

A compact audio demonstrator which permits connection of any combination of twenty tuner/amplifiers or amplifiers to any of twenty speak-



ers systems for up to 400 different combinations is available as the "SelecTronic."

Housed in a furniture-quality wood cabinet measuring only 11½" high × 16½" wide × 8" deep, the brushed gold panel accommodates 40 closely spaced, interlocking switches which activate the unit. Indicator lamps adjacent to the switches show which buttons are being depressed. These are 10,000-hour lamps that operate at half normal rated voltage for long life.

Typewritten cards in Lucite holders in line with each switch identify the components in operation at the time.

The company will forward full details on request. Amco Electronics

Circle No. 5 on Reader Service Card

TAPE CASSETTE

A cassette which utilizes chromium-dioxide-coated recording tape is now being marketed as the "Chrome Cassette" in 30 and 60 minute playing times.

According to the company, the special coating offers a number of advantages over iron-oxide formulations, including higher sensitivity with lower print-through, better high-frequency response and dynamic range, excellent fidelity at the slower cassette recording speed, and freedom from dropouts and head clogging. BASF

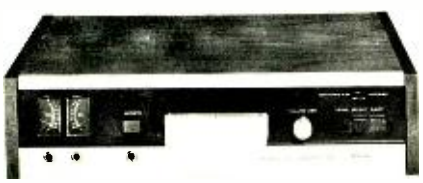
Circle No. 6 on Reader Service Card

CARTRIDGE DECK

A stereo tape deck that makes it possible to record 8-track stereo cartridges for playback through home stereo music systems or stereo tape players in cars or boats is available as the Model 1188.

The deck can record up to 80 minutes of program material—live, from microphones, or from a stereo or mono radio or phonograph—and play back pre-recorded 8-track stereo tape cartridges or all cartridges recorded by the machine itself.

The unit has an all-silicon transistor circuit for distortion-free performance with a frequency response of 30-15,000 Hz. The deck starts to play automatically when a cartridge is inserted and stops when the eject button is pushed. Other push-buttons select continuous play of the entire cartridge or automatic repeat-play of any individual program on the cartridge. Indicator lights show which portion of the tape is playing. Allied



Circle No. 7 on Reader Service Card

CARBON-FILM POTS

Amperex Electronic Corporation, 35 Hoffman Ave., Hauppauge, N.Y. 11787 has developed a new line of competitively priced carbon-film preset trimmer pots for the OEM market.

Offering nominal resistances from 1000 ohms to 2.2 megohms, these 20-turn trimmers dissipate up to ⅛ watt at 70°C. Tolerance on nominal resistance value is ±20% and repeatability is 0.1%.

Developed originally for precision resistance-adjustment in capacitance diode tuners for u.h.f. and v.h.f. TV receivers, these devices can also be used for any application requiring fine-resistance-tuning in other types of equipment such as radios, test instruments, servomechanisms, and tape recorders. Only 1⅞" long, the units are suited for mounting on PC boards in miniaturized equipment.

For additional information, address your letterhead request to the Component Division of the company.

STEREO RECEIVER

The Model 71/2R AM/stereo-FM receiver provides 150 watts r.m.s. with both channels driven. Power bandwidth is 10-40,000 Hz at 0.3% distortion, +0, −1 dB at all frequencies.

The FM section features tuning via computer for complete noise suppression, a four-gang FET

cascode varactor tuner for manual and preset tuning, three ultra-high-gain IC's with crystal filters in the i.f. section, IC's in the multiplex section, a "center tune light" for optimum station tuning, and a sensitivity of 1.2 μV.

Baxandall-type controls are used to provide individual adjustment of left and right channels. A four-page engineering bulletin covering all the features of this receiver is available on request. BIC/LUX

Circle No. 8 on Reader Service Card

COLOR-GUN CONTROL

A new color-TV service accessory, the "Single-Brite," Model B-150, which permits restoration of color picture balance when a single color gun weakens prematurely is now available for distribution.

This new potentiometric device lets the technician adjust the bias between the G1 and G2 grid leads of the weakened gun, permitting color intensity variation as needed for a balanced picture.

Installation involves just two simple connections and no soldering. Additional information on this solid-state device is available on request. Perma-Power

Circle No. 9 on Reader Service Card

DUAL-CHANNEL SCOPE

A dual-channel oscilloscope designed for field or laboratory use has been put on the market as the Model SM111.

