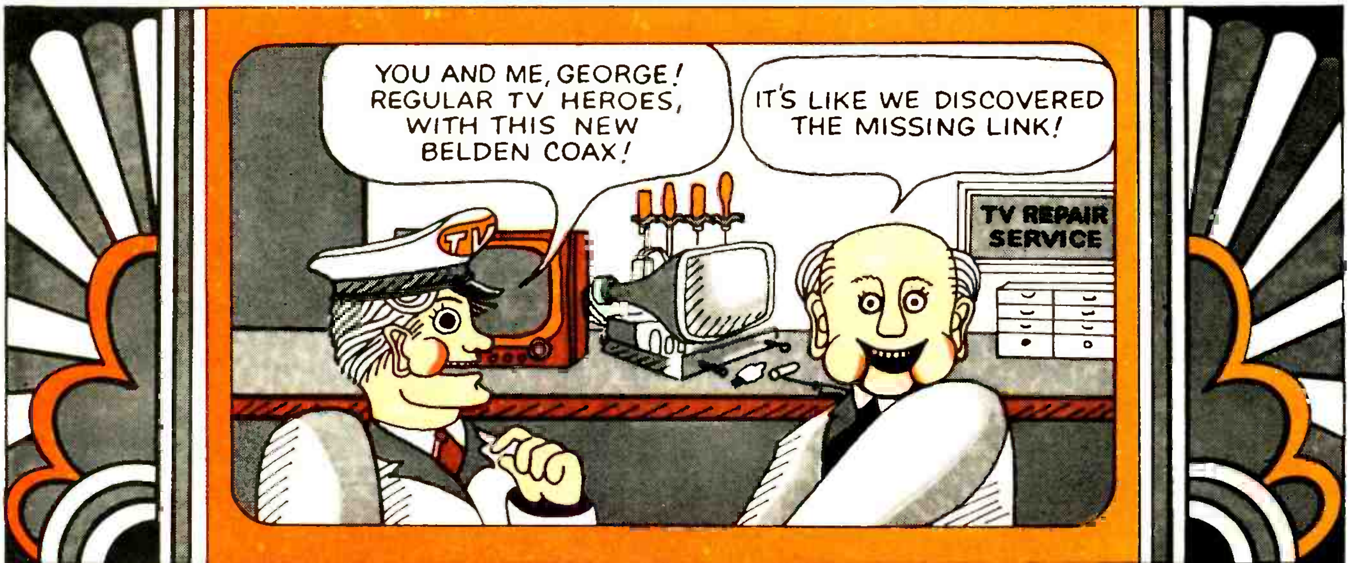
Electronics World

JUNE, 1969
60 CENTS

HOW TO INSTALL HOME TV SYSTEMS
EXPERIMENTAL LASER ENGINES
TAPE-RECORDER WOW & FLUTTER
THE POWER FIELD-EFFECT TRANSISTOR

CASSETTE TAPE RECORDERS



Jacket
Black all-weather PVC .030 nominal wall with a .242″ nominal O.D.

Dielectric
Low loss cellular polyethylene, .180″ nominal O.D.

Conductor
18 AWG solid, annealed, bare copper.

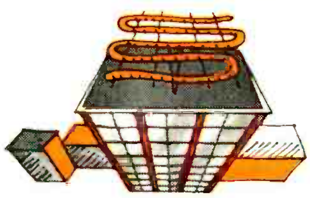
Drain Wires
4—28 AWG solid tinned copperweld conductors applied spirally and positioned uniformly around the circumference of the shield.

Shield
Belden DUOFOIL 100% shield is a polyester film with aluminum lamination on both outside surfaces.

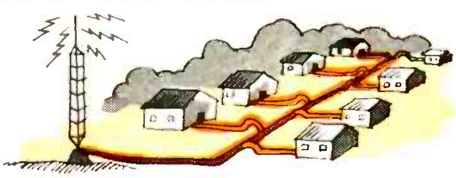
THE MISSING LINK TO PERFECT VHF AND UHF COLOR AND B/W RECEPTION

BELDEN 8228 DUOFOIL®

75 OHM COAXIAL CABLE • 100% SHIELDED • 100% SWEEP TESTED



For MATV distribution systems, DUOFOIL is the finest coax yet. Its low loss, 100% shielding keeps B/W and color VHF and UHF signals pure. Apartment dwellers, hotel and motel tenants, etc.—even in congested areas—get sharp, clear reception. Its small diameter provides extra space savings in conduit installations.



Is CATV coming into your area? DUOFOIL is the perfect underground drop cable. Its exceptional flexibility and moisture resistance assures extra-long service life, and preserves the impedance values of the cable design.

LOW, LOW ATTENUATION

Nom. Attenuation per 100′	
mc	db
50	1.5
100	2.1
200	3.1
300	3.8
400	4.5
500	5.0
600	5.5
700	6.0
800	6.5
900	6.9

Available in 100, 500 and 1000 ft. spools. See your local Belden Distributor for full details or to order. For a copy of the reprint article, "Electronic Cable," write: Belden Corporation, P.O. Box 5070-A, Chicago, Illinois 60680.

Don't forget to ask them what else needs fixing?

BELDEN

8-5-8

CIRCLE NO. 125 ON READER SERVICE CARD

MALLORY **Tips for Technicians**

Versatile Sonalert® Signal makes a great ingenuity tester

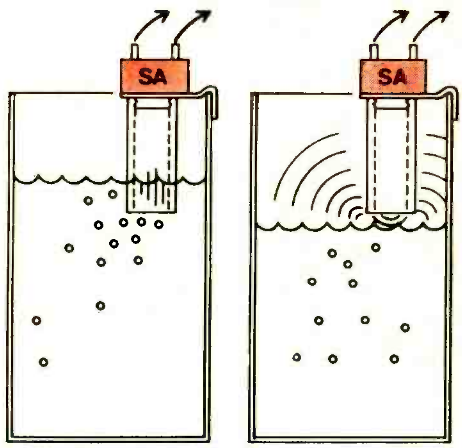


Fig. 1—Trapped Sound System

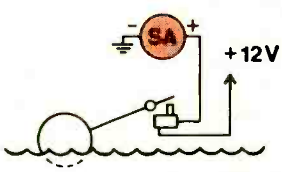


Fig. 2—Mechanical System

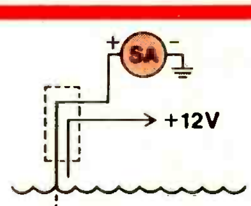


Fig. 3—Simple Electronic System

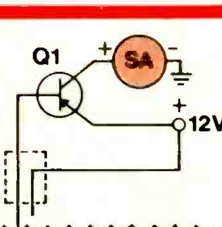


Fig. 4—High Output Electronic System

Crank up your inventive powers and put them to work with Sonalert®, the low-drain, solid-state tone signal that gives a big sound with just a few milliamp drive. More than likely you can come up with some great ideas for your shop, home or car. Ideas for fun, safety—and, perhaps, profit.

Just to give you a few clues, let's take a look at the way would-be Edisons turned Sonalerts into interesting ideas. We've picked four ways in which others have used this new signaller for one application: liquid level alarm.

One of the simplest is a compact system that requires no trigger circuits or complex mechanical devices. All you have to do is install a glass or plastic tube on the unit's nose cone, and hook the Sonalert to a power source. (See figure 1.) Insert the tube into the liquid to the level required for alarm. Since the tube is immersed, no sound can escape. Once the fluid falls below the critical level, out comes a loud, clear, unmistakable signal. Here's an ideal system for use in explosive atmospheres; Sonalert produces no arcs or sparks.

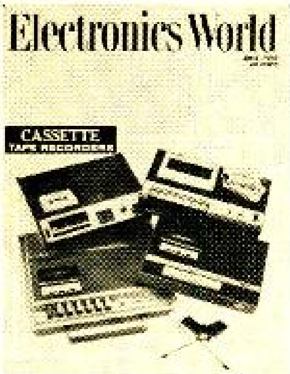
Figure 2 shows a mechanically actuated system—float and switch. It's made up by mounting a float ball on a lever arm that actuates a plunger switch in series with the Sonalert and power source. Reliability might be a problem because of mechanical failures.

For greater reliability, the simple electronic system (figure 3) is hard to beat. Fluid acts as the switch to close the circuit between Sonalert and the source. Just one problem presents itself. The sound level from Sonalert is proportional to current flow. If the liquid is not a good conductor, current flow may be too low.

To overcome this limitation, a high output electronic signal system was developed (refer to figure 4). Here transistor Q1 acts as a low resistance switch; and current flow to the Sonalert is maximum as long as there is enough base current flowing through the fluid to hold Q1 ON.

Here are four variations on one theme. Bet you can come up with some great ideas on your own. Try. If you can't, we've got more tips for you in booklet No. 9-406 that's yours for the asking at your Mallory Distributor's. It's chock-full of information: how Sonalert works, ratings, specs, mounting instructions and more tips. You can write for a copy, if you prefer. Mallory Distributor Products Company, a division of P. R. Mallory & Co. Inc., Indianapolis, Indiana 46206.

DON'T FORGET TO ASK 'EM—*"What else needs fixing?"*



THIS MONTH'S COVER shows a group of representative cassette tape machines. All of these are stereo recorders that operate from the a.c. power line. The two upper units are tape decks that will play back through your stereo system, while the two lower units are complete recorders with power amplifiers and speakers (not shown). The deck at the top left is Harman-Kardon CAD-4; at the top right is Sony TC-125. At the bottom left is Ampex Micro 88; at the bottom right is Norelco Continental 450. The dual microphone at the lower right is used with the Ampex recorder. Prices of these machines range from $129 to $200. For further details on these and other cassette tape recorders, see our lead story this month. Photograph: Dirone-Denner.

ZIFF DAVIS PUBLISHING COMPANY

Electronics World

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CONTENTS

MONTHLY FEATURES

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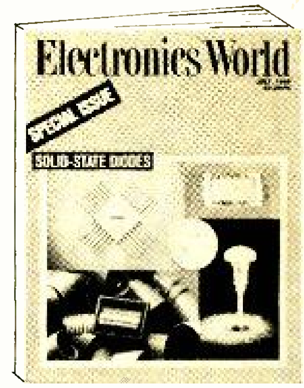
COMING NEXT MONTH

SPECIAL ISSUE:



SOLID-STATE DIODES

A 16-page Special Section, designed to give you up-to-the-minute information on the state-of-the-art, will be featured in our July issue. Such well-known industry figures as Irwin Caroll of Motorola will give you the lowdown on varactors and their circuit applications; R. S. Myers and J. O'Brien of RCA will cover light-sensitive diodes from the designer's viewpoint; Stephen Adams of Hewlett-Packard has the word on Schottky diodes—especially in TV receiver applications; while Walter Niblack and Clifford Levi of Sylvania delve into the mysteries of microwave diodes and how they work. Arthur Seidman has gathered important data on junction diodes and their applications as rectifiers, detectors, mixers, and switches.

COMMUNICATIONS SATELLITES
F.A. Gicca, Raytheon's Manager of Space Communications Systems, reveals details of developments in space communications that may have an important impact on our daily lives. In this, the first article in a two-part series, he covers our satellites from Score to Intelsat II.

HIGH-"Q" INDUCTIVE ELECTRONIC IGNITION SYSTEM
A special storage choke coil plus a pulse transformer are used to generate the spark-gap voltage to provide good performance at high engine speeds. Herb Keroes of Quaker City Transformer provides the information needed to build this tested system.

ATOMIC RADIATION: MEASUREMENTS
In his concluding article of this three-part series, Author Joseph Wujek, Jr. discusses the systems and circuits used to measure and evaluate the radioactivity phenomenon. Various commercial systems are analyzed.

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

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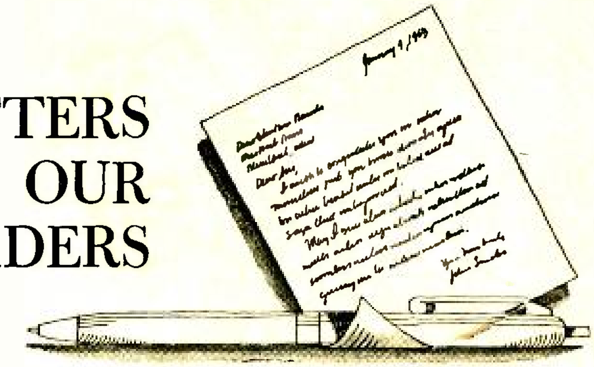
LETTERS FROM OUR READERS



USING CONTROLS TO TROUBLESHOOT

To the Editors:

Congratulations on a fine servicing article ("Using Controls to Troubleshoot TV") by Don Matsuda in the March ELECTRONICS WORLD. The helpful analysis and diagnostic clues show that the author has acquired some of the traditional quick-tests that are a technician's greatest tools. His line of thinking is very similar to the approach used by many knowledgeable technicians. To know one's trade so finely as to use the eyes, the ears, and the mind to make important tests, is an indication of a dedicated and successful craftsman.

I plan to refer to this article, as it is a gem of ready hints, and also represents, in my opinion, the classical down-to-earth methods used by some of the experts of radio servicing's early days.

Thanks also to your magazine for the broad coverage of developments and progress in electronics.

NICHOLAS COSMIDES
Daly City, Cal.

* * *

CHROMA CIRCUIT ALIGNMENT

To the Editors:

The article "TV Chroma Circuit Alignment" (Feb. issue) by Forest Belt contains several fundamental errors. In fact, following the direct-bandpass-alignment or the indirect-bandpass-alignment methods would lead to degraded performance of the TV receiver.

The error in the direct-bandpass-alignment section (p. 50) is the author's neglect of the fact that color frequencies are not amplified equally by the i.f. amplifiers. In particular, the color carrier is located at the 50% amplitude point on the i.f. response curve. The color bandpass amplifiers must not be aligned as shown in the article's Fig. 4, but must be aligned to accentuate those frequencies attenuated by the i.f. response. If the author's method were followed, the lower color frequencies would be emphasized, resulting in color smear. Although the author does recommend following the manufacturer's instructions, I believe, the above facts should be pointed out.

The error in the indirect-bandpass-alignment section is the suggested very accurate setting of the 45.75-MHz marker signal. Tuning in a strong station will produce a marker on the i.f. sweep response curve, at the frequency difference between the station picture carrier frequency and the local-oscillator frequency. This marker will appear at 45.75 MHz *only* if the fine tuning (local oscillator) happens to be perfectly adjusted. For the usual case, the local oscillator would not be set accurately and the marker will appear at a frequency other than at 45.75 MHz. If the TV receiver happens to have a properly operating automatic fine tuning circuit, the author's method would be accurate.

The author's video-sweep-modulator method, as recommended by RCA, is a method that would lead to correct color bandpass alignment.

KENT R. BOURQUIN
Los Altos Hills, Cal.

Reader Bourquin's comments on Fig. 4 are correct for some but not all recent color-TV sets. In most RCA's, for example, the 3.58-MHz color subcarrier is placed on the 50% point of the chroma bandpass response. On the other hand, other color sets, both new and old, have the color subcarrier placed just exactly as shown in Fig. 4 and no attempt is made to exactly equalize the i.f. response curve with the chroma response.

On the matter of the accuracy of the 45.75-MHz marker, technically Reader Bourquin is right except that Author Belt's position is that extreme accuracy is not required here just so long as the video-i.f. frequency, no matter what its precise value, is located halfway down the slope of the i.f. curve.—Editors

* * *

PULSES ON AERO BAND

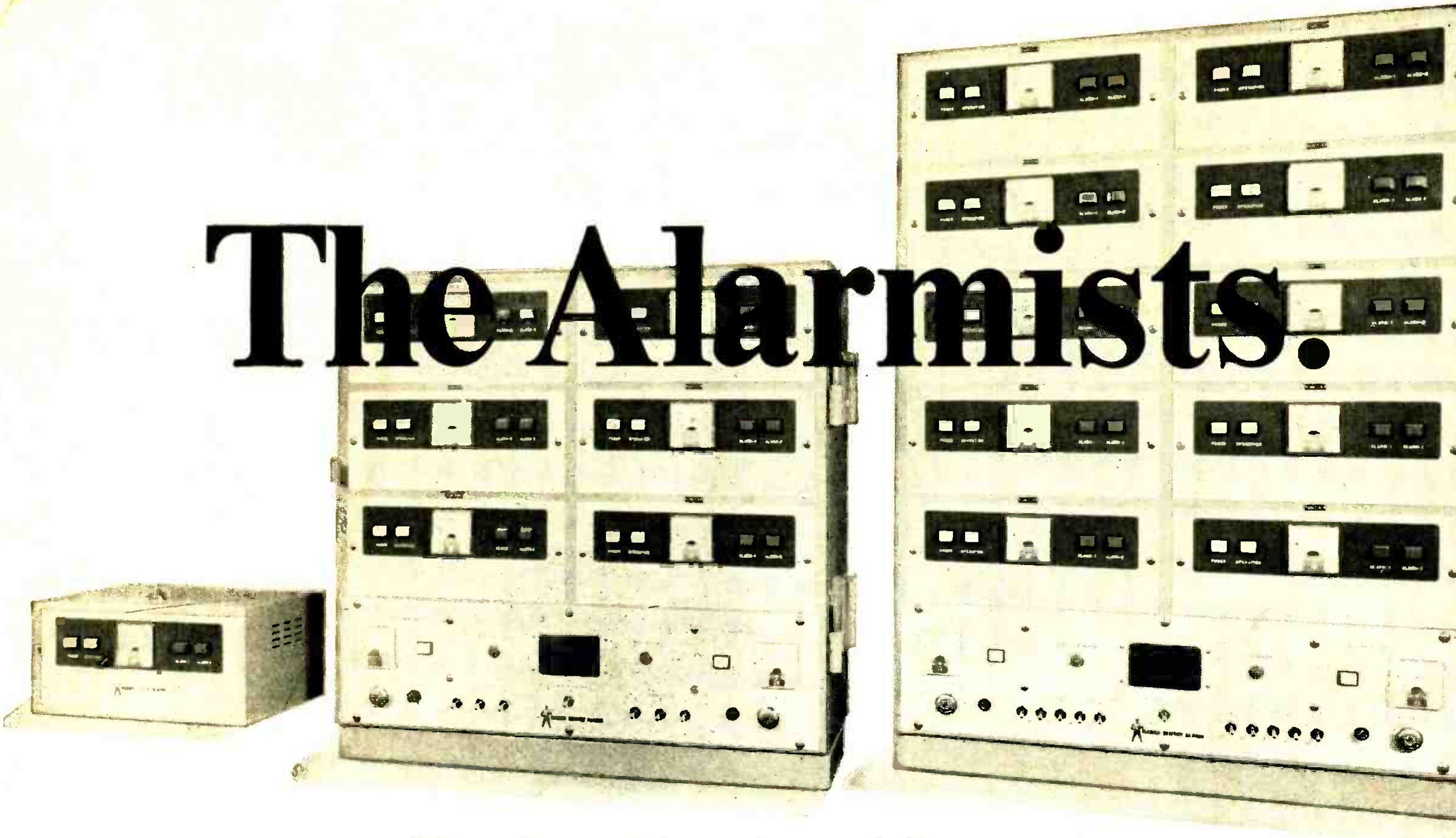
To the Editors:

In listening to signals near the high end of the aeronautical radio band, I noticed a very large amplitude pulse-type transmission around 128 MHz. I thought that frequencies in this area were all supposed to be voice signals rather than pulses. Any idea what these pulses are?