Bandwidth is d.c. to 18 MHz and the instru-

ment offers 2 mV/cm to 50 V/cm range, a time base of 200 nanoseconds/cm to 1 s/cm, and a 10 cm × 8 cm CRT with a phosphor 31 trace.

Occupying less than 1 cubic foot (10" high × 10" wide × 14" deep) and weighing only 25 pounds, this portable scope can be powered either by a.c. or its optional self-contained battery pack.

Complete details on this instrument are available on request. B & F Instruments

Circle No. 10 on Reader Service Card

VOLTAGE-VARIABLE DIODES

Teledyne Crystalonics, 147 Sherman St., Cambridge, Mass. 02140 has added four diodes to its Varactron line of voltage-variable capacitance diodes.

Included in the new series are the JAN 1N5139A-5148A high-*Q* varactor diodes, the first to be JAN-qualified; the VA5139-5148 90-volt diodes for applications requiring higher output power; the SV1858D series of pill diodes designed for use in waveguide or stripline circuits; and the 1N5714-5718 diodes for high-voltage, high-capacitance applications requiring broad tuning ranges in the high-frequency band.

A comprehensive catalogue giving full specifications, prices, and distributors for this line is available on letterhead request to the company.

STROBE/TACHOMETER

A new stroboscope-tachometer with position (phase) control has been introduced as the "Tachlite" Model 910. The new unit is a portable, 100 percent solid-state device housed in a steel case with detachable strobe lamp which permits observation of cycle devices in motion.

The instrument can stop motion of moving objects such as fans, shafts, propellers, printing webs, and other similar devices. The built-in position control permits inspection of stamping machines during the process of stamping at desired points.

It can also be used as a tachometer. The unit has four ranges covering up to 30,000 r/min, with an accuracy of 1½% full-scale. Its features

include photoelectric or magnetic input, high intensity light (xenon daylight), taut-band readout meter, and a separate lamp with 8-foot shielded cable and connector. It operates at 117 volts, 60 Hz a.c. Power Instruments

Circle No. 11 on Reader Service Card

AM/STEREO-FM TUNER

A solid-state AM/stereo-FM tuner, Model LT-670, featuring automatic time-switching multiplex circuits and stereo indicator light is now available in a compact metal enclosure measuring just $10^5/_8$" wide × $3^1/_2$" high × $8^3/_8$" deep.

Among the controls provided are MPX filter "on-off," a.f.c., mode selector for mono/stereo operation, AM or FM selector, as well as tape output jacks on the front and rear panels for recording directly to an external tape recorder.

The tuner has a built-in FM antenna and a ferrite rod antenna for AM, plus terminals for an external FM antenna.

FM sensitivity is 3.5 μV, HD is 0.7% at 400 Hz, and selectivity is 35 dB. The tuner will operate from 105/120 volt, 50/60 Hz power sources. A matching amplifier is available as the Model LA-324A. Lafayette

Circle No. 12 on Reader Service Card

CASSETTE RECORDER LINE

A new series of hi-fi cassette tape recorders, battery-operated and solid-state, has been designed for portable applications at home, in business, or on the road.

The recorders feature automatic level control, dynamic speaker for full-range tone, and fast forward and rewind that permits replay of any part of the tape. A push-button "pop-up" system makes it easy to remove and replace the cassette.

The new units are being sold complete with cassettes and batteries. Details on available models will be supplied on request. Mallory Battery

Circle No. 13 on Reader Service Card

BRAZING KIT

A brazing kit containing the basic materials needed to make a wide range of brazing and soldering joints with the most commonly used metals is available as the #23-1005.

The kit includes materials for silver brazing, soft soldering, and aluminum soldering. It is designed for joining small or miniature components and is especially well suited for use by small shops, experimental or research laborato-

ries, and industrial model makers. Each kit has 20 silver brazing rods, 6 aluminum soldering rods, soft solder, fluxes, flux brush, welding putty, insulated brazing board, sandpaper, and instructions. Tescom

Circle No. 14 on Reader Service Card

STEREO TAPE DECK

The Model 850 three-motor stereo tape deck will handle up to 10½-inch reels of tape and features an automatic program scanner which permits playing a tape from a preselected spot automatically. Any number of sensing foils can be used to divide the programs on the reels.

Other features include a 15-in/s tape speed

and completely modular electronic construction. Fully accessible bias and equalization adjustments make service and maintenance easy. The two-track and quarter-track head blocks can be interchanged in seconds with no need for head realignment. Each head block contains one erase, one record, and two playback heads.

The walnut-housed, three-motor tape deck also provides speeds of 7½ and 3¾ in/s. The closed-loop, dual-capstan tape drive system is responsible for the low wow and flutter of the new machine, according to the company. Sony/Superscope

Circle No. 15 on Reader Service Card

PORTABLE MULTIMETER

The "Unimer 1" multimeter incorporates a number of unique features both in its circuitry and shock-resistant movement. The all-transistor amplifier permits 10 megohms impedance on both a.c. and d.c. voltage scales for 100/300/1000 volts. The 0.3- to 30-volt ranges have a 200,000 ohms/volt resistance. There are six current ranges from 50 μA to 5 A for both d.c. and a.c. with voltage drop of 100 mV; five resistance ranges from ohms × 1 to ohms × 10k are also provided as well as 9-dB output ranges from −20 to +50 dB.

The company suggests using this instrument for PC board checkout and troubleshooting and for field service work. It comes with three penlight cells, leads, a cowhide carrying case, and instruction booklet. Readout Electrical

Circle No. 16 on Reader Service Card

4-CHANNEL PLAYBACK

Two four-channel playback units, a deck model for use with stereo component systems and an amplified unit which is available with separate speakers, have been introduced as the Models 6154 and 6364, respectively.

Dubbed "Quad/Stereo," both units offer 4-channel playback, 4-track mono and stereo recording/playback, 3 heads, 3 speeds, 2 motors, and push-button tape controls.

Both units have solid-state electronics; inputs for magnetic phono, tuner, microphone; and auxiliary, tape/source monitoring; sound-on-sound, sound-with-sound, reverberation, enhanced mono recording; and separate bass and treble controls.

A colorful brochure detailing these and other

Wollensak tape recorders and players is available on request. 3M

Circle No. 17 on Reader Service Card

AUTOMATIC RECEIVER

The Model SX-2500, 340-watt (IHF) solid-state AM/stereo-FM receiver features precision automatic tuning which requires just a touch to send the tuning pointer from one station to the next, where it locks in to the signal with hairline accuracy. The tuning point travels along the dial, lighting up and stopping precisely at the next station, with the help of a center-tuning meter and a servo-mechanism, where the signal strength is maximum.

The receiver also provides remote control for automatic tuning and volume from distances up to 23 feet. The FM front-end tuner section is a two-stage r.f. circuit using three FET's, five IC's, two crystal filters, and a 4-gang variable capacitor. Sensitivity is 1.6 μV and capture ratio is 1 dB at 98 MHz.

Complete specifications on the SX-2500 receiver will be forwarded on request. Pioneer

Circle No. 18 on Reader Service Card

CASSETTE RECORDER

The Model A-25 cassette recorder features automatic pinch-roller disengagement; an input selector which provides its own selection of tuner or line source or can be connected to an existing stereo system; push-button controls for simple and foolproof operation of stop, rewind, record, play; non-latching fast-forward, cassette pop-up, and instant pause; dual controls; headphone monitoring; dual vu meter; 3-digit index counter; pause button; and hysteresis-synchronous outer-rotor motor.

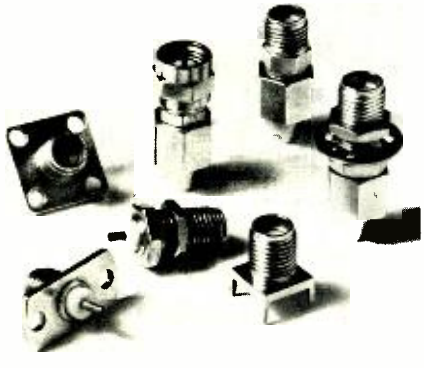
Frequency response of the deck is 40-12,000 Hz and the amplifier response is 20-50,000 Hz. S/N ratio is 45 dB. The cassette recorder measures $13\frac{5}{8}$" wide × $9\frac{5}{8}$" deep × $4\frac{1}{4}$" high while each speaker measures $9\frac{7}{8}$" wide × $7\frac{1}{2}$" deep × $14\frac{13}{16}$" high. Teac

Circle No. 19 on Reader Service Card

R.F. COAX CONNECTORS

E.F. Johnson Company, Waseca, Minn. 56093 has just introduced a new line of JCM miniature r.f. coaxial connectors designed for applications up to 30 GHz.

According to the company, the new connectors yield an electrical performance comparable to that of the more expensive SMA-types designed to MIL-Specs.