PAUL FERRELL
Park Ridge, N. J.

We've heard these signals too, and very loud. Upon investigation we learned that the signals are from an ex-

The Alarmists.



Radar Sentry Alarm supervises security from every angle.

Radar Sentry Alarm covers every angle.

It works on the same principle used by the U.S. government to protect our borders. Microwaves beamed by an installation of modular units are foolproof.

Any human movement, even the slightest gesture, sets off the alarm. And what an alarm! An ear-splitting blast that would frighten anything. You can't beat it.

And there's no way to escape detection ...whether the intruder comes in from the wall, window, door or ceiling. Even if he shuts off the power, the alarm sounds.

This is the newest and completely proven system that everyone's talking about.

Take any of the set-ups pictured here.

The smallest is our model 301: its remote detector unit covers up to 5,000 square feet. Can set off an alarm that's heard half a mile away. Add up to 3 antennas for a coverage of up to 15,000 square feet. Model 5006 modular unit is 6 units in one. It will cover up to 90,000 square feet. The big one on the right, 5010, will give customized coverage of up to 150,000 square feet.

Take any of these solid state numbers, add Dialtronic automatic telephone dialer, programmed to phone the police or direct-hook-up or, in case of fire, the fire department. Or add the special Radar Sentry Alarm holdup and prowler alarm. It can be used in combination with any of these set-ups, plus the telephone alarm, without the thief's knowledge.

There's no hiding place. These units are considered the best burglar traps in the world. Solid state circuitry gives effective performance, means a minimum of false alarms and reliable operation. And the heart of the electronic system is printed on one single printed circuit module. To replace, just pull out the old one, plug in the new one, no lapse in security.

Design your own inviolable customized system with Radar Sentry Alarm and accessories. You won't be able to find a more versatile, more adaptable system...nor one that is more tamper-proof against burglars.

Get the full story on Radar Sentry Alarms. Write now for our new booklet covering all the facts.

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St. Clair Shores, Michigan 48080

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☐ Also send me booklet outlining available dealerships.

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CIRCLE NO. 92 ON READER SERVICE CARD

perimental Decca data-link transmitter located atop the Pan Am building in downtown Manhattan. The exact frequency is 127.85 MHz and pulse power output is around 20 watts. These pulses are able to interrogate a large number of in-flight aircraft. Transponders within the planes can automatically send back data giving the aircraft identity, position, and height. This data can be displayed to the flight controller on the ground to show where the planes are located. Currently, some of the major airlines are experimenting with the system.—Editors

* * *

WRONG-WAY COMPASS NEEDLE

To the Editors:

In the February issue there is an article called "Geomagnetic Observatories" in which a sketch (Fig. 5, p. 42) purports to show the dip of a magnetic needle at various points on the earth. Now anyone knows that at the magnetic poles the dip is 90° (the needle points straight down) while at the magnetic equator the dip is zero. This sketch, however, shows it to be just the opposite.

EDWIN C. DAVIS
Bremerton, Wash.

You are correct, of course—the directions of the needles at the North Pole and on the Equator are reversed. The needle at the North Pole should be vertical, in line with the north/south axis. —Editors

* * *

50-MHz DIGITAL COUNTER

To the Editors:

I read with interest the article "A 50-MHz Digital Counter" in the March, 1969 issue of ELECTRONICS WORLD. I would like to construct this piece of equipment and would appreciate more information about it. In Fig. 4 on page 42, there are no identifying parts on the drawing.

HOBART J. PAINE
Chief Engineer, Station KUAT/TV
Univ. of Ariz., Tucson, Ariz.

We regret that some part numbers were omitted in Fig. 4. The IC used for the time-base oscillator is a Motorola *MC799P; the remaining IC's in the count-down decade are* Motorola *MC790P types. We have available a limited number of copies of the author's board-layout drawings, which we will send upon request.—Editors*

* * *

LOOKING FOR HELP

To the Editors:

I am trying to locate someone who would be willing to build some small solid-state projects for me. Please contact me directly at my home address.

GEORGE F. HARLAN
1029B Spruce St.
Myrtle Beach, S. Carolina 29577 ▲

By FOREST H. BELT / Contributing Editor

Semiconductor Color-TV

Motorola's Quasar stole the march to solid-state color two years ago. Then, last year, *RCA* brought out the all-transistor CTC-40. Three more transistor color sets are promised this year—all Japanese. Two of them can be seen at the June 15-18 Consumer Electronics Show at the New York Hilton and Americana hotels. *Sony* expects to have 50,000 of its 12-inch Trinitron sets available after the CES. An 18-inch Trinitron CRT, in a prototype chassis, is available with aperture grille or shadow mask; *Sony* people are vague about the reason for having both. Panasonic recently displayed a 12-inch conventional shadow-mask model, to be in production for U.S. import by the end of June. Another 12-inch solid-state color chassis was previewed by *Hitachi*, who also plans a 14-inch version, but neither size will show up in quantity before the end of the year.

Nothing official yet, but *RCA* may have a large-screen transistor chassis to show in June. The Electronic Components Division announced a package of two SCR's and three silicon switching rectifiers especially aimed at large-screen, wide-sweep solid-state color. The five components fit the SCR horizontal sweep design pioneered in the CTC-40 chassis. There's no indication—at press time—that the new version will eliminate the vacuum-tube h.v. rectifier, but a semiconductor for that is available. Best surprise of all would be all-electronic tuning for u.h.f. and v.h.f.

No other American color producer is committed publicly to transistor color. *Philco-Ford* seems close, but denies having one for June. The *Sylvania* plug-in transistor concept would be welcomed by servicers who repair the sets, and seems one natural answer to the modular concept of *Motorola*. *Zenith* is working on a transistor/IC approach to solid-state color. *Magnavox* is mum about it.

Electronic TV Tuners

We reported briefly last month on variable-capacitance-diode TV tuners by *RCA* and *Standard-Kollsman*. Since then, the idea is heating up. *Oak Electro/Netics*, which has played down diode tuning because of its cost, says now that it is feasible after all and that *Oak* has it available. We haven't found out if any sets will include that version this year.

Matsushita-Panasonic has shown diode-tuned-and-switched tuners, and hints they may be used in its own solid-state color-TV chassis.

The word is that many top-line color receivers, which carry high price tags anyway, will sport diode (electronic) tuning this fall. Industry opinion is that *RCA* is most likely to be first. *RCA* admits being hopeful that it will be in the new color line to be publicized in June, but no one promises anything. Officials of other set makers smile and avoid saying "yes" or "no" to questions about their plans for electronic tuning.

IC's Come into Power

There's a new breed of integrated circuits for audio, and they can handle big power—which has been one hangup in IC's. *G-E* may have started it, with a 5-watt monolithic IC late last year. Recent activity began when *Sony* brought out a 26-watt IC audio amplifier. *Sanken Electric* in Tokyo then announced 20-watt and 50-watt thick-film hybrid units; distortion is claimed to be under 0.5 percent.

Top dog for the moment is *RCA*, with a 100-watt thick-film hybrid. Over-all power gain is 60 dB. The unit contains its own driver circuitry—23 resistors, 7 capacitors, 9 transistors, and 6 diodes. The high-power section has two power transistor chips and two diodes. Overload protection for the output circuit is built in.

To go with the high-power IC, *RCA* also developed a four-stage amplifier—a monolithic IC. Each amplifier is independent of the others, but they can be cascaded to develop up to 2 volts of audio output. None of them will appear in finished consumer products before late this year or early next.

Matrix-Type Flat-Screen TV

An IEEE Show highlight was a 13-in flat-screen monochrome TV set (*Matsushita/Panasonic*). Main flaw is inability to produce a picture bright enough for daylight viewing. The screen is a matrix sandwich of

230 vertical and 230 horizontal electrodes. The vertical electrodes in front are strips and are transparent. Next comes a layer of electroluminescent phosphor. Then a reflective layer to enhance the light-producing ability of the phosphor. Finally comes a layer of horizontal electrodes, which are strips of evaporated aluminum. The sandwich is on a glass substrate; the rear is protected by an epoxy deposit.

Scanning is by a complex integrated-circuit counter system that triggers an SCR for each electrode. The points where the vertical and horizontal electrodes cross make up 52,900 electroluminescent cells that can be switched "on" or "off" in sequence by matrix action of the electrodes. The amount of brightness from each cell is a characteristics of the phosphor and the sharpness of the pulse applied. Definition is reasonable, but neither it nor brightness is commercially acceptable yet. But it is a working prototype.

Not to be outdone, *Mitsubishi Electric* also has a matrix-type flat screen. *Sony*, *Toshiba*, *Sharp*, and *Hayakawa* are other Japanese firms that are developing flat-screen TV displays. *Zenith*, here in the U.S., has investigated the "glass semiconductor" developed by Stanford R. Ovshinsky as a possible flat TV display device. *Sylvania* has done some work in the field, too, but offers no clue to when or even whether a set will be out. And, *RCA* has considered applying liquid-crystal technology to a flat-screen TV display.

Colored Plastics for TV

Bright and lively are words that describe youth-oriented TV sets in *RCA*'s forthcoming line. All kinds of colors are going into mod-style plastic cabinets for portable TV's. A company spokesman says you can expect colored cabinets before long even in color-TV consoles. They won't be as colorful as the portable sets, but will use colors that fit in with the brighter way people are decorating their homes.

Motorola brings color styling to black-and-white TV, too, along with a new plastic cabinet that promises high impact strength, abrasion resistance, and stain repellency. The plastic is *Monsanto* Lustran ABS, a thermoplastic resin.

Wide-Angle Color CRT

Late next year, you'll see color-TV sets with very shallow profiles. That's because *Sylvania* has built the industry's first 110-degree color picture tube. Its viewable diagonal measurement is 18 inches. The tube isn't in production yet, nor have deflection components been made for it.

Also, watch for color sets with sharp-corner screens. The company is building a 25-inch (true viewable measurement) CRT with flat face and square corners. Present 90-degree color tubes waste some overscan in the corners; the new ones won't. There'll be a 21-inch tube with similar characteristics, too.

Getting CATV Off the Wires

In some small communities in Oregon and New Mexico, *TelePrompTer Corp.* is again trying out microwave for CATV. These tests are in the 18-GHz band—the frequencies that didn't work out well in Manhattan a year or so ago because of rain and fog.

The Federal Communications Commission has also suggested tests in the 12-GHz spectrum. So far, we haven't heard that anyone has taken the Commission up on that idea. Special rulemaking is necessary if that band is to be used, but the FCC says it's willing.

EVR to be Modular

The electronic video recorder developed by *CBS Laboratories* is to be built and marketed by *Motorola*, but not this year. When it comes out early in 1970, it will be constructed on modules similar to the Quasar solid-state color chassis. Sections will be mounted on plug-in printed-circuit boards. First marketing will be to educational and industrial users, with home-type units to follow. The home-consumer market probably won't develop until a color unit is available. Cost for a color version will be well over $1000, which will limit sales, but *Motorola* expects a substantial market by 1975.

Flashes in the Big Picture

Clock radios with digital numerals are becoming popular; both *Panasonic* and *Sony* have them . . . *General Electric* built its 150-millionth multi-function compactron. . . . Electronic Industries Association gets first full-time paid president June 30; George D. Butler, formerly with *Electra/Midland Corp.* . . . *Arvin's* low-price VTR, expected this summer, won't be available until next year . . . Apparently, *Westinghouse* will not quit making TV picture tubes, as reported in this column last month, according to word received direct from headquarters. Sorry if we led you astray. ▲

The first cassette deck with the guts to talk specs.

Most high fidelity buffs have been, at best, amused by the notion of a fine quality cassette deck. And perhaps with good reason. Many cassette recorders have been little more than toys. We, on the other hand, have always felt that a *component* quality cassette deck was a totally viable product.

And we've proved it. Conclusively.

The CAD4 has a frequency response of ±2 db 30-12,500 Hz with less than 0.25 RMS wow and flutter. Signal to noise is better than 49 db. And record and playback amplifier distortion is less than 0.5% THD @ zero VU. Cross talk is better than 35 db.

These specifications compare favorably with those of the most popular reel-to-reel recorders. They were achieved by developing a revolutionary new narrow gap head with four laminations per stack. This head, combined with specially designed low-noise solid state electronics makes it possible for the CAD4 to deliver wideband frequency response and virtually distortion-free performance.

The CAD4 also features electronic speed control and carefully balanced capstan drive with precision mechanism for precise tape handling and minimum wow and flutter.

It has two large illuminated professional type VU meters; overmodulation indicator light on the front panel that ignites at +2 VU on either channel; unique electronic automatic shutoff and pushbutton switches for recording and shuttling functions.

Unlike most other cassette decks on the market, the CAD4 is solidly crafted in steel (walnut end caps) to assure rigidity and mechanical alignment of all moving parts. It weighs 10 pounds and is 12½" W, 9" D, 3¼" H.

The CAD4 is at your Harman-Kardon dealer now. It's only $159.50. And we guarantee it will change your mind about tape cassette recorders.

For detailed technical information on the CAD4, write to Harman-Kardon, Inc., 55 Ames Court, Plainview, N.Y. 11803, Dept. EW-6.

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— more value, more solid experience so essential to careers in Electronics. NRI's pioneering "discovery" method is the result of more than half a century of simplifying, organizing, dramatizing subject matter. In each of NRI's major courses you learn by doing. You demonstrate theory you read in "bite-size" texts programmed with NRI designed-for-learning professional lab equipment. Electronics comes alive in a unique, fascinating way. You'll take pleasure in evidence you can feel and touch of increasing skills in Electronics, as you introduce defects into circuits you build, perform experiments, discover the "why" of circuitry and equipment operation.

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— By actual count, the number of individuals who have enrolled for Electronics with NRI could easily populate a city the size of New Orleans or Indianapolis. Over three-quarters of a million have enrolled with NRI since 1914. How well NRI training has proved its value is evident from the thousands of letters we receive from graduates. Letters like those excerpted below. Take the first step to a rewarding new career today. Mail the postage-free card. No obligation. No salesman will call. NATIONAL RADIO INSTITUTE, Electronics Division, Washington, D.C. 20016.

L. V. Lynch, Louisville, Ky., was a factory worker with American Tobacco Co., now he's an Electronics Technician with the same firm. "I don't see how the NRI way of teaching could be improved."

G. L. Roberts, Champaign, Ill., is Senior Technician at the U. of Illinois Coordinated Science Laboratory. In two years he received five pay raises. Says Roberts, "I attribute my present position to NRI training."

Don House, Lubbock, Tex., went into his own Servicing business six months after completing NRI training. This former clothes salesman just bought a new house and reports, "I look forward to making twice as much money as I would have in my former work."

Ronald L. Ritter of Eatontown, N.J., received a promotion before finishing the NRI Communication course, scoring one of the highest grades in Army proficiency tests. He works with the U.S. Army Electronics Lab, Ft. Monmouth, N.J. "Through NRI, I know I can handle a job of responsibility."