Seven JCM connector types will be available for panel and PC mounting and for flexible cable assemblies. All types are interchangeable and intermateable with standard SMA connectors. The new units can be designed into existing circuits without changes and without compromising required performance, according to the company.

Write Clarke Willson, Component Product Manager, on your business letterhead for more details.

LOW-COST V.O.M.

An inexpensive v.o.m. which features a mirror scale, single selector switch, easy-access bat-

tery compartment, diode-protected meter movement, and a.c. rectifier pre-calibrated for easy replacement, has been introduced as the "Omnimeter-50K."

The v.o.m. measures 4½" × 2⅜" × 5⅞" and weighs just 22 ounces with batteries. Unimetrics

Circle No. 20 on Reader Service Card

MANUFACTURERS' LITERATURE

POWER-MODULE DATA

Catalogue No. 701 provides complete data, electrical and mechanical, on more than 3000 power modules and accessories, including the new PK series for 0-32 V d.c. up to 80 watts, designed to meet MIL-Specs for vibration, shock, moisture, RFI; have IC control circuitry; are field serviceable, and are designed for multi-surface mounting with computer power applications in mind. Also included is the new OP Series for low-cost overvoltage protection devices and a new logic card supply which provides regulated 5 V d.c./1 A d.c. with overvoltage protection. Technipower

Circle No. 21 on Reader Service Card

HEADPHONES BROCHURE

A 16-page, four-color brochure designed to explain stereophones and stereophone listening is now available for distribution.

In addition to describing and picturing the entire dynamic and electrostatic lines of stereophones, the brochure devotes a section to explaining the sound of headphone listening and how it is achieved. It includes cutaway illustrations and line drawings to support the text and aid consumer buying decisions. Koss

Circle No. 22 on Reader Service Card

TURNTABLES

A six-page brochure which covers the entire Thorens line of transcription turntables has been issued. Included is information on the TD-150 MKII, 2-speed turntable; the complete series of TD-125's; as well as an entire accessory line of bases, dust covers, mounting frames, tonearm mounting boards, and maintenance equipment. Elpa Marketing

Circle No. 23 on Reader Service Card

SEMICONDUCTOR DEVICES

All of the company's major semiconductor devices are presented in easy-reference format in the new 20-page, full-color, illustrated "short form" Semiconductor Device Digest recently issued.

The electronic devices covered are indexed on the front cover for quick reference and includes SCR's, power logic triacs, high-power silicon rectifiers, selenium rectifiers, zener regulators, low-power silicon rectifiers, silicon assemblies, light-sensitive devices, and heat exchangers.

An additional catalogue feature is a complete alphanumeric cross-reference index of individual device numbers to the corresponding catalogue page. International Rectifier

Circle No. 24 on Reader Service Card

PHONO/TAPE ACCESSORIES

A 36-page catalogue covering an extensive line of phono and tape accessories for home, car, and hi-fi applications has been issued as No. FR-70-A.

Included in the publication are tape head cleaners, cartridge player head cleaners, microphones, tape strobes, tape head demagnetizers, bulk tape erasers, splicing tapes, pressure pads, sensing tapes, earphones, pillow speakers, diamond replacement needles, audio controls, phono accessories, test records, testing strobes and discs, audio cables, TV-FM couplers, as well as plugs, jacks, and adapters. Audiotex

Circle No. 25 on Reader Service Card

TV DISTRIBUTION DATA

A 32-page catalogue entitled "Systems and Products for TV Distribution," is now ready for mailing.

The booklet includes numerous product photos and specifications on an extensive line of equipment for apartments, hotels, motels, schools, and hospitals.

Including numerous specifications, tables, and applications notes, the catalogue covers systems antennas and accessories, head-end equipment, distribution equipment and components, and installation aids.

Copies of Catalogue S will be forwarded upon request. Jerrold

Circle No. 26 on Reader Service Card

POWER CONVERTERS

An 8-page condensed catalogue describing the features, specifications, modifications, and mounting dimensions of an extensive line of miniature and subminiature power converters is now available for distribution.

The catalogue covers a.c.-d.c. converters, miniature solid-state d.c.-d.c. converters, subminiature 3-watt d.c.-d.c. converters, d.c.-sine wave inverters, 400-Hz power supplies, switching regulators, and a.c. power controllers as well as miniature power transformers, inductors, and toroidal winding machines. Arnold Magnetics

Circle No. 27 on Reader Service Card

AUDIO/MUSIC EQUIPMENT

A 60-page, four-color "1971 Home Entertainment/Electronics Catalogue" covering an extensive line of audio products from a representative group of hi-fi manufacturers is now available for the asking.

In addition to all sorts of component and compact systems, the publication lists separate speakers, stereo headphones, turntables, cassette player/recorder decks, stereo tape decks, portable cassette player/recorders, AM/stereo-FM receivers, two-way radios, CB equipment, mobile and base-station antennas, monitor radios, microphones, telephone answering devices, security systems, CCTV equipment, replacement tubes, antenna rotators, and all types of musical instruments—both with and without amplification. Sears, Roebuck

Circle No. 28 on Reader Service Card

PROJECTS MANUAL

The Semiconductor Division of International Rectifier has just issued a second volume of its popular "Hobby Projects" Manual with an extensive assortment of all-new projects for hobbyists and experimenters.

The 64-page, full-color manual is in a handy 5½" × 8½" workbench size format. Projects are presented in sequence of varying levels of technical competence required of the builder.

An introductory section includes a basic description of semiconductors, construction hints, soldering tips, pictorial representation of circuit symbols, troubleshooting procedures, and other pertinent information.

Copies of the manual are available from the company's "Diamond Line" suppliers for 85 cents a copy.

PLASTIC TRANSISTORS

A cross-reference guide listing the company's complete stock of plastic transistors which are the nearest equivalents to more than 400 standard industry 2N types is now available from the Distribution Center, Fairchild Semiconductor, Box 880A, Mountain View, California 94040.

The listings are contained in a two-color pamphlet that folds out into 18 panels. Each panel measures 7" × 3½". In addition to the transistor listings, it provides the names and addresses of Fairchild stocking distributors and the locations of all of the firm's sales offices.

CIRCUIT BREAKERS

Airpax Electronics, P.O. Box 8488, Fort Lauderdale, Florida 33310 has available a new 16-page, two-color bulletin (No. 2002) which describes a line of UL-approved hydraulic magnetic circuit breakers molded in a phenolic case for panelboard applications.

Types APL, UPL, and MPL are discussed with current ratings listed. Series, shunt, and relay trip is discussed as well as single and multiple pole breakers. Block diagrams, delay curves, impedance charts, applications, outline drawings, and specifications are also included.

Write on your business letterhead for a free copy of this brochure.

INDICATOR LIGHTS

Leecraft Manufacturing Company, Inc., 21-16 44th Road, Long Island City, N.Y. 11101 has just issued a "Product Lighting Guide" which features a quick index to enable users to quickly match lights to their needs.

Illustrated with photographs and schematics, the catalogue furnishes complete specs on an extensive line of indicator and pilot lights. Available in both neon and incandescent types, the indicators are designed for use in appliances and electrical and electronic equipment of all types.

Copies of the Guide (#1-70) are available on letterhead request.

LC FILTER BROCHURE

ESC Electronics, 534 Bergen Blvd., Palisades Park, N.J. 07650 has announced a new 12-page brochure describing its dual in-line LC filter series.

The brochure gives part numbers, specifications, feasibility ranges, attenuation, phase shift, and group delay characteristics and time response for its low-pass, linear-phase, and high-pass filters. Frequency ranges of these filters are 1 kHz to 10 MHz.

A letterhead request will bring your copy.

METAL FILM RESISTORS

A report on established reliability metal film resistors is now available from Dale Electronics, Inc.

Detailing the status of its established reliability (EMF) resistors, the report lists complete electrical and physical specifications, summarizes testing data, and types of screening available.

Copies of the report as well as information on custom established reliability program for metal film resistors can be obtained upon letterhead request to Dept. 860 of the company, Box 609, Columbus, Nebraska 68601

RESISTOR DESIGN GUIDE

The complete line of Corning glass tin-oxide resistors is described in the updated 16-page resistor design guide (RBR-2.00) published by the Electronic Products Division of the company.

The brochure emphasizes that the reliability of these resistors results from the firm's continuous manufacturing process. It also notes that

MIL-R-22684 and MIL-R-10509 have been inactivated and superseded by MIL-R-39017 and MIL-R-55182, respectively, and that the company is prepared to supply resistors to these new specifications.

Copies of this guide can be requested from Corning Glass Works, Corning, N.Y. 14830.

TRANSISTORS/DIODES

An 80-page transistor and diode condensed catalogue listing Fairchild's complete line of discrete off-the-shelf products is now available to engineers on request.