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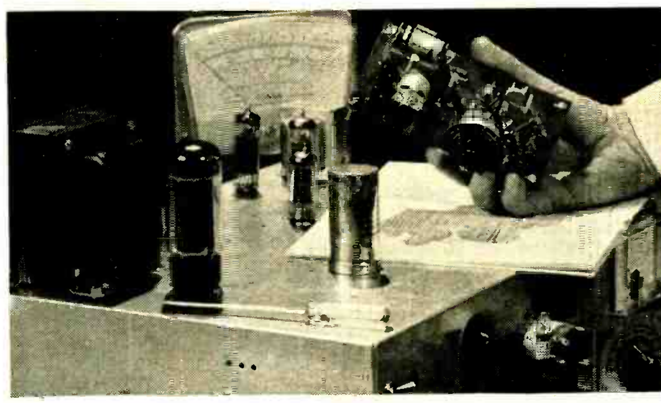
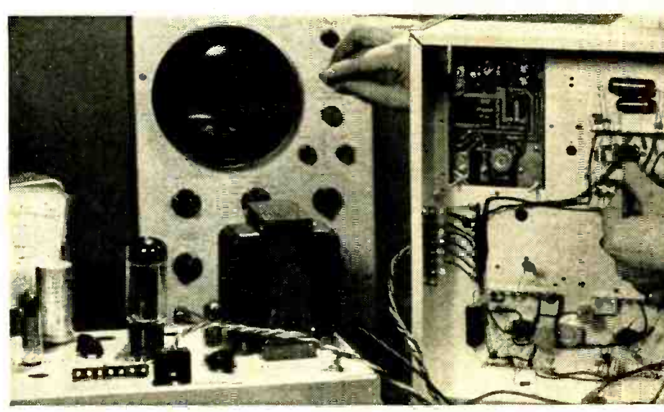
as you build, stage-by-stage, the only custom Color-TV engineered for training. You grasp a professional understanding of all color circuits through logical demonstrations never before presented. The TV-Radio Servicing course includes your choice of black and white or color training equipment.



COMMUNICATIONS EXPERIENCE

comparable to many months on the job is yours as you build and use a VTVM with solid-state power supply, perform experiments on transmission line and antenna systems and build and work with an operating, phone-cw, 30-watt transmitter suitable for use on the 80-meter amateur band. Again, no other home-study school offers this equipment. You pass your FCC exams—or get your money back.



COMPETENT TECHNICAL ABILITY

can be instantly demonstrated by you on completing the NRI course in Industrial Electronics. As you learn, you actually build and use your own motor control circuits, telemetering devices and even digital computer circuits which you program to solve simple problems. All major NRI courses include use of transistors, solid-state devices, printed circuits.

Reflections on the news

The Moon is Only . . .

a steppingstone to further space exploration. Two more Mars probes are on their way: Mariner 6 and Mariner 7. Mariner 6 will fly to within 2000 miles of the Martian surface on July 31 to transmit television pictures and environmental measurements back to earth. Mariner 7 will get there August 5, but some of its electronics may have bugs. In fact, some equipment was removed before launch because of suspected failure.

Almost everyone knows about the Apollo 11 flight that, if all goes well, will land astronauts on the lunar surface this summer. Following that, ten more moon landings are planned, to allow concentrated exploration. The public hasn't heard much yet about the program called Viking. Its scientist teams are already working on a capsule scheduled to soft-land on Mars in 1973. The Viking vehicle will be similar to Surveyor craft that landed on the moon. Planned for the Viking Mars-surface research package are visual and infrared photography, ultraviolet measurements, atmospheric study, surface sampling, radio propagation tests, seismic analysis of subsurface planet activity, and an experiment trying to find life in any form on the Red Planet.

Piezoelectricity Has Many Uses . . .

you might not have suspected. A recent example is a flyback transformer for television. *Matsushita Electric (Panasonic)* has taken a thin slice of very special ceramic, with piezoelectric polarization in two directions, and fashioned a device that amplifies a small 15.75-kHz signal into many thousands of volts peak-to-peak. The result is a solid-state flyback transformer that is less than 3 inches long and about an inch square—and with no windings.

Brush Clevite Co. Ltd., British subsidiary of *Clevite* in this country, worked on this idea some seven or eight years ago, but never put a product on the market. *General Electric* also looked into it about ten years ago, when solid-state TV sets were barely getting off the ground. Although they won't publicize it as yet, other U.S. companies are known to be working on the same idea, hoping to gain the size and reliability advantages.

That isn't the end to ingenuity in ceramic. *Matsushita* also has a piezoelectric FM detector. It's a ceramic resonator that vibrates in a thickness-shear mode. Units are available with either 4.5-MHz or 10.7 MHz center. No tuning or diodes are needed.

Sixty-Page/Min Printout . . .

for computers is possible with a new dry-copy electrostatic printer—the *Clevite* 4800. It accepts ASCII (American Standard Code for Information Interchange) digital information from computer memory or telephone lines, and can be interfaced with virtually any computer. It prints 4800 lines/min, with a definition of 80 dots/inch. Assuming 80 lines per page an 8½" x 11" page can be printed every second. It can print alphanumerics or graphic copy.

The rather small machine (21" wide, 14" deep, 39" tall) is filled with RTL integrated circuits. The only mechanical parts are the liquid toning head and a drive for the 300-foot paper roll. The coded paper is pulled over a 7½" row of 600 styli by an asynchronous stepping motor, advancing 0.012" at a step. The styli that are addressed by the input data leave a charge on the coding. The paper moves over a liquid toner, from which oppositely charged particles stick to the charged dots on the paper. Any remaining liquid is vacuumed off, and the emerging copy is dry. The system can be adapted to other paper sizes without sacrificing definition.

Free Trips to Cuba . . .

may be about to cease. The wave of aircraft hijackings dropped an enormous challenge in the laps of electronics technology. What was needed was a weapons detector, one that wouldn't worry passengers or be fooled by other metal objects. Suprisingly, for a time no company seemed up to finding an answer, either. Too many complications, they said.

However, one system is being tested now. About all that has leaked out is that the unit is a form of magnetometer, and that it works. Only a few know who built it (three companies cooperated, we hear) or what's in it, and they aren't talking. FAA spokesmen say the newest unit isn't the last word; research teams are working on a system that combines several electronic ideas: x-ray, magnetometry, and perhaps infrared. The final system needs to detect plastic bombs as well as metal weapons.

When it's ready, the equipment will be quietly put into operation. Unsuspecting Cubanistas will find their reservations suddenly canceled.

Global Air Navigation . . .

in three dimensions is the goal of a satellite system proposed by Dr. J. B. Woodford of *Aerospace Corp.* Major advantages include accuracies to the tens of feet even with high-performance aircraft; Doppler effects of motion would be almost nil. The idea depends on readings taken from four satellites operating in the 1-2 GHz range and correlated with real-time computer tracking readings from ground stations. The readout, for the user, could resemble that presently used for loran, but the electronic means of producing the information bears no resemblance. Dr. Woodford estimates a system could be operating by 1974.

An environmental approach to the navigation problem of the future is part of another system, suggested by J. W. Lazur, technical director of *The Mitre Corp.* This system would integrate all three important interfaces of travel in our air-ground-sea environment: navigation, communications, and identification. Military technical needs already dictate an integrated system like this although it doesn't yet exist. The total system should operate in the 1-5 GHz range; if antenna problems can be solved for aircraft, 6 or 8 GHz would be better. The best system would involve satellites combined with computer-operated ground stations. Equipment size and weight are already limiting performance of high-speed aircraft; an integrated system cuts equipment needs drastically. Mr. Lazur says test hardware for the system could be ready within a year.

Neither system is operational. But they and other advanced (and hopefully simplified) navigation systems are top priority. The Air Force has the lead in evaluating them, but civil aviation officials are scrambling for dollars and authority to have a say-so in the next generation of air-traffic electronics.

An Underwater Exploration Slowdown . . .

can be blamed on the multiplicity of problems that have plagued Sealab 3, latest phase of the Navy's Deep Submergence Project. Worst blow, of course, was the death of Aquanaut Berry L. Cannon; he was the victim of an unfilled Baralyne canister—the unit that takes carbon dioxide out of the air the aquanauts must breathe over and over. But, equipment failures of almost every description preceded the human failure that resulted in that final tragedy.

At least three things should be obvious from the abortion of Sealab 3—which is to be halted for a year or more. These are: (1) A more thorough, systems-type approach to undersea operations is necessary. The ocean environment has, in its way, all the dangers and risks aerospace explorers live with. As much forethought and consideration should be given to aquaspace research as is devoted to aerospace. (2) Electronic communications, monitoring, and warning systems must be instituted. True, lack of experience with the undersea environment has hindered many companies' efforts. And the glamor of outer space has diverted interest and dollars away from deep-water exploration. But it is a sad commentary on electronic engineering if these needs continue unfulfilled. (3) As long as these two prerequisites are lacking, safety and long-range success dictate a less frantic approach. If equipment is inadequate, develop it before entrusting lives (and the whole program) to it.

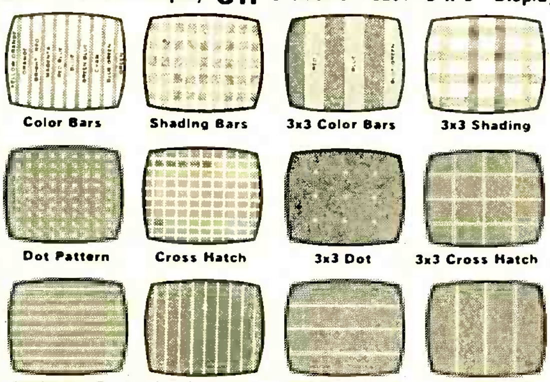
Radiations from the Field . . .

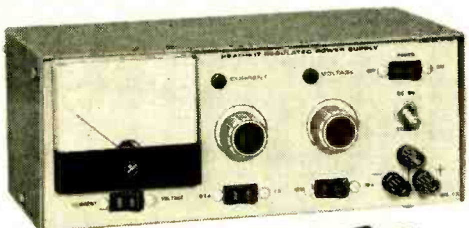
of electronics. . . . Speaking of magnetometer sensors—Wilmington, Delaware police have electronic nightsticks built by *Infinetics, Inc.*; officer just waves it near suspect and it detects guns, knives, and iron or steel object (no good for brass knuckles?). . . . Air Force and Pentagon have private color-TV link, using interception-free coded digital video system made by *Philco-Ford;* may be way to go for commercial firms not using CCTV now because of industrial spying. . . . New optoelectronic use for gadolinium molybdate (ferroelectric and ferroeleastic material) is announced by *Hitachi;* blocks or passes light, depending on voltage stress; might be useful in color-TV displays—it can be used as color-variable filter. . . . Bacteria monitor for high-purity water systems, built by *Millipore Corp.*, may have water-pollution monitoring applications. . . . New *RCA* TV camera is infrared-sensitive, giving it ability to see in dark; key component is integrated-circuit sensor with 16,000 infrared photoconductors. . . . *New York Times* is installing an *IBM* 360/50 computer for retrieval of its Index and other reference material to be stored over next 15 or 20 years. ▲

9 Exciting New Kits

NEW
Kit IG-28 79^{95}*

Standard 9 x 9 Display **OR** Exclusive Heath "3 x 3" Display



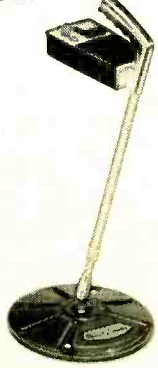


NEW
Kit IP-28
47^{50}*

NEW
Kit ID-29
29^{95}*

NEW
Kit GR-88
49^{95}*

NEW
Kit GR-98
49^{95}*



NEW
Kit GD-48
59^{95}*

NEW Heathkit Color Bar-Dot Generator . . . Advanced Integrated Circuitry Produces 12 Patterns Plus Clear Raster, Eliminates Divider Chain Instability Forever

The new IG-28 is the signal source for all color and B&W TV servicing. No other instrument at any price will give as much stable, versatile TV servicing capability. Its solid-state circuitry produces dots, cross hatch, vertical and horizontal bars, color bars, and shading bars in the familiar 9x9 display . . . plus exclusive Heath 3x3 display of all these patterns . . . plus a clear raster that lets you adjust purity without upsetting AGC adjustment. Fifteen J-K Flip-Flops and associated gates count down from a crystal controlled oscillator, eliminating divider chain instability and adjustments. And for time-saving convenience the IG-28 has variable front panel tuning for channels 2 through 6. Plus & minus going video signals at the turn of a front panel control . . . for sync, in-circuit video or chroma problems, use the front panel sync output. Two front panel AC outlets for test gear, TV set, etc. Built-in gun shorting circuits and grid jacks too. Add any service-type scope with horizontal input and you have vectorscope display capability as well. Fast, enjoyable circuit board-wiring harness construction. You can't beat the Heathkit IG-28 for versatility or value . . . put it on your bench now. 8 lbs.

NEW Heathkit 1-30 VDC Solid-State Regulated Power Supply

The new modestly priced IP-28 is an excellent power supply for anyone working with transistors. Compact Heathkit instrument styling with large, easy-to-read meter . . . two voltage ranges — 10 V., 30 V. . . . two current ranges — 100 mA, 1 A. External sensing permits regulation of load voltage rather than terminal voltage. Adjustable current limiting prevents supply overloads and excessive load current. Convenient standby switch. Fast, easy assembly with one circuit board and wiring harness. Order yours today! 9 lbs.

NEW Heathkit Solid-State Auto Tune-Up Meter . . . Measures Dwell, RPM And DC Voltage

The new Heathkit ID-29 is most versatile . . . really three automotive test instruments in one. Measures Dwell on all 4-cycle, 3, 4, 6, or 8 cylinder engines . . . measures RPM in two ranges, 0-1500 and 0-4500 . . . measures DC voltage from 0 to 15 volts. And no batteries are needed . . . running engine provides both signal and power. Easy to use . . . on both 6 and 12 volt system without changing leads. Lightweight and easy to carry . . . its black polypropylene case has a built-in lead storage compartment and is resistant to virtually everything. Fast, simple assembly . . . only about 5 hours. The perfect accessory for the handyman, emergency road service personnel or shop mechanics . . . order your ID-29 now. 4 lbs.

NEW GR-88 Solid-State Portable VHF-FM Monitor Receiver

Tunes both narrow and wide band signals between 154-174 MHz . . . for police, fire, most any emergency service. Exceptional sensitivity and selectivity, will outperform other portable receivers. Smart compact styling, portable or fixed station capability with accessory AC power supply, variable tuning plus single channel crystal control, collapsible whip antenna, adjustable squelch control, easy circuit board construction. The new GR-88 receiver is an added safety precaution every family should have . . . get yours today! 5 lbs.

NEW GR-98 Solid-State Portable Aircraft Monitor Receiver

Tunes 108 through 136 MHz for monitoring commercial and private aircraft broadcasts, airport control towers, and many other aircraft related signals. Same exceptional features as the GR-88 above. The perfect receiver for aviation enthusiasts. 5 lbs. **GRA-88-1, Accessory AC Power Supply . . . $7.95***

NEW GD-48 Solid-State Metal Locator

A low cost, versatile, professional metal detector at one-third the cost of comparable detectors. Packed with features for long life, rugged reliability, and dozens of uses . . . battery operated, completely portable, weighs only 3 lbs. . . . highly sensitive, probes down to 7′ depth . . . built-in speaker signals presence of metal, front panel meter gives visual indication, built-in headphone jack, telescoping shaft for height adjustment, easy-to-use and easy-to-assemble. Whether you're an amateur weekend hobbyist or a professional treasure hunter, the GD-48 is for you . . . also a great help to contractors, surveyors, Gas, Electric, Telephone and other public Utility Companies. 4 lbs.
GD-396, Headphones, 2000 ohm (Superex) . . . $3.50*

From The Leader HEATHKIT®

NEW Heathkit Ultra-Deluxe "681" Color TV With AFT . . . Power Channel Selection & Built-In Cable-Type Remote Control

The new Heathkit GR-681 is the world's most advanced Color TV with more built-in features than any other set on the market. Automatic Fine Tuning on all 83 channels . . . eliminates touchy fine tuning forever, power push button VHF channel selection, built-in cable-type remote control . . . or you can add the optional GRA-681-6 Wireless Remote Control any time you wish . . . plus the built-in self-servicing aids that are standard on all Heathkit color TV's but can't be bought on any other set at any price. Other features include a bridge-type low voltage power supply for superior regulation; high & low AC taps to insure that the picture transmitted exactly fits the "681" screen. Automatic degaussing, 2-speed transistor UHF tuner, hi-fi sound output, two VHF antenna inputs, top quality American brand color tube with 2-year warranty.

GRA-295-4, Mediterranean Cabinet shown **$119.50***

Heathkit "295" Color TV

Big, Bold, Beautiful . . . with the same high performance features and built-in servicing facilities as the GR-681 above . . . but less the Automatic Fine Tuning, push button VHF power tuning and built-in cable-type remote control. You can add the optional GRA-295-6 Wireless Remote Control at any time.

GRA-295-1, Contemporary Walnut Cabinet shown **$62.95***

Both the GR-681 and GR-295 fit into the same Heath factory assembled cabinets; not shown, Early American style at $99.95.*

NEW Deluxe Heathkit "581" Color TV With AFT

The new Heathkit GR-581 will add a new dimension to your TV viewing. Brings you color pictures so beautiful, so natural, so real . . . puts professional motion picture quality right into your living room. Has the same high performance features and exclusive self-servicing facilities as the GR-681, except with 227 sq. inch viewing area, and without power VHF tuning or built-in cable-type remote control. The optional GRA-227-6 Wireless Remote Control can be added any time you wish. And like all Heathkit Color TV's you have a choice of different installations . . . mount it in a wall, your own custom cabinet, your favorite B&W TV cabinet, or any one of the Heath factory assembled cabinets.

GRA-227-2, Mediterranean Oak Cabinet shown **$99.50***

Heathkit "227" Color TV

Same as the GR-581 above, but without Automatic Fine Tuning . . . same superlative performance, same remarkable color picture quality, same built-in servicing aids. Like all Heathkit Color TV's you can add optional Wireless Remote Control at any time (GRA-227-6). And the new Table Model TV Cabinet and roll around Cart is an economical way to house your "227" . . . just roll it anywhere, its rich appearance will enhance any room decor.

GRS-227-6, New Cart and Cabinet combo shown **$49.95***

Both the GR-581 and GR-227 fit into the same Heath factory assembled cabinets; not shown, Contemporary cabinet $59.95.*

NEW Heathkit Deluxe "481" Color TV With AFT

The new Heathkit GR-481 has all the same high performance features and exclusive self-servicing aids as the new GR-581, but with a smaller tube size . . . 180 sq. inches. And like all Heathkit Color TV's it's easy to assemble . . . no experience needed. The famous Heathkit Color TV Manual guides you every step of the way with simple to understand instructions, giant fold-out pictorials . . . even lets you do your own servicing for savings of over $200 throughout the life of your set. If you want a deluxe color TV at a budget price the new Heathkit GR-481 is for you.

GRA-180-1, Contemporary Walnut Cabinet shown **$49.95***

Heathkit "180" Color TV

Feature for feature the Heathkit "180" is your best buy in color TV viewing . . . has all the superlative performance characteristics of the GR-481, but less Automatic Fine Tuning. For extra savings, extra beauty and convenience, add the table model cabinet and mobile cart. Get the value-packed GR-180 today.

GRS-180-5, Table Model Cabinet & Cart combo **$39.95***

Both the GR-481 and GR-180 fit the same Heath factory assembled cabinets; GRA-180-2, Early American Cabinet $75.00.*

Add the Comfort And Convenience Of Full Color Wireless Remote Control To Any Rectangular Tube Heathkit Color TV . . . New Or Old!

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Kit GRA-227-6, for Heathkit GR-581; GR-481 & GR-180 Color TV's **$69.95***

Now There Are 6 Heathkit® Color TV's To Choose From

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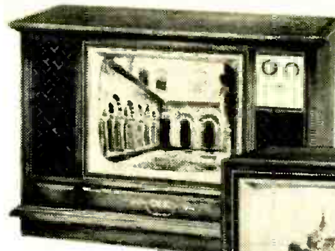

NEW
Kit GR-681 With AFT
$499.95*
(less cabinet)

Kit GR-295
$449.95*
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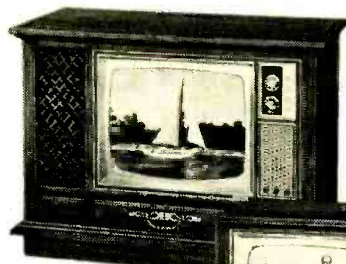
2 Models In 227 Sq. Inch Size



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Kit GR-581 with AFT
$419.95*
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Kit GR-227 NOW ONLY
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$359.95*
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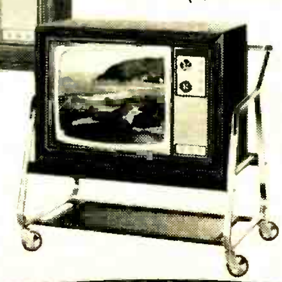

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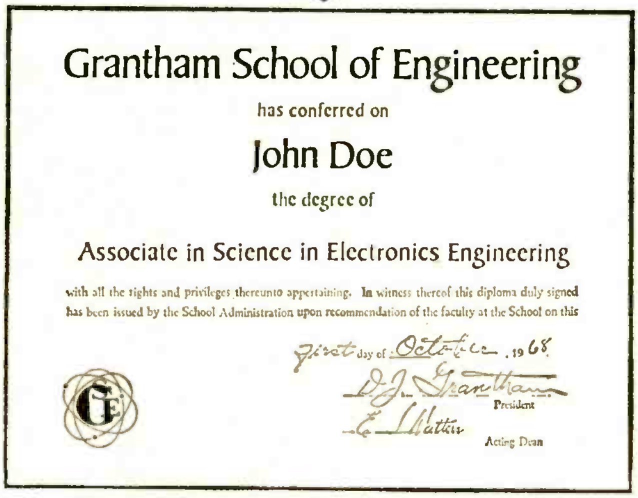
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has conferred on
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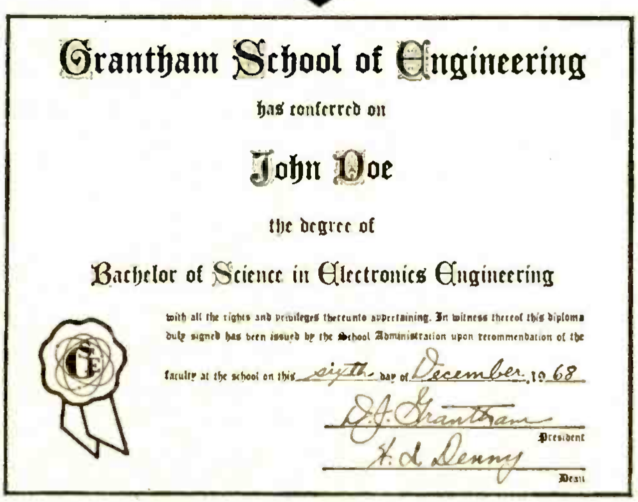
the degree of
Associate in Science in Electronics Engineering
with all the rights and privileges thereunto appertaining. In witness thereof this diploma duly signed has been issued by the School Administration upon recommendation of the faculty at the School on this first day of October, 1968
President
Acting Dean

3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Engineer, teacher, editor, and author, Lothar Stern has been involved in communicating electronic technology for the past 18 years. After receiving his B.S. in television engineering, he worked as an electronics engineer and instructor of electronic engineering and servicing for several years. In 1961 he joined the Semiconductor Products Division of Motorola as Manager of the Technical Information Center, charged with the responsibility of conveying the changing aspects of semiconductor technology to semiconductor users. He is the author of several books.

GUEST EDITORIAL

By LOTHAR STERN, Manager
Technical Information Center, Motorola Semiconductor Products Inc.

Some "Technical Terms" Aren't

IT is deplorable that a field as technically precise as semiconductor electronics should be so permeated by ambiguities in vocabulary that even those directly involved are finding it increasingly difficult to communicate. In part, this is an unfortunate but perfectly understandable condition in a rapidly advancing technology. For example, we can no longer expect the word "transistor" to convey a definite meaning without modifying it by the adjective "bipolar" or "field-effect." Nor can we speak meaningfully of an "integrated circuit" without qualifying it in terms of structure (i.e., monolithic, hybrid, etc.). But, in addition to the word explosion brought on by the expansion of functions and processes, we find ourselves victimized by the proliferation of terms without clear-cut meaning or value. Such a term is the overworked acronym "LSI."

Anyone connected with electronics in any way probably knows that LSI stands for "large-scale integration." It's a good bet, however, that out of any group of three engineers chosen at random, no two will define it the same way.

There's no record of how this term got its start. But so ambiguous has the word become that one executive in the industry has disgustedly defined LSI as "large-scale insanity," while an engineer has been quoted as saying that, "LSI is anything more complex than anything we can make today."

There have been attempts, of course, to define LSI more quantitatively. One group proposed that any monolithic circuit composed of more than "100 gates" should be called LSI. This was amended to "100 equivalent gate functions" (whatever that is), when it was pointed out that linear circuits, too, might become very complex.

Finally, when challenged with the question of what a monolithic circuit of only 99 gates might be called—well, what is more logical than to coin another completely ambiguous term, Medium-Scale Integration (MSI). Thus, MSI might be defined as any circuit larger than small-scale integration, but smaller than large-scale integration.

The big problem of placing numbers on LSI is, of course, the changing technology. While a 100-gate circuit might have seemed difficult three years ago, it certainly is within the realm of practicality today. And within a year or two, such circuits are likely to be very simple in comparison with the state of the art.

Another school of thought has it that, to achieve LSI-status, a circuit must have two or more layers of interconnecting metalization. The rationale for this line of reasoning is that no circuit with the interconnecting metal on the same plane as the components themselves can achieve a high enough order of complexity for LSI. The fallacy here is that multilayer metalization technology is rapidly becoming so routine that it is being adopted, for economic reasons, even for some of the not-so-complex devices. Obviously, this definition won't stand up either.

One might be tempted to avoid the entire LSI/MSI hassle by ignoring the terms altogether, were it not for the fact that provocative headlines and ad copy continually remind us that something unusual and very exciting is happening in our technology. And how the reader interprets this liberally used term is usually quite incidental.

In the absence of any industry agreement through the EIA, we proffer the following definition, which is currently endorsed by and practiced at *Motorola Semiconductor.*

LSI is the simultaneous realization of large area circuit chips with optimum component packing density, for the express purpose of reducing circuit costs by maximizing the number of system interconnections performed at the chip level.

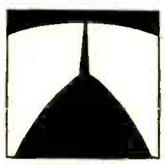
Note here the complete freedom from the "tyranny of numbers." Not a hint as to process or manufacturing technique. Simply a statement of goals that, to its credit and its detriment, can be construed to fit any complex integrated circuit—including those envisioned for tomorrow as well as those in existence today. ▲

A message from the heads of Ampex.

Listen.

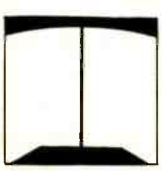
The message is about stereo sound. Listen to Ampex tell it like it is.

The heads are unquestionably the most important part of any stereo tape recorder.



As you know, in order to obtain outstanding frequency response from tape heads, it's necessary to maintain an extremely narrow gap between their poles. Most quality tape heads look like the one pictured here.

But as the head begins to wear down, the pole gap widens, causing frequency response to decline. To maintain original frequency response, heads may need replacement after as little as 500 to 1000 hours of normal playing.

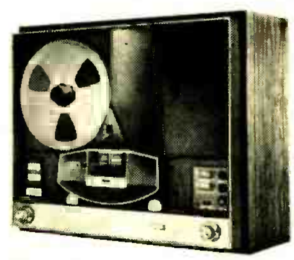


Ampex exclusive deep-gap heads consist of two *parallel* poles. Thus the gap remains constant after years of use. And so does your frequency response. Ampex heads have been known to last well over 12 years, based on an average of two hours use per night, every night.

We invite you to listen to four of the Ampex stereo tape recorders featured during the "Ampex Stereo Hear-In" at participating Ampex dealers now.

Listen to the Ampex 755 Stereo Tape Deck. It adds professional tape capabilities to your existing system, and gives you sound-with-sound, sound-on-sound and echo. Plus direct tape monitoring, three Ampex heads and pause control. It mounts in your present cabinet or in its own handsome walnut base (optional).

Listen to the 2161, the Ultra-Automatic Portable Stereo Tape System featuring two-second automatic threading, silent electronic signal automatic reverse, new bi-directional recording and a two speaker system with a 6" woofer and 3½" tweeter in each. Plus built-in mixer and two omnidirectional dynamic microphones.



Listen to the Ampex 1455 Automatic Reverse Stereo Tape Deck. Get professional features like sound-with-sound, tape monitor and pause control. Plus two-second automatic threading, silent electronic automatic reverse, and four deep-gap heads.

Listen to the Ampex 761 Portable Stereo Tape System. It has sound-on-sound, sound-with-sound, echo, direct tape monitoring, three exclusive Ampex deep-gap heads, dual capstan drive, two dynamic stereo microphones and acoustic suspension cube speakers. (You must hear these speakers to believe the sound.)

AMPEX

Hear them all during the "Ampex Stereo Hear-In" at participating Ampex dealers. Learn how you can save over 50% on an Ampex Stereo Tape Library. Pick up your free 36 page booklet, "Head Start to Better Tape Recording," just for listening.

AMPEX CORPORATION, CONSUMER EQUIPMENT DIVISION, DEPT. 591, ELK GROVE, ILL. 60007

CIRCLE NO. 121 ON READER SERVICE CARD

Cassette Tape Recorders
—a new breed

By LEONARD P. KUBIAK / Supervisor, Tape & TV Lab., Texas Dept. of Education

How do the new cassette recorders stack up against reel-to-reel types? Here is a close look at one of the hottest items to hit the audio market.

WITH its high degree of portability, simplicity of operation, and good over-all performance, the new cassette tape recorder is one of the hottest items to hit the home entertainment market in recent years. Most of these high-performing newcomers are equally at home as car tape units; portable recorders for taping staff meetings, conferences, and class lectures; or as compact tape decks to upgrade a home stereo console to include the versatility of tape.

Development of the Cassette

Over five years ago, the *Philips Company* of Holland pioneered in the development of a new concept in the recording field—a cartridge tape recorder as easy to load as a film-cartridge camera, yet offering all of the features of a conventional open-reel recorder.

At the heart of this new recorder was a small tape cartridge containing two miniature plastic reels wound with ⅛-inch (actually 150-mil) magnetic tape and completely enclosed in a small plastic case—or *cassette* (Fig. 1). The tape operates at a slow speed of 1⅞ in/s.

The first cassette recorder was marketed in the United States in 1964 under the *Norelco* "Carry-Corder" label. A short time later, an unusual licensing agreement was worked out to encourage other tape-recorder manufacturers to adopt the cassette design.

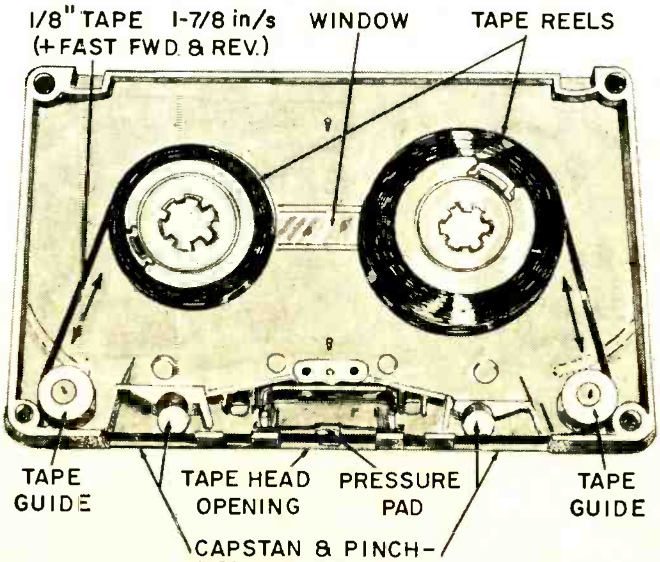
In view of the tremendous reception accorded the cassette recorder, a number of companies rushed to obtain the right to market their own lines of cassette recorders. This explains the similarity among early makes and models.

Today there are over 200 different models from more than fifty tape-recorder manufacturers. Included in this growing list of cassette manufacturers are such well-known names as *Ampex*, *Norelco*, *Sony*, *Wollensak*, *Mercury*, *Panasonic*, *Aiwa*, *Crown*, *RCA*, *Concord*, and *G-E*.

Perhaps the most significant result of *Philips'* generous licensing agreement was instant standardization. Today, all cassettes, both stereo and mono, are completely interchangeable and can be played back on any make or model of cassette recorder.

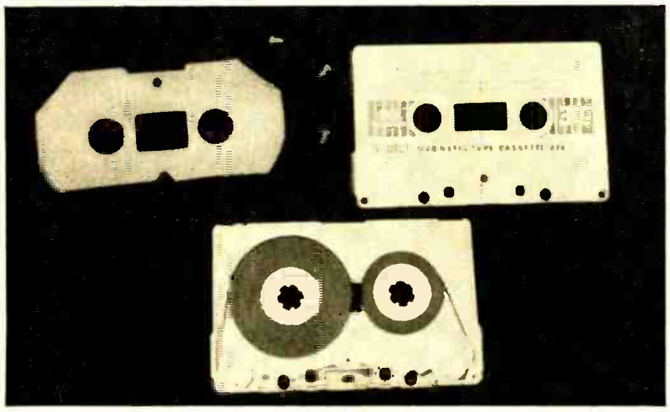
The fact that both mono and stereo cassettes may be

Fig. 1. The cassette is a compact reel-to-reel cartridge using special thin ⅛-in (actually 150-mil) tape. The tape is pulled from one of the reels (acting as supply reel), past a tape-guide idler, then past pressure pad and tape head. The tape then moves between the capstan and pinch roller on the tape deck, around the other tape-guide idler, and then to the other reel (acting as take-up). When the cassette is flipped over at the end of the tape, the capstan and pinch roller are in the other openings and the function of the reels is reversed.



interchanged represents a major breakthrough in recorder technology. Recall that conventional four-track stereo tapes *cannot* be played on a mono recorder because of the location of the quarter-track head gaps in relation to the tape tracks. Since the quarter-track stereo recorder places two quarter tracks in the upper half of the tape, recorded in opposite directions, a mono half-track head picks up both upper tracks which results in a garbled output.

The cassette quarter-track heads, on the other hand, record two tracks in the upper half of the tape, but both are recorded in the same direction and may be picked up equally well by either a cassette stereo or mono playback head (see Fig 2).



A disassembled tape cassette is shown here. Outside dimensions of the cassette are 4 by 2½ inches. Thickness is about ⅓ inch.

Cassette tape cartridge is compared here with an endless-loop cartridge shown at left. The latter will operate in only one direction and it cannot be operated at high speeds.

Cassette is compared with an ordinary 7-inch open reel of tape. The portable cassette recorder shown at right is not very much larger than the 7-inch reel of tape.

All cassette cartridges are equipped with a unique safety feature which serves to prevent accidental erasure of a pre-recorded tape. This safety feature consists of two plastic tabs located along the rear edge of the cassette. Removal of the plastic tabs automatically activates a record safety interlock any time the cassette is placed into a cassette recorder.

In order to re-record over a pre-recorded tape, simply place short lengths of adhesive tape over each of the two spaces left by the missing tabs. The cassette can then be erased and re-recorded just like an ordinary blank cassette.

Blank cassette tapes are available in three basic lengths: 300 feet, 450 feet, and 600 feet. The 300-ft tape can record continuously for 30 minutes on each side for a total of 60 minutes. Likewise, the 450-ft cassette provides for 45 minutes of recording time per side, and the 600-ft cassette records up to two full hours (one hour per side).