The new catalogue presents key parameters and package outline information on more than 2000 semiconductor devices. Offered in standard letter size, the publication is an updated and expanded version of the 64-page condensed catalogue issued by the company last year.

Letterhead requests for this catalogue should be addressed to Distribution Services, Fairchild Semiconductor, Box 880A, Mountain View, California 94040.

SHRINKABLE TUBING

An illustrated brochure which shows how "Shrinkdown" plastic tubings can be used in a number of applications is now available from L. Frank Markel & Sons, Inc., Norristown, Pa. 19404.

Nine types of tubings and their properties are covered in this handy pocket-size brochure which is available on letterhead request.

REED SWITCHES

Hamlin, Inc., Lake and Grove Sts., Lake Mills, Wis. 53551 has issued a 12-page illustrated guide covering the selection and application of reed switches.

The line includes nearly 2000 models, ratings, and types of magnetically actuated reed switches, most of which are included in Guide A-00001. ▲

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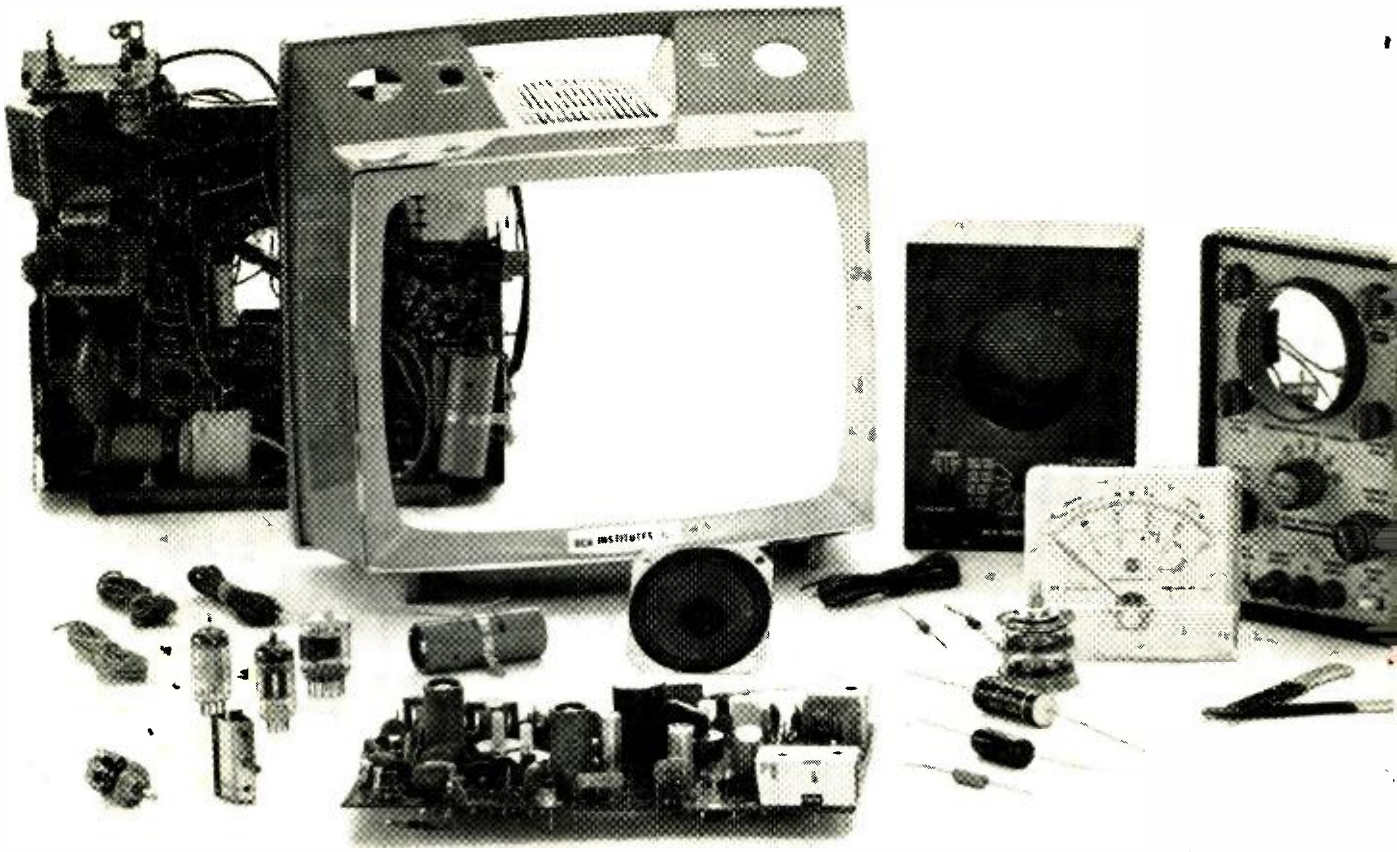
Answers to C.E.T. Test, Section #9