Since all cassettes are interchangeable, they all look alike. However, some brands of tape cassettes employ a better system of internal lubrication, and a special low-noise tape formulation provides for improved recording performance at 1⅞ in/s, especially for the higher frequencies. Therefore, in order to obtain consistently good-quality recordings, it is advisable to stick to one of the known brands of cassette tapes and avoid the bargain counter offerings.

The four- and eight-track car-tape units are examples of endless-loop cartridges. In comparison to the cassette, the endless-loop cartridge system should have slightly better fidelity because of its higher tape speed (3¾ in/s compared to the cassette's speed of 1⅞ in/s). However, this endless-loop design has a major drawback. It cannot be operated fast-forward or rewound but can only play in a forward direction at normal speed.

The cassette, on the other hand, is constructed of two miniature reels which operate in the very same manner as a conventional open-reel recorder. Therefore, fast-forward and reverse are standard features on the cassette recorder.

Other recent developments in favor of the cassette have been the development of better recording and playback heads along with the improvement in low-speed master-recording techniques. Both the *Dolby* and the *Ampex* EX+ processes have been quite successful in reducing surface and background noise for low-speed tape-recording systems. These processes are responsible for new lines of relatively high-quality pre-recorded musical tapes currently being marketed for the cassette recorder.

What About Fidelity?

The over-all acoustic response of most inexpensive portable cassette recorders ranges from about 200 to 7000 Hz. This limited response is due, in part, to the small speakers employed in the cassette's space-saving design. However, the full-size stereo systems have a much broader acoustic response extending from approximately 80 to 10,000 Hz.

Even though the acoustic response of the portable line of cassette recorders is somewhat limited, their preamp fidelity is quite good. What is more, some of the new a.c.-operated stereo tape decks now available boast an electrical preamp output signal (that may be applied to your stereo system) that is within 2 dB from below 50 Hz to 12 kHz.

(Editor's Note: Also helping to maintain good high-frequency performance is the use of a playback equalization curve that exhibits somewhat less bass boost and a little less treble rolloff than is employed to play back tapes at higher speeds. The playback curve is shown in Fig. 3. This curve is usually further modified with some added treble boost to overcome high-frequency losses in the tape head.)

Although the cassette's response is below the 15,000 Hz normally considered essential for high-fidelity reproduction of classical music, even a portable cassette machine does surprisingly well in recording and playing back music.

To illustrate this point, the author recently arranged a tape demonstration involving a professional reel-to-reel recorder and one of the good-quality portable cassette recorders. A dub of the "1812 Overture" was made from the conventional recorder to the cassette and then each of the recorder's preamp outputs was wired into a professional-quality sound system by means of an audio switcher.

The two recorders were then carefully synchronized and playback levels matched. At this point, a half-dozen music enthusiasts were invited to sit in on the demonstration and attempt to determine which was the original tape being played on the conventional recorder and which was the cassette dub. After a dozen runs, the scores of each of the judges were tabulated. The fact that they scored less than 50% accuracy may be viewed as a relative indication of the fidelity of the cassette recorder at a preamp or tape-deck output level.

(Editor's Note: For a complete report on the lab performance of a number of these new units, refer to the boxed copy at the end of this article.)

Some of the Problems

Although the cassette design is relatively trouble-free, there are some problems associated with the cassette recorder. Among these, especially with the less-expensive portable models, are: inconsistent speed, excessive flutter and wow, poor frequency response, noisy recordings, and broken or binding cassettes. Many of these problems can be easily eliminated through the adoption of a good maintenance program.

Inconsistent tape speed, intermittent operation, and excessive flutter and wow, may often be traced to low battery voltage. Most portable cassette recorders are equipped with ordinary carbon-zinc batteries which have a usable battery life of approximately 14 hours in this service. After that, the battery voltage is too low to maintain proper tape speed. Also, a number of cassette recorders are damaged by leakproof carbon-zinc batteries that somehow manage to leak.

In order to obtain better battery performance, it is advisable to switch to alkaline activated batteries or, whenever possible, use an a.c. adapter. The a.c. adapter will rejuvenate the alkaline batteries a number of times, provided the batteries are not allowed to discharge below half of their full-charge level. Alkaline batteries cost up to twice as much as the carbon-zinc batteries but the alkaline batteries last up to twice as long and deliver much better performance in the long run.

Another battery-saving tip is to stop the cassette recorder as soon as possible after it reaches the end of the reel. Although the cassette recorder has a built-in slip clutch to prevent the drive motor from stalling, the increased load on the motor causes rapid battery drain, particularly if left in this condition for any length of time.

Similarly, the use of a good-quality cassette tape can also increase battery life by decreasing the drag on the drive motor.

Occasionally, a portable cassette recorder will develop intermittent operation due to poor battery connections. Generally, good electrical contact can be restored by rubbing the battery terminals with a pencil eraser.

There are three basic problems encountered in using cassette tapes: bunching of tape near the capstan due to a loose or uneven tape wind, internal binding of the reels due to poor lubrication, and end-of-the-reel leaders which come loose from the reel.

To avoid these problems, use a known brand of cassette for those critical recordings. Carefully check the smoothness of the tape wind as seen through the small window on the front of the cassette. If necessary, rewind the tape before using it.

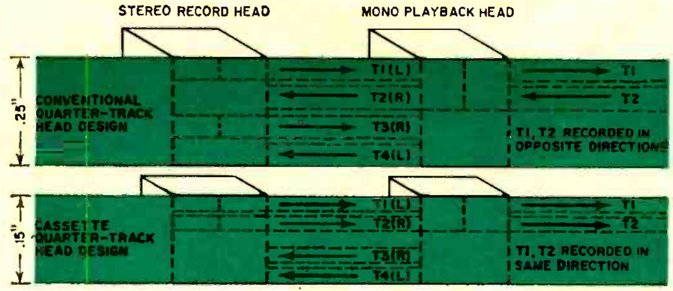


Fig. 2. The conventional quarter-track reel-to-reel recorder uses tracks 1 and 3 for a stereo program while the cassette uses tracks 1 and 2. This means that a mono cassette machine is compatible in that it picks up the upper two similar tracks.

If the leader tape should happen to break loose from the end of the reel, simply remove the screws holding the cassette together and reconnect the leader to the reel by means of the special hold-down connector located near the hub of the reel.

In order to maintain the cassette's high-frequency response, signal-to-noise ratio, and low percentage of flutter and wow, a good maintenance program similar to that of a conventional reel-to-reel recorder should be employed. (See "Tape Recorder Maintenance Program" in the October 1968 issue of this magazine.) For example, the heads and transport unit should be cleaned often with a cotton swab and denatured alcohol. In addition, the heads should be demagnetized any time the surface or background noise becomes noticeable.

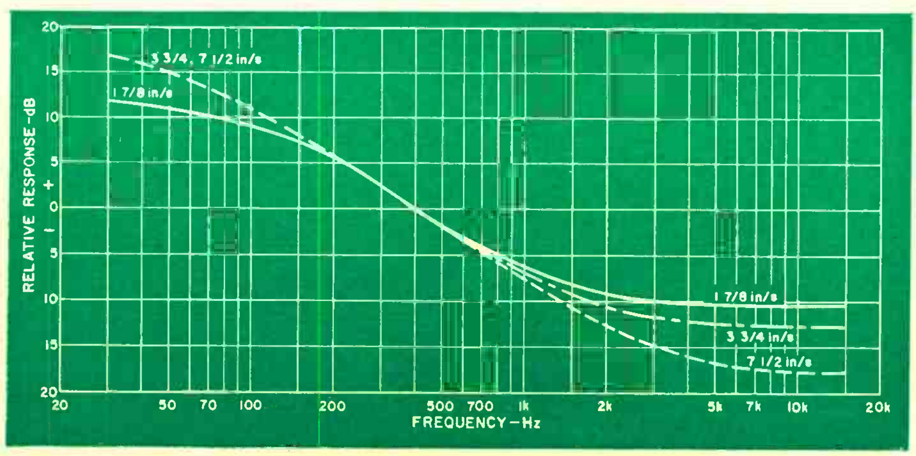
Prior to recording an important conference or speech, it's a good idea to check the battery level, battery connections, and thoroughly clean the unit. In this manner you can be assured of getting your best recording.

If head replacement is required, there is a line of replacement cassette heads available equipped with pre-set integral tape guides for correct tracking without the need for elaborate equipment. A mono head lists for approximately $16.00 and the stereo version is available at approximately $22.00.

What's Available?

In the first generation of cassette recorders, most makes and models closely resembled the original *Norelco* "Carry-Corder." However, today, most manufacturers have modified the original design to include such features as push-button control, automatic record-level control circuitry, tone controls, pop-up control for ease in loading and unloading cassettes, hysteresis synchronous drive motors, etc.

Fig. 3. The standard playback equalization curve for pre-recorded cassettes (1 7/8 in/s) shows less bass boost and less treble roll-off than is used at higher tape speeds. The characteristics of the curve are the same as would be produced by RC circuits with a time constant of 1590 μs at the low frequencies and 120 μs at the high frequencies.



In addition, the cassette recorder is available in a number of formats including portable mono, stereo tape deck, full-size stereo system including built-in stereo power amp and external speakers, and combination cassette systems which include AM-FM receivers and a stereo cassette recorder. There is even a stereo cassette tape deck which automatically plays up to six pre-recorded cassettes without any handling by the user.

EW LAB TESTS of NEW CASSETTE TAPE RECORDERS

TESTING a cassette recorder is basically no different from testing a conventional reel-to-reel tape recorder. The playback frequency response, which includes the effects of head characteristics and playback equalization, requires a standard test tape. We used a *Philips* test cassette (HU-717/23), made to the precision standards required for this application. It contains voice-identified frequencies (from 31.5 Hz to 10,000 Hz) recorded with a standard pre-emphasis characteristic which has been accepted throughout Europe and elsewhere. Since all cassette machines today use mechanisms built in Europe or Japan, and since *Philips* was the originator of the cassette, the choice of its standard test tape seems justified.

For over-all recording/playback frequency response, we recorded constant-level input signals (through the high-level inputs of the recorders) at a level 20 dB below the maximum recording level indication on the level meters of the recorders. Both recording and playback were done with a *General Radio* automatic response plotter, with which we made measurements on both channels. A similar procedure was employed in making the playback response curves. Since there are often differences between channels, the two sets of data were averaged to plot a single response curve.

The record/playback frequency response of any tape recorder is strongly affected by the type of tape used. One of the machines tested (the *Harman-Kardon* CAD-4) was supplied with a blank cassette of *Harman-Kardon* tape; the others (*Ampex* Micro 88, *Norelco* 450, and *Sony* TC-125) came with no specific recommendations as to make of tape. We made our measurements using cassettes from several manufacturers and found in most cases an appreciable difference among them, mainly in high-frequency response.

Normally, wow and flutter are measured with standard tapes whose intrinsic wow and flutter are known to be very low. A suitable test cassette was not available, but we recorded the necessary 3000-Hz test tone on a cassette of blank tape and played in back into our wow and flutter meter on the same machine. Since some wow and flutter are introduced in the recording process, and more during playback, the measurements may be slightly higher than would otherwise have been obtained, but are nevertheless representative of the performance of the machines.

For signal-to-noise measurements, we recorded a 1000-Hz signal at maximum level (as shown on the recorder's meter) and used the played back output level as a reference level. The noise output during an un-recorded portion of the tape was expressed as so many dB below maximum recording level.

We measured the input signal required at 1000 Hz to obtain maximum recording level, and the line (preamp) output developed when playing back the same signal. Two of the recorders have low-powered playback amplifiers and detachable speakers. We measured the continuous-power output per channel at the clipping level, into 8-ohm loads. No measurements were made on the speakers, but we did listen to them when playing commercially recorded tapes.

In addition to listening tests with recorded tapes, we made many recordings off the air, and also from wide-range disc records. The latter then served as a reference signal when making A-B comparisons between the original signal and the playback from the recorder.

Measurements of harmonic distortion were not practical due to the amplitude irregularities and output "bounce" occasioned by tape dropouts. This condition exists on all cassette recorders we have tested, due to the very narrow track width. We did, however, observe the output waveform for signs of distortion during the measurements.

Summary of Test Results

Although none of the machines tested actually meets all the standards which most of us expect from high-fidelity tape recorders, some of them come very close to doing so. The playback frequency response, which is a guide to how these machines will reproduce commercially recorded cassettes, proved to be quite flat over most of the audio range of all of them. During our record-playback measurements

Table summarizing the results of our laboratory tests on the four cassette recorders listed.

RECORDER	PLAYBACK RESPONSE	REC/PLAY RESPONSE	WOW (%)	FLUTTER (%)	S/N (dB)	INPUT (V)	OUTPUT (V)	PWR. OUT (W)	PRICE
Ampex Micro 88	32-10,000 Hz +0.5, −2.5 dB	39-8000 Hz ±3 dB	0.04	0.20	45	0.14	0.55	4.5	$199.95
Harman-Kardon CAD-4	32-10,000 Hz +1, −2.5 dB	20-10,500 Hz ±3 dB (20-12,000 Hz with H-K tape)	0.04	0.12	45	0.30	0.55	--	$179.50
Norelco 450	32-10,000 Hz +0.5, −3 dB	40-9200 Hz ±3 dB	0.05	0.30	47	0.133	1.55	0.95	$199.95
Sony TC-125	38-10,000 Hz ±1 dB	42-8700 Hz ±3 dB	0.035	0.17	45	0.06	0.51	--	$129.50

Before you go out to buy that recorder, decide how it will be used most often. If over-all acoustic response is important, select one of the full-size a.c.-operated stereo cassette systems. If portability represents your primary criterion, select from a number of top-quality, battery-operated mono cassette recorders. But there is a cassette system of the new breed which is specifically engineered to meet your recording needs. ▲

By JULIAN D. HIRSCH / Hirsch-Houck Laboratories

Four cassette machines, representative of the better models available, show good hi-fi performance that exceeds many 3¾ in/s reel-to-reel recorders. They still don't match 7½ in/s reel-to-reel machines in response, distortion, and low flutter.

three of the recorders showed a cyclic variation in low-frequency response (*probably due to the particular design of the heads—Editor*), although the average low-frequency response was quite satisfactory. The *Harman-Kardon* CAD-4 had a very uniform and extended low end which, in fact, surpassed that of many far more expensive reel-to-reel tape recorders.

There were some differences in the high-frequency response of the four machines. On playback, the *Norelco* 450 had a roll-off above 5000 Hz, but the others had relatively uniform response out to the 10,000-Hz limit of the test tape. Upon readjusting the head azimuth of the *Norelco* unit, the high-frequency performance improved, as shown in the curve (Fig. 1). In the record/playback response test (Fig. 2), the *Harman-Kardon* CAD-4 had quite uniform output to about 10,000 to 12,000 Hz, but the other three began to roll off between 8000 and 9000 Hz. These measurements were made with *BASF* tape, which in most cases had better high-frequency characteristics than others we tried. It seems probable that the operating conditions of the recorders were optimized for a tape such as the *BASF*.

All the recorders had negligible wow. The flutter was in the vicinity of 0.2% for the *Ampex* and *Sony*, 0.3% for the *Norelco*, and an impressively low 0.12% for the *Harman-Kardon*. The signal-to-noise ratio was about 45 to 47 dB for all the machines. All the recorders had low-impedance microphone inputs, and suitable microphones are available from the manufacturers. The *Ampex* comes with a pair of stereo microphones, mounted together at a 90-degree angle.

We found great differences in the ease of installation and use among these recorders. The *Sony* and *Harman-Kardon* are designed for use with an external music system. The *Sony* is the simplest of the group to set up and use. It has no level controls for input or output, and no meter or level indicator. Instead, a built-in a. g. c. system accommodates the recording circuits to a wide range of input levels. At or below the rated 60-millivolt maximum input level, there is no compression. Very large increases of level, above 60 millivolts, produce only a few dB of increase in the recorded level, and we found no trace of visible waveform distortion, even with the input increased by 40 dB. It is virtually impossible to install or operate this machine incorrectly, and the only operating control besides the piano-key transport controls is a high-frequency roll-off filter switch for hiss suppression. It introduces a sharp cut-off above 6000 Hz, but we found it to have little effect.

The *Harman-Kardon* is designed for the user who prefers to have more control of the recorder's functions. It has two recording level controls, and two level meters which read on both recording and playback. Like the *Sony*, it has no playback level controls. The two microphone jacks are on the front, and a switch permits them to be connected for mono, recording on both channels from a single microphone. The "Stop" key of the *Harman-Kardon*, when partially depressed, stops the tape motion. Pressing it all the way ejects the cassette. On the *Sony*, a separate key stops the machine. However, a light touch on the "Eject" key pops the cassette cover open for easy viewing of the cassette label, without interrupting operation. A somewhat firmer pressure ejects the cassette.

The *Norelco* 450 comes with a pair of small speakers in wooden cabinets. Unlike the *Sony* and *Harman-Kardon* machines, which use standard phono jacks for most inputs and outputs, the *Norelco* uses phone jacks for speaker and line outputs and the microphone inputs. It has phono jacks for the high-level inputs, but they are marked "Phono." While they might possibly be used with ceramic or crystal phonograph cartridges (although their impedance is certainly too low for these devices), they are actually high-level line inputs. A single recording level meter reads the combined levels of both channels. The *Norelco* 450 has separate recording and playback volume controls, a balance control, and a tone control (the latter two only effective on playback). Although the instruction manual refers to the use of the recorder's amplifiers for low-power public-address work, the recording equalization is always in the circuit and the high-frequency peak is excessive for such applications. Also, the continuous-power output per channel of the amplifier is just under 1 watt, which would only drive high-efficiency speakers adequately.

The *Ampex* Micro 88 is a handsomely styled, a.c.-operated, portable machine, whose detach- (*Continued on page 67*)

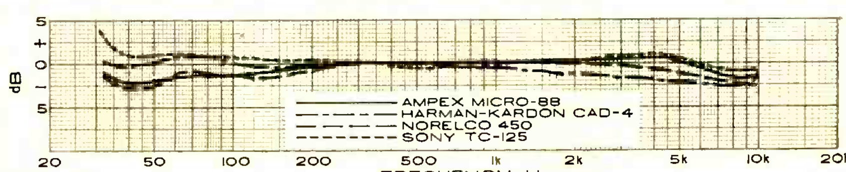
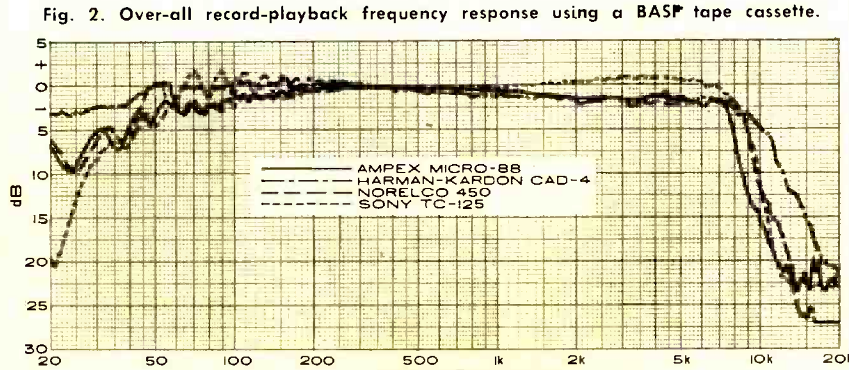
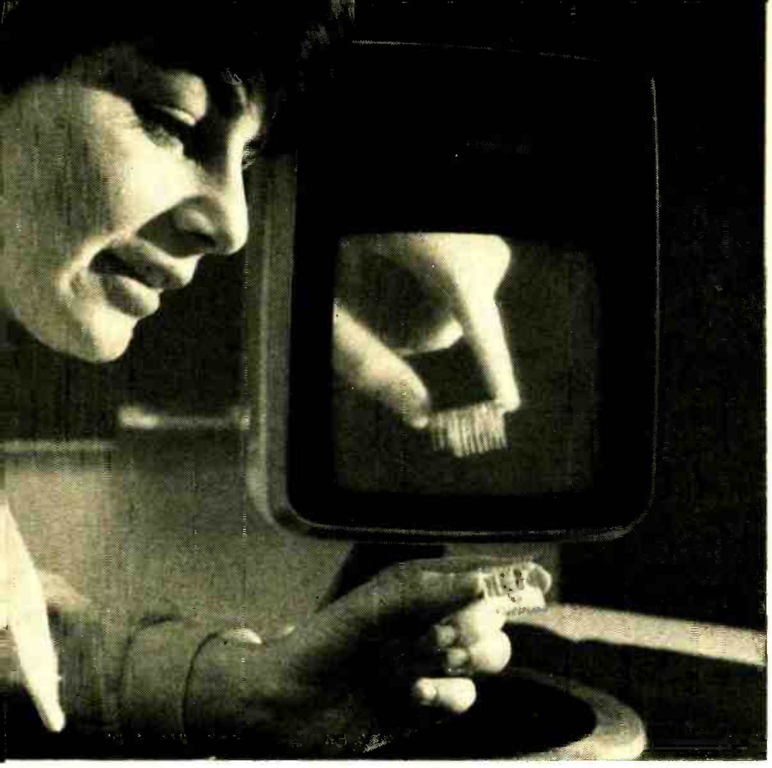


Fig. 1. Playback frequency response using Philips HU717/23 standard test cassette.

Fig. 2. Over-all record-playback frequency response using a BASF tape cassette.





RECENT DEVELOPMENTS IN ELECTRONICS

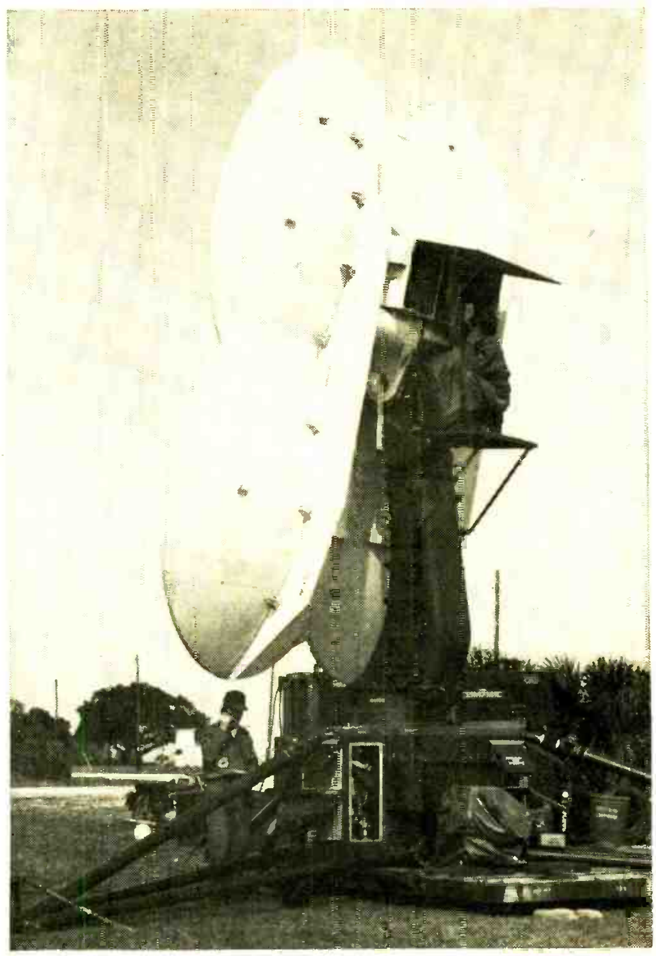
IC's Come to Picture Telephone. (Top left) When Bell's new picture telephone was put into use between New York and Pittsburgh (see "New Picture Telephone Goes Commercial" in our March 1968 issue), the solid-state circuitry used mainly discrete components. Now some of the circuits have been integrated and no doubt before the picture telephone sees widespread commercial use, just about all the internal electronics will be integrated except for the power transistors. The model shown in the photo uses a fully integrated timing generator. It consists of five beam-leaded diffused silicon and two thin-film tantalum integrated circuits all mounted on one square inch of ceramic. There are no less than 217 transistors, 345 resistors, and capacitors totaling 4000 pF on the ceramic. Other IC's are now being tested for use as an independent timing generator, a voltage regulator, and as a video gate. A lab technician is using the close-up lens and the graphic mode of the set (which employs a small angled mirror in front of the pickup tube just above the viewing screen) in order to display an image of the integrated circuit on the picture telephone's screen.

World's Strongest Magnetic Material. (Center) This scale-model demonstration shows a tiny cube of a new magnetic material picking up a cylinder that weighs 500 times as much as the magnet. The powerful new material is made from cobalt and the rare-earth element samarium. In terms of energy product, the material is about seven times stronger than most ferrites, four times stronger than most alnicos, and twice as strong as platinum-cobalt. The energy product is a figure of merit that takes into account residual magnetism after a strong magnetizing field is removed and the ability to resist subsequent demagnetization in the opposite direction. The new material will be used by Raytheon to focus electron beams in the company's traveling-wave tubes. Samarium-cobalt magnets will also be cheaper than the platinum-cobalt magnets used previously since samarium is far more common than platinum. Also, the new magnets can be lighter for a given field strength.

Portable Display Shows Enemy Planes. (Left) When the soldiers see red dots on this portable display unit, they know that enemy planes are nearby. Friendly aircraft show up as green dots on the screen. The display unit provides visual target information on low-flying aircraft that would escape detection by conventional radar. When aircraft approach battle areas, they are detected and identified as friend or foe by this special forward-area alerting radar (FAAR) system. Information on their location is immediately transmitted to Chaparral and Redeye (both heat-seeking missiles) air-defense batteries equipped with these displays. The main radar console display uses a CRT which depicts a matrix of squares, each representing a specific combat sector. This information is transmitted by v.h.f. radio link to the portable red and green light display units located at the batteries. The radar system was developed for the Army by Sanders Associates, which recently received a $1.5-million award for advanced engineering and pilot production of system.

Solid-State Electronic Engine Analyzer. (Top left) A prototype model of a new solid-state analyzer for testing military vehicles in the field is shown being checked prior to delivery. The unit, designed by Marquette Corp., is slated for delivery to the Army Tank Automotive Command at Warren, Mich. The anaylzer can perform 26 pre-programmed tests in 10 minutes and replaces six separate pieces of equipment now required to perform similar analyses. The instrument checks battery, starting and charging systems, distributor conditions, primary ignition system, sparkplugs and high-tension wiring, carburetor balance, and power analysis. To use the tester, the vehicle's shielded ignition wiring is broken at No. 1 sparkplug, and connections are made to the battery and distributor cap, where a special transducer designed for the analyzer is installed.

Low-Priced Computer on a Pedestal. (Top right) This is a 115-lb computer for scientific and control uses that sells for $9700. The machine marks the entry of Honeywell into the market for small computers. This market is estimated to be $100 million annually, at this time, and is expected to grow more than 40 percent a year through 1975. Although there are more than a dozen companies selling under-$10,000 machines, Honeywell is said to be the first major computer company in the field.



Communications-Satellite Terminal. (Center) Air Force technicians are shown here tuning up a communications-satellite terminal which relays messages via outer space. This terminal can be linked to other worldwide communications systems by a series of Defense Communications Agency satellites which are in orbit 18,000 nautical miles above the Earth. The system has a surface range of 8000 miles and is not hampered by atmospheric conditions or inclement weather. The terminal was recently tested successfully during a U.S. Strike Command training exercise conducted at Eglin Air Force Base, Florida.

Counter Checks Heart Beats. (Below right) Weighing less than a pound, this new arrhythmia medical counter continuously monitors an electrocardiogram, analyzes successive heart beats, detects arrhythmias (irregularities), and stores the count for instant recall when wanted. The compact counter is all solid-state, using the latest MOSFET integrated circuits. The unit is battery-powered and can monitor a patient continuously for 72 hours, before battery recharging is required. When the doctor presses a switch, tiny lighted lamps display the cumulative arrhythmia count. The instrument is available from Bio/Med Products, Birmingham, Mich. at a price of $1000.

Experimental Laser Engines

By L. GEORGE LAWRENCE

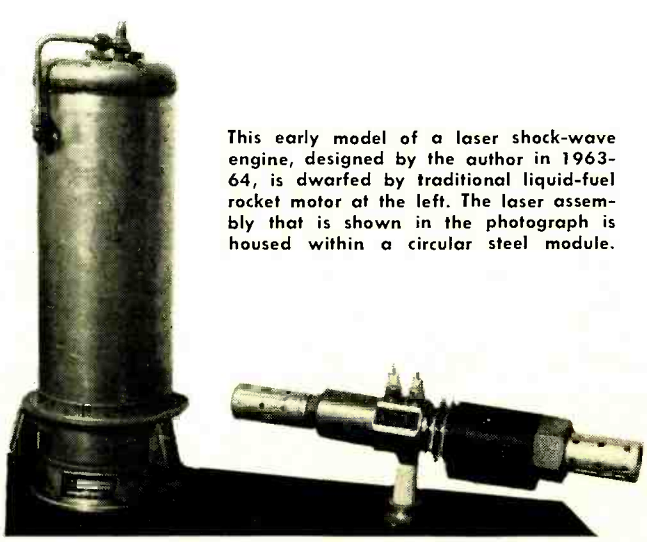
Future space vehicles may be propelled by lasers that can produce immense shock waves in the vacuum of outer space.

ALTHOUGH lasers have been thought about and used in areas of communications, medicine, and metallurgy, the idea of using them as prime movers for space vehicles is unique. What makes the laser so attractive to propulsion engineers is its inherent ability to develop immense shock waves and light-pressure phenomena of considerable magnitude. Research in this area is continuous, and both theoretical and practical findings permit hopes for the not-too-distant future.

Laser engines, taken together, fall into the classification of electric propulsion systems. Related thrustors, as exemplified by the contemporary ion engine, are not a distinctly new concept. One of Dr. Werner von Braun's teachers, H. Oberth, discussed these systems as early as 1929. Not, however, until shortly before actual space flights did serious development of the associated technology begin.

Fig. 1 illustrates one of a family of electronic thrustors. The processes integral to the engine's function are: (1) generation of charged particles, (2) their acceleration, (3) deceleration, and (4) neutralization of the ion beam by electron addition; this latter process being required to restore the (positive) ions to electrical neutrality by replenishing them with lost electrons. Otherwise the electrons will collect on the vehicular system, building up a negative charge that will slow down the positively charged exhaust stream. A "hot" filament serves as an electron injector.

Much energy is lost during operation. The efficiency of ion engine is very, very low—something on the order of 50 kilowatts of electrical energy is required to produce little more than one pound of thrust.



This early model of a laser shock-wave engine, designed by the author in 1963-64, is dwarfed by traditional liquid-fuel rocket motor at the left. The laser assembly that is shown in the photograph is housed within a circular steel module.

It is no coincidence, therefore, that more efficient propulsion methods are being sought. Thoughts have turned to all-nuclear engines. But, to date, no electronics-based nuclear engine has emerged. Nor do we yet have a genuine anti-gravity device. And the true electromagnetic space ship, much speculated upon by science-fiction writers as being the best of interstellar vessels, does not exist.

A laser-type engine's most noteworthy features for propulsion purposes are light-pressure generation and the ability to produce shock waves. We shall examine these properties individually.

Light-Pressure Generation

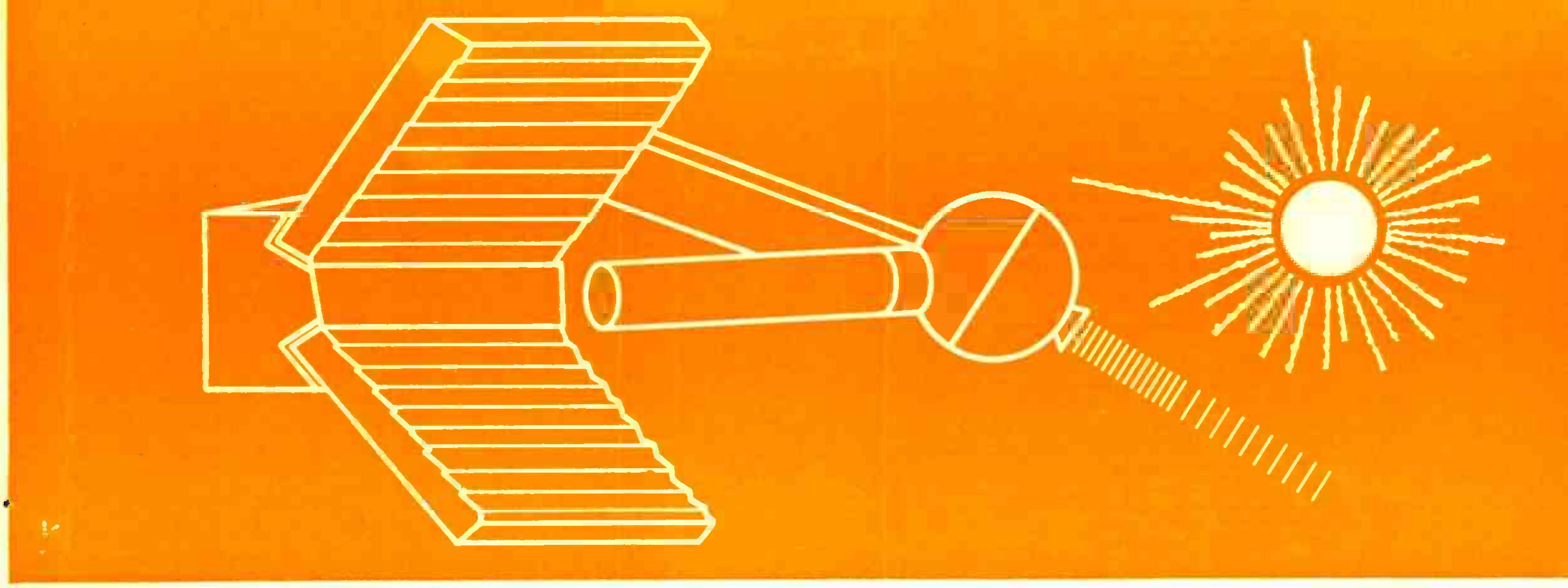
Most of us are familiar with the fact that moving air or water has momentum when striking an object at a certain velocity. Both streaming jets of air and water can drill a hole if these streams are powerful enough. But not so well known is the fact that electromagnetic waves may also have momentum. They are able to exert "radiation pressure." In the case of objects that are hit by light, a definite mechanical force can be imparted to the object. The effective force is, however, very small indeed.

A different situation arises, however, if laser-generated light is point-focused upon a substrate acting as a light-pressure cell.

By using an experimental system like that shown in Fig. 2, it is possible to generate a very powerful, coherent and monochromatic beam of intensely focused light that can be directed at some surface.

According to calculations by Dr. Arthur L. Schawlow, one of the pioneers in optical masers, the following light-pressure values were postulated: Working with a ruby laser having a peak power of 500 million watts in a beam whose cross-section is less than 1 cm^2, and assuming that the beam intensity is roughly 1 billion watts per cm^2, the intensity of the corresponding electric field would be about 1 million volts per centimeter in the unfocused beam. Using a good convex lens with a focal length of 10 mm, the laser's light could be directed to a small spot one thousandth of a centimeter in diameter. Here, the beam intensity would be one million billion (10^{15}) watts per cm^2, and the optical-frequency electric field would have a magnitude of about 1 billion volts per centimeter. Under these conditions, *light pressure* as a result of the focused laser beam would attain a magnitude of 15 million pounds per square inch!