Published in Last Month's Issue

1. **(b)** Bypassing the cathode resistor reduces degeneration.
2. **(a)**
3. **(b)** This would, in effect, be placing the diode Y401 directly across the secondary.
4. **(c)** No flyback keying pulse to "turn on" the V4B a.g.c. tube eliminates conduction of V4B and thus development of a.g.c. voltage.
5. **(b)**
6. **(b)** Without the "bucking" plus voltage from R158 total a.g.c. at TP II would be slightly lower.
7. **(a)** C201 provides vertical retrace blanking pulses to the picture tube; without these, vertical retrace lines would be evident.
8. **(a)** R269 is already a thermistor, however adding "T", results in symbol in most common use.
9. **(a)**
10. **(d)** R168 would have to be closer to 20 watts to survive a direct short of T154.



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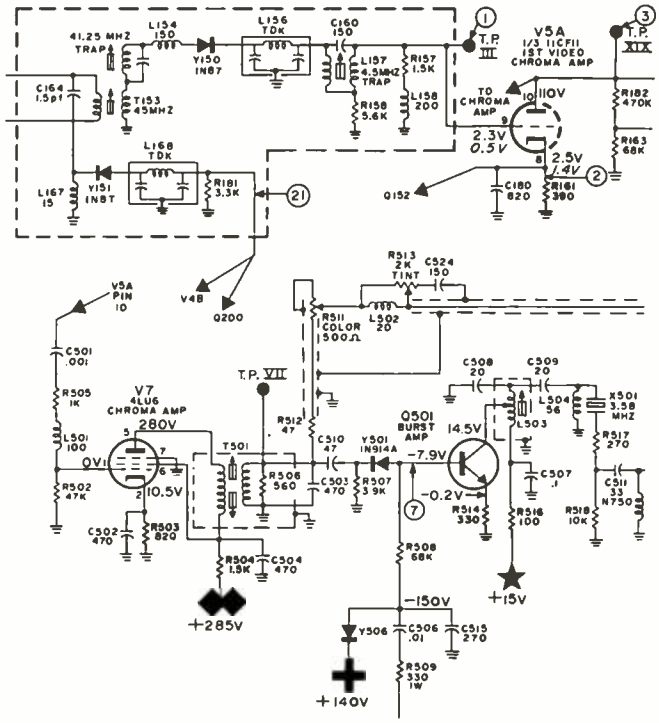


WITH recent designs stressing serviceability, it is becoming easier for technicians to find their way around television receivers. It is only logical, then, that schematics also be easier to read.

Circuits can be difficult enough without further confusion from cluttered schematics. Especially hard to trace are interrupted lines connecting one section of a schematic with another, separated, section. Typical interrupted lines are: interstage coupling, feedback, and "B+."

More convenient point-to-point schematic reading might be possible if there were no interrupted lines at all, but this would result in many criss-crossing lines and would still be confusing. So another solution had to be found.