Unfortunately, the immediate effect of this immense force is that there are severe disruptions in even transparent sub-



stances, since the optical-frequency electric field is more than that binding the outer electrons in most atoms. Consequently, a given material (including diamond) is either drilled through or vaporized without providing the desired propulsion effect.

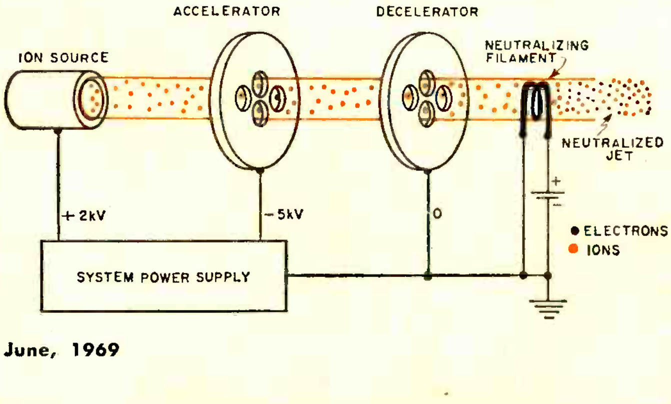
However, the magnitude of laser-generated light pressure is large enough to have more than passing technological significance, and much thought is being given to materials that are able to physically withstand and transfer imparted momentum without—literally speaking—going to pieces. A semi-critical nuclear mass might be able to do this, and we also have a byproduct in the form of plasma—which is easier to work with.

Shock-Wave Investigations

Intense mechanical shock waves can be generated by focusing a laser beam in free air or compressed gas, since a special product is generated at the focus point. This product, called "plasma," can be regarded as a collection of positively and negatively charged particles. Plasmas are everywhere in the universe, forming intensely hot gas under high pressure in the sun and the stars. Plasmas are present in the flames of burning fuel and in gas-discharge devices such as neon signs. Research on plasmas, particularly on many gas discharges, led to the discovery of the electron and to the elucidation of atomic structure.

A basic experimental setup for investigating shock-wave-type laser engines is shown in Fig. 3. An engine assembly, designed by the author during 1963-64, is shown in the photograph on page 30. The high-pressure laser engine is dwarfed by a liquid-fuel rocket motor, shown here for comparison of size.

Fig. 1. Electrostatic ion engine, although functional, has very low efficiency. Neutralizing filament is used to prevent collection of electrons on vehicle, building up negative charge which slows down positively charged ion exhaust stream.



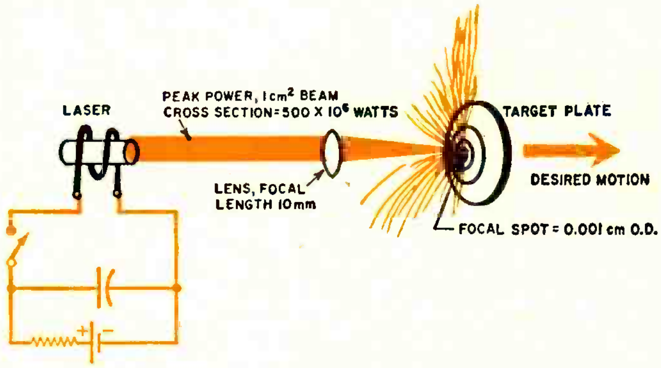


Fig. 2. Laser light-pressure engine can produce tremendous radiation pressure; however, the target plate is destroyed.

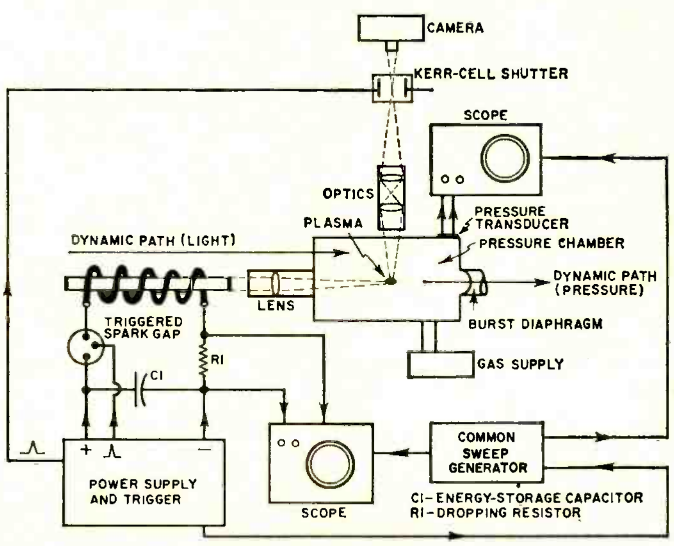


Fig. 3. Laser engine test assembly that has been employed for investigating shock waves generated by means of plasmas.

Strong blast waves and gaseous plasmas will occur in high-pressure gases by focusing giant pulsed optical lasers with short-focal-length optics to converge within the test volume. Using argon gas at an initial pressure of 100 atmospheres and a laser energy discharge of 1.0 joule (1 joule equals 1 watt-second of energy), pressures in excess of 8×10^8 newtons/m² have been reported. These forces are equaled only by chemical explosions that are similar to those obtained from rocket fuels confined to small volumes of expansion. Here, as there, if the "exhaust" that is produced by the device is propagated in a unidirectional manner, then effective propulsion will be the result.

The working principles of the laser engine have been simplified in Fig. 4.

The ruby-type pulse laser is equipped with a helical xenon lamp and is pulse-switched by means of a "Q"-spoiling Kerr-cell shutter. This shutter, a sample of which is in photo below, is based upon the principle that certain liquids transmit light only when an electric field is applied to them. Thus, after the laser has been "pumped" by its xenon lamp and is in a highly excited state, light oscillations between the reflectors (or end mirrors) can occur only *after* the intervening Kerr cell has been opened. At that instant, laser action takes place and the coherent, monochromatic beam is emanated in the form of a giant pulse of light. Other switching principles may also be used, such as rotating mirrors and polarizers, which can be inserted between a ruby laser's end reflectors. These choices vary considerably from one experimental system to the next.

Referring back to Fig. 3, formation of the plasma is detected by a Kerr-cell-operated camera using *Polaroid* film with an A.S.A. rating of 10,000. The magnitude of pressures developed can be sensed by fairly traditional high-speed transducers. When the shock wave is generated, the gas attains high temperatures, is ionized, and exhibits the unique ability to *absorb* light. Aside from air, gases such as helium, argon, nitrogen, and deuterium have been used. After the laser has been activated and propagates its radiation into a test cell, plasmas generated in an argon atmosphere reach a peak after approximately 125 nanoseconds. Extinction takes place shortly after about 850 nanoseconds have elapsed.

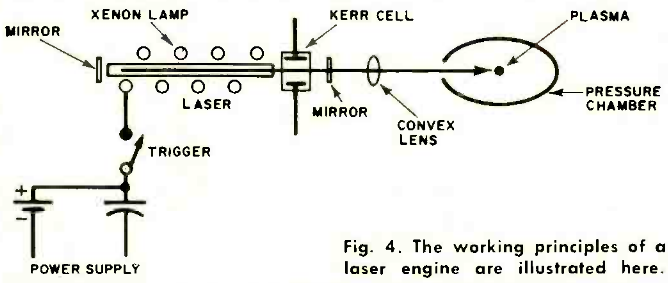
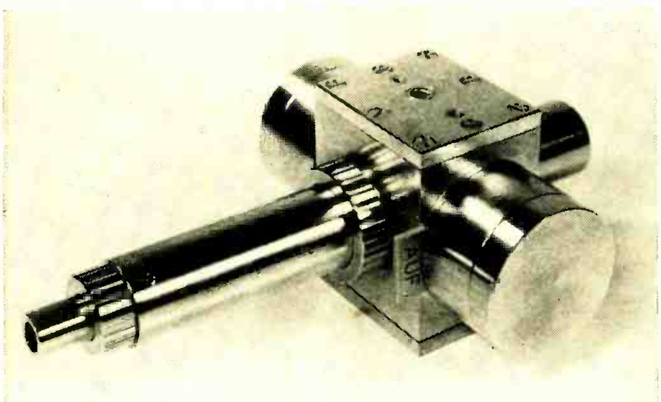


Fig. 4. The working principles of a laser engine are illustrated here.


A typical Kerr cell assembled for operation is shown here. Filled with nitrobenzine or similar liquids, cell is opaque to light unless it is energized by high-voltage electric field.

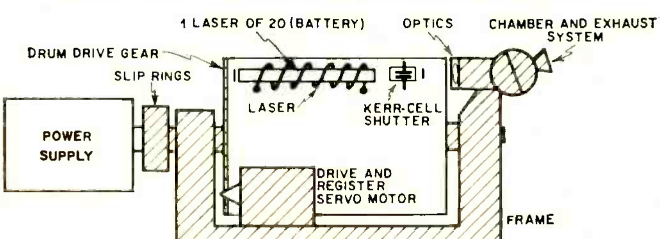
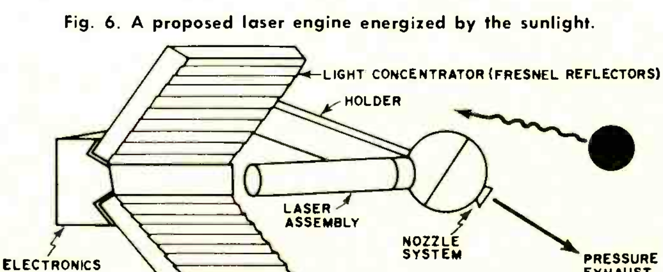


Fig. 5. One proposed design employs battery of 20 lasers inside rotating cylinder, all firing into a common chamber.

Fig. 6. A proposed laser engine energized by the sunlight.



In order to determine a point of maximum electric field beyond the focusing convex lens, a small piece of aluminum foil may be placed at a given spot. Then, by moving and tilting the foil during successive firings, a precise target position can be found.

Shock-wave-type laser engines have much in common with detonation-based force generators. High load factors can be achieved by pressurizing the plasma-forming gas, sometimes up to 2000 psi. At standard pressure, and using air as the working medium with a laser input energy of 3 joules, a shock-front velocity of approximately 3×10^4 cm/sec can be obtained.

Practical Applications

Regarding practical applications, the problem remains of providing proper exit systems and plasma-forming "combustion" chambers of small working size and mechanical rigidity. To afford strong, rapid pulsing of the laser engine, proposed designs include rotating laser batteries which, like a revolver's cartridge drum, fire into a common chamber, as shown in Fig. 5. This particular design allows the individual battery members sufficient time for recycling and cooling.

In deep-space operation, it is desirable to operate vehicular propulsion systems from natural rather than on-board power sources. The sun, above all, should certainly be able to provide an adequate amount of power for this type of operation.

Fig. 6 illustrates the author's concept of a laser engine powered by sunlight. The light concentrators take the form of Fresnel reflectors focused onto a "Q"-spoiled laser assembly. Auxiliary electronics, energized by solar cells, effect switching and en-route steering of the chamber and nozzle structures. A gas supply is required as well.

The laser's basic capability as a promising prime mover for spacecraft has been recognized both here and abroad. Ideally, the ultimate engine will be one that can lift a large vehicle off a planet's surface and supply continuous deep-space propulsion for any given length of time. Today, it would be safe to place our bets with the light-pressure engine. The shock-wave engine should be regarded as an intermediate step since it is too similar to a rocket. ▲

(Editor's Note: In addition to the references cited below, readers who have access to early issues of this publication will find a basic article on ionic and plasma engines in our April, 1962 issue (page 25) under the title "Electric Engines for Outer Space" by Ken Gilmore.)

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FET Sine-Wave Crystal Oscillators

By FRANK H. TOOKER

Here are a few simple oscillator circuits which engineers can use to obtain a linear sine-wave output with low harmonics.

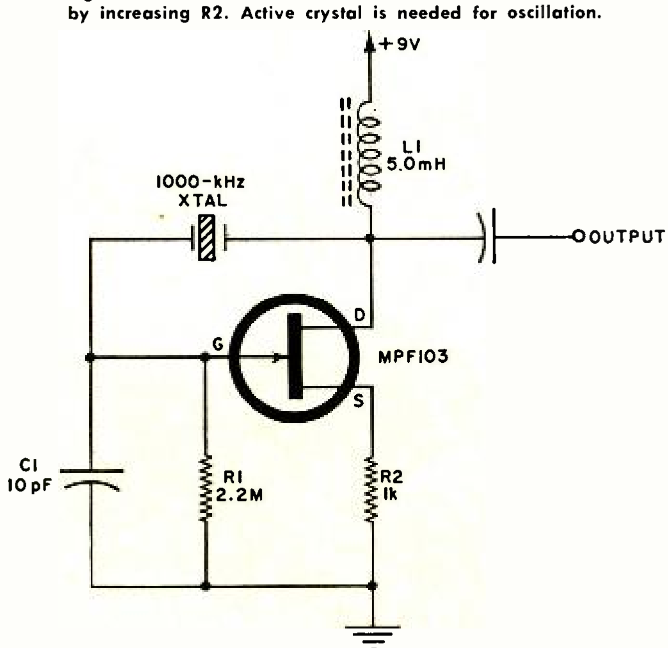
ENGINEERS who design crystal oscillators know one of the factors contributing to frequency instability is harmonic generation in the oscillator itself. In the past, designing sine-wave generators has not been easy. Vacuum-tube oscillators raised the signal level until it was limited—or clipped and elaborate circuits were needed to obtain linear operation and sine-wave output. Even with junction bipolar transistors the situation was the same, except clipping was sharper.

Field-effect transistors (FET's) promise to solve this problem. Their characteristics make them a "natural" as sine-wave generators, and with simple circuitry. This article describes 100-kHz and 1000-kHz sine-wave oscillators in three familiar configurations: (1) The Pierce circuit; (2) the tuned-drain, tuned-gate oscillator (equivalent to the tuned-plate, tuned-grid vacuum-tube circuit); and (3) the grounded-drain circuit (equivalent to the grounded-plate) or Colpitts oscillator.

While these circuits do not function perfectly—they do pull some slight gate current in order to establish self-regulating gate bias—they are nevertheless a significant step forward in view of their simplicity.

As in its vacuum-tube counterpart, the 1000-kHz Pierce oscillator shown in Fig. 1 needs a crystal of good activity (one which requires very little electrical energy to vibrate). Clean sine-wave output is obtained when the gate resistor, *R*1, has a value of 2.2 megohms and the unbypassed source resistor, *R*2, a value of 1000 ohms. If waveform distortion occurs in this circuit or any of the other circuits in this article, it can be reduced by increasing the value of *R*2. Values of *R*2 in the schematics are practical minimum values and larger values can often be used to advantage. In the circuit of Fig. 1, inductor *L*1 is preferably a high-quality, 3-pie (an inductor wound in three distinct layers or pies, side by side) component, wound on a powdered-iron core.

Fig. 1. Distortion can be reduced in the Pierce oscillator by increasing R2. Active crystal is needed for oscillation.



With crystals of poor activity, the Pierce FET circuit may not operate and, in some setups, parasitic oscillation can occur at or near the self-resonant frequency of the drain inductor. The gate-to-ground capacitor, *C*1, tends to inhibit parasitic oscillation.

When a crystal of good activity is in the circuit, drain current in the unloaded oscillator will be about 30 microamperes. Parasitic oscillations tend to produce a much higher drain current, 500 μA or more. Thus, measuring the drain current of the unloaded oscillator is generally used as a method of determining whether the circuit is operating properly.

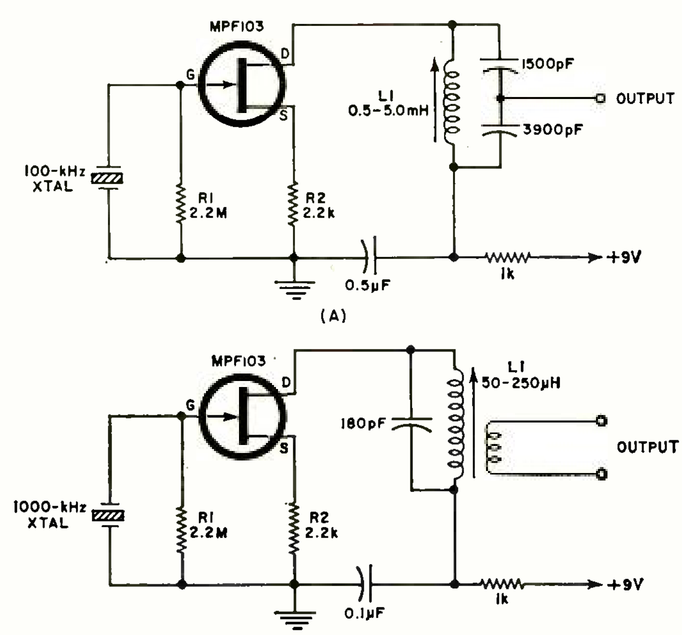


Fig. 2. Tuned-drain, tuned-gate oscillator can have a split-drain output as in (A) or a link output as shown in (B).

The Pierce FET circuit makes a satisfactory oscillator for some applications but, for the most part, the following circuits are to be preferred.

Tuned-Drain, Tuned-Gate Oscillator

The tuned-drain, tuned-gate crystal oscillator circuits of Fig. 2 put out a clean sine wave when properly adjusted, *i.e.*, when the inductor, *L*1, in the drain circuit is set for minimum drain current (about 150 μA, unloaded). This occurs when the drain tank is tuned just slightly *higher* than the resonant frequency of the crystal. (*Continued on page* 83)

THE POWER FET

By JOHN TAMOSAITIS
Applications Engineer, Crystalonics
A Teledyne Company

Power field-effect transistors, capable of dissipating up to 8 watts, offer engineers new design opportunities, but their operating characteristics need special care.

This large interdigitated chip by Crystalonics contains 40 individual channels.

ENGINEERS have been using field-effect transistors (FET's) for about eight years, but the majority of such FET's have been small-signal devices rated at drain currents of 0.1 to 10 mA and drain voltages of 5 to 30 volts. For the past few years, most new FET designs feature interdigitated structures, consisting of a number of optimum-size channels connected in parallel. The optimum-size structure, having an average drain current of 5 mA, is based on a compromise of characteristics and minimum resolvable dimensions.

Fig. 1 shows a cross-section of an *n*-channel structure, similar to the one used in the power FET. The bottom or "back" gate is uniform, while the top or "front" gate consists of a series of narrow diffused strips. The isolation *p*-region surrounding the device is a deep diffusion which meets both the back and front gates, thereby connecting them electrically. The device is actually made up of several channels connected in parallel by a metallization pattern over a top oxide coating. Each channel has its own source and drain contact; the contacts are in series (source-drain, source-drain), a front gate separating each one. A front gate-isolation gate combination surrounds each contact.

Designing a channel in the bulk of the semiconductor overcomes the difficulty of a MOS structure, which has its channel between a gate and a surface. Surface effects, such as ionization of absorbed impurities, result in low output impedance and noise characteristics.

Theoretically, the channels can be stacked up indefinitely to produce FET's with drain currents of up to 200 amperes, limited only by the size of the silicon slice. This is impossible in practice despite the fact that the average number of defects per slice has plummeted over the years, resulting in generally higher yields for all semiconductors. Field-effect transistors with drain current ratings of up to 1 ampere have thus become a reality.

Although several manufacturers presently supply FET's in the 100-mA range, they are specified and packaged as low-power switching devices. Units like the 2N4091 in a heat-sink package handle up to 1 watt. *Amelco* and *TI* make a series of JFET's in the 10-mA range with drain ratings up to 250 volts, which are also capable of dissipating 1 watt. Presently, the only true power FET is the CP650 series made by *Crystalonics*. Packaged in a solid TO-5 can, they have an I_{DSS} as high as 1 ampere and a maximum drain voltage of 25. These units closely resemble the interdigitated power transistor. Because of their chip size and complexity (total channel length approximately 2 inches), the power FET is a relatively low-yield, high-cost device.

Why a Power FET?

Power FET's enjoy several advantages over bipolar transistors:

1. They do not suffer from second breakdown, the hot-spot condition that lowers a bipolar's maximum collector voltage as the current increases.
2. Having a negative temperature coefficient, thermal runaway is impossible in a power FET.
3. When maintained below breakdown voltage, power FET's are self-current-limited to I_{DSS}.
4. Because FET's have much higher power gain than bipolars, driver stages are unnecessary.
5. The FET does not saturate, permitting faster switching than that attained with bipolars.

While the power FET is technically superior to the bipolar and the SCR in many applications, its higher cost ($42 in small quantities) places many of its uses in the luxury class. Where performance is the overriding criterion, though, the power FET is often the only choice. With constantly improving yields and higher volume, the power FET should, over the next few years, cut into the power bipolar markets to the same extent that its small-signal cousin has in its sphere of application.

The *Crystalonics* device (lead photo) is a large (0.04 × 0.06 inch) interdigitated chip containing 40 individual channels, each 0.02 inch long. The top gate, which is only 0.0001-inch wide, adds all the channels. The total channel is almost two in. long. The typical I_{DSS} value is 600 mA. If a standard transistor had these dimensions, the peak collector current would be about 6 amperes—10 times as great. It is rather easy to see why this large difference exists. Referring to Fig. 2A, current in the FET flows from the drain between the gates to the source. In the bipolar, where the top gate is equivalent to the emitter and the bottom gate the collector, the path is much shorter and less restricted. Structurally, the power FET is equivalent to a 100-watt, 500-MHz bipolar power transistor.

As a rule of thumb, FET's need ten times the active area of bipolars for the same current-handling capacity. Similar to the interdigitated bipolar, the power FET maintains its high-frequency performance in spite of size because it is equivalent to a number of small-signal devices connected in parallel. And, while the power gain of an FET does not increase with size, the junction capacity and small-signal transconductance do. This means that the gain-bandwidth product remains constant and all impedances are decreased proportionately.

Because the drain and source contacts are on the same side of the junction, the only breakdown path is from the drain to gate. FET's feature a zener characteristic somewhat like a bipolar, exhibiting avalanche breakdown instead of punchthrough. Thus, no safe operating area is needed. Since the FET is self-current-limited to I_{DSS}, there is no danger of transient current damage.

Most of the JFET parameters are more stable than those of the bipolar transistor because the JFET parameters are purely bulk dependent. The negative temperature coefficient of I_{DSS} (approximately —0.7%/mA) is contrasted to the reduction of input base-emitter voltage and increase of current gain with temperature that causes thermal runaway in bipolars. Altogether, the power FET has fewer and simpler failure modes than the bipolar; in fact, for reliability analysis, it is closer to a rectifier.

Both bipolars and FET's are limited to 200° C junction temperature, having similar thermal resistance in the same package type. Although the FET has a slight advantage, owing to its larger chip size (see Fig. 2B), this is balanced by the FET dissipating most of its power in narrow strips between the gates on the drain side, rather than across the entire back junction, as in the bipolar.

The FET cut-off frequency, f_T, is determined by G_m and junction capacity. Because the output capacity between drain and source is only in contacts and leads, it is less than 1 pF. Therefore, the cut-off frequency is determined primarily by the feedback capacity between drain and gate, and the G_m that drives it. The order of f_T for the power FET is about 1 GHz.

At any frequency substantially below f_T, the power FET has much greater power gain than the bipolar. Even though it requires higher voltage drive, its input current is practically zero and driver stages are not needed. It is interesting to note that bipolars have about 10 times the G_m of an FET operating at the same current level, but FET's have a much higher effective *beta*—a sort of backwards situation.

Because the FET is a majority-carrier device, it has two inherent properties which should be stressed. One of the bipolar's principal noise sources is carrier recombination noise in the base. The FET is free from such noise because the current flow mechanism is determined by majority carriers (electrons in an *n*-channel), just as in a metal conductor. Also, in a bipolar, radiation reduces minority carrier lifetimes and results in a degradation of the transport factor. This is not possible in a field-effect device.

Field-effect transistors generate almost no odd harmonics, resulting in much lower cross-modulation than that attainable with bipolars. For this reason, FET's are now used in most FM tuners for high adjacent-channel rejection. For example, for a given two-input signal level where bipolars exhibit third-order products about 60 dB down, the third-order products of small-signal FET's are about 110 dB down. Owing to its high G_m, the power FET has a noise figure of under 3 dB at 30 MHz when driven from a 50-ohm source. Small-signal levels do not have to be transformed to 1000 ohms to obtain a low noise figure; and the FET is capable of handling an additional 30 dB of signal with the same intermodulation distortion level. This 30-dB improvement is very significant where receivers must pick up weak signals in a high signal-strength area, such as in a mobile receiver operating next to a kilowatt transmitter.

Because of their high power gain, amplifiers built with a power FET require fewer stages. Actually, since the input impedance is so high, a complete amplifier can consist of an input transformer to raise the signal voltage level and a single power FET.

When run at low drain currents (approximately 10 mA), the power FET still exhibits a high G_m. In FET's, G_m decreases as the square root of drain current. For example, if a power FET has a G_m of 100,000 micromhos at 500 mA, it will have a G_m of 10,000 micromhos at 5 mA. It actually changes even less than this amount (*Continued on page* 82)

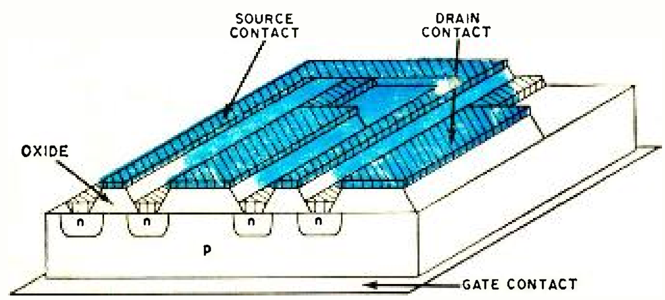


Fig. 1. Cross-section of an "n"-channel structure similar to the power FET. Several channels are connected in parallel.

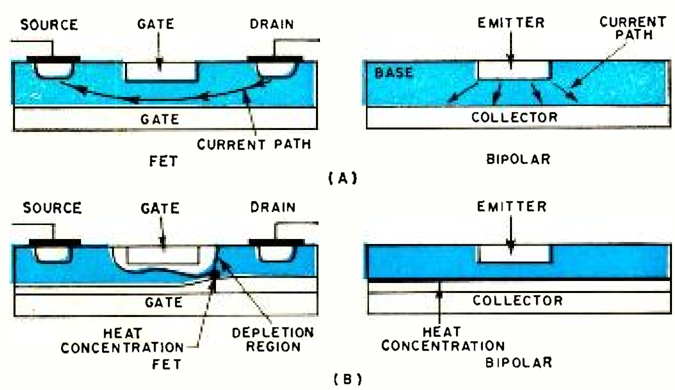
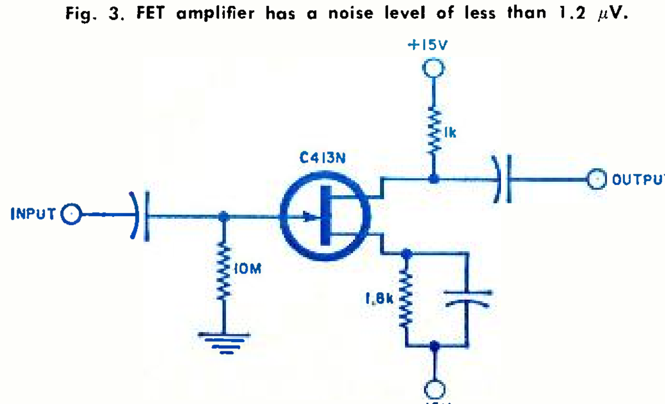


Fig. 2. Current paths in the FET and bipolar transistor (A). (B) Areas of heat concentration are shown for comparison.

Fig. 3. FET amplifier has a noise level of less than 1.2 μV.



TAPE-RECORDER WOW AND FLUTTER

By JAMES HAWK

The new lower tape speeds are making it more difficult to maintain low wow and flutter. Here is what these specifications and terms really mean. Also, how they are measured and what effect they have on reproduced sound.

IN addition to the kinds of distortion usually associated with electronic systems, magnetic tape recorders invariably modulate the recorded signals because of small changes in tape speed. The modulation effects are changes in the amplitudes and frequencies of the reproduced signals. For most applications, the change in frequency is the most critical one, especially when music is being reproduced and the change is audible.

Wow and flutter are the two terms used to identify the speed changes. *Wow* is an onomatopoetic word for the subjective impression of the slow up and down changes in pitch, received when the tape speed changes at frequencies between 0.5-5 Hz. *Flutter* means to move with quick vibrations; it identifies speed changes at frequencies of 5-200 Hz.

A compilation of the wow and flutter specifications for some fifty different model tape transports showed that of the fifty, eleven provided no wow and flutter information, one was specified as 0.3%, twelve were between 0.20-0.25%, sixteen were between 0.15-0.19%, three were between 0.10-0.14%, and six were less than 0.09%. Seven included the term "r.m.s." as part of the specification, and one listed both an r.m.s. limit and a peak limit. The higher percentages were generally associated with lower tape speeds, and the lower percentages were generally associated with the higher priced, professional machines.

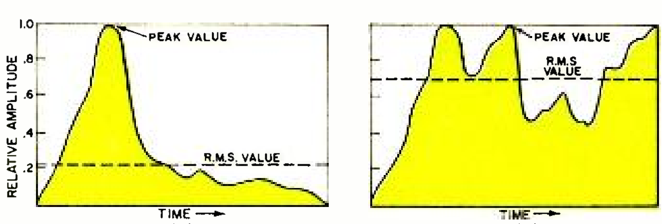
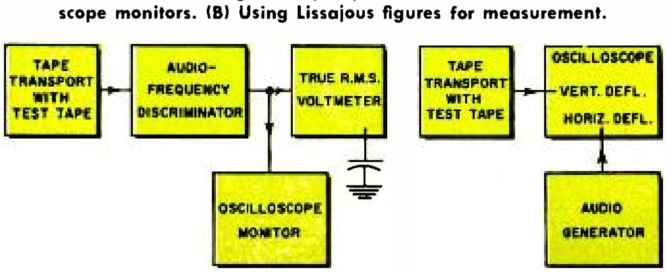


Fig. 1. Typical wow and flutter waveforms showing (A) low and (B) high r.m.s. values for the same peak values.

Fig. 2. (A) Setup for measuring r.m.s. wow and flutter. Commercial flutter meters are available which contain a.f. discriminators, metering circuits, output meters, and even oscilloscope monitors. (B) Using Lissajous figures for measurement.



This seemingly wide variety of values complicates the already complex problem of matching a particular recorder to an application or a pocketbook. In any event, insofar as reproduced music is concerned, three things are involved: the program material, the tape machine, and the ear. The one thing we can probably do the most about is the machine.

R.M.S. and Peak Values

Wow and flutter are stated as a percentage, expressed by: $K = 100\ \Delta f_o/f_o$, where K is the wow and flutter in percentage, f_o is the average frequency, and Δf_o is the frequency deviation.

An example of the expression's use is the following: If a test tape with a 3000-Hz constant tone were played and variations in tape speed changed the 3000-Hz tone to 3003 Hz, then a peak frequency deviation value of 3 Hz would be used in the expression and the resulting value would be 0.1% peak wow and flutter.

There are three popular ways of expressing wow and flutter: r.m.s., peak, and instantaneous peak. In the event that the sole wow and flutter component is a sine wave, the peak and instantaneous peak would be the same and the r.m.s. value would be related to peak by 0.707. Such an occurrence is extremely unlikely, however, as the waveshape is more likely to resemble random noise, voice or music, and it's only similar to these, not the same as. A measurement error of varying magnitude will result if the r.m.s. value is established simply by measuring peak and relating it to r.m.s. by 0.707.

The rates of change in tape speed and their amplitudes follow no set pattern such as that described by a sine or a square wave; they follow no law of nature, nor do they lend themselves to statistical prediction. For these reasons there are no practical mathematical relationships between peak wow and flutter and r.m.s. wow and flutter. An illustration of why this is so may be seen in Fig. 1. This shows that the peak value may remain constant as the r.m.s. value varies considerably. The r.m.s. value will be lower than the peak and that's just about all that can be said about the two together.

A relationship between peak and r.m.s. might be established for a particular machine but it will change with a flywheel change, or with increased or reduced friction, or even with cleaning. The r.m.s. value must be measured; it cannot be inferred or calculated.

Three basic items (see Fig. 2A) are necessary to measure r.m.s. wow and flutter: a test tape with a prerecorded average frequency (usually 3000 Hz), an FM discriminator, and a true r.m.s. voltmeter. The kind of discriminator used will usually accommodate audio test frequencies to 10 kHz and is linear, with good carrier rejection characteristics. *(Frequently, the discriminator is preceded by a limiter to keep any amplitude variations out of the discriminator. —Editor.)*

The voltmeter must be a true r.m.s. voltmeter which establishes the r.m.s. value, or d.c. equivalent, of complex waveshapes such as those developed by wow and flutter, random noise, voice, and such. The customary shop voltmeter is designed to read an r.m.s. value, or d.c. equivalent, of a sine wave and this design limitation cannot be circumvented by calibration. The meter just won't do to measure r.m.s. wow and flutter. Another problem is that the r.m.s. value may vary considerably; most of the true r.m.s. meters provide a means to increase the time constant of the metering circuit by attaching capacitors externally, and this is usually done in order to obtain a steady average r.m.s. reading on the meter.

Peak values of wow and flutter may be measured with a peak-reading voltmeter or with an oscilloscope. The metering inertia of the voltmeter restricts its use in measuring instantaneous peaks, and so a strip-chart recorder or an oscilloscope is employed.

Instantaneous peak values are of interest when the application involves a computer. When a series of bits is recorded on tape and then played into computer interface equipment, the interface equipment is usually synchronized to the bit rate. The servo system which maintains the synchronism can readily track the majority of the wow and flutter components; however, an instantaneous change (instantaneous within the frequency spectrum involved) gives the servo its most severe test. In fact, most servo systems cannot accommodate severe transients. The net result is that a few bits on the tape are rapidly displaced in time and the circuits which decide whether the bits are one's or zero's see the wrong bit at the wrong time, and may make a wrong decision. A wrong decision is an error and the number of errors made per number of bits is referred to as an *error rate*. Sometimes as much time is spent reducing error rates as is spent debugging computer programs, and consequently wow and flutter of the tape machine in such an application can be critical.

Sometimes the problem at hand is not buying an audio tape recorder or testing it to specifications, but simply its diagnosis and repair. For such occasions, a Lissajous pattern setup can be useful. The equipment required for the setup is merely an audio oscillator and an oscilloscope (Fig. 2B). A tone frequency is recorded and played back into the vertical deflection system of the oscilloscope. The audio oscillator is connected to the horizontal deflection plates. A little experimentation will quickly show to what source the movement of the Lissajous pattern can be attributed