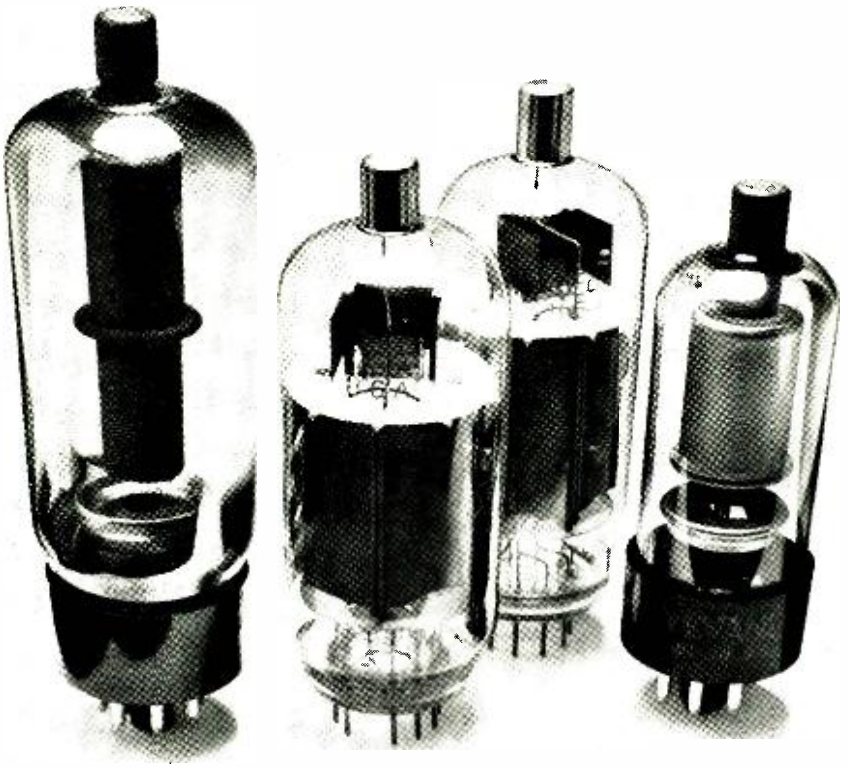
When the purpose of interrupted lines is considered, an obvious answer to the problem becomes evident. Since these lines show a signal going from one point to another, the direction of the interconnection could be shown. In this way, one can "visualize" the point-to-point connection between interrupted lines.

The partial schematic above shows this idea. There are two specific things about these interrupted lines: (1) different slopes, and (2) arrowheads. A line going from a point is at the *same slope* as the line going to another point being connected. Also, an arrowhead shows the from/to direction of signal flow. Then, to complete identification, reference points are given at each arrowhead.

The significant feature of these lines is the slope which permits easy tracing of signals. Note, for example, how easy it is to trace the line from *V5A*, pin 10, to *C501*.

Also to be noted are the different symbols used for various "B+" lines. Such eye-catching symbols help in quickly finding power distribution throughout the schematic.

Still another schematic technique is the shaded gray on some components. The shaded areas on the schematic (and parts list) designate components in which safety can be of special significance. Use of substitute replacement parts which do not have the same safety characteristics as recommended may create a hazard. ▲



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OFFSET Printing. Free catalog. Speedy Print, 1906 Swede, Norristown, Pa. 19401.

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ELECTRONICS WORLD

November 1970

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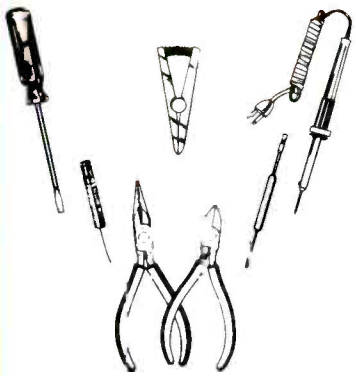

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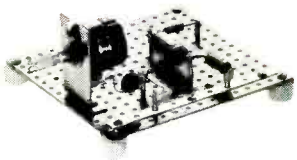

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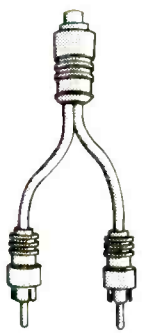

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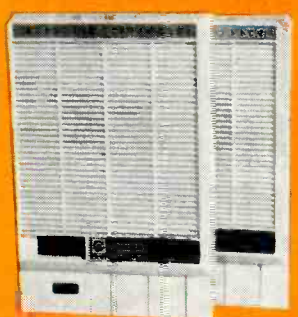

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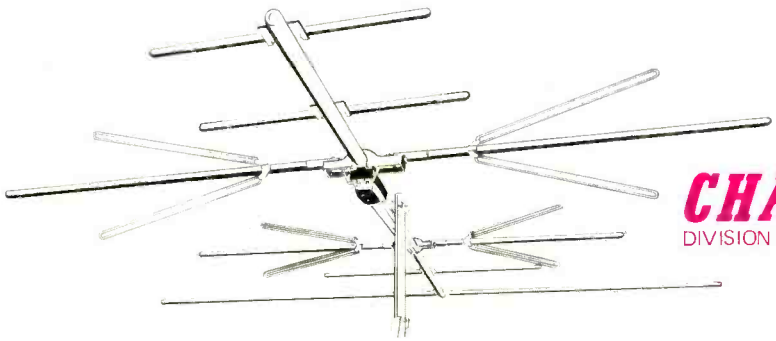

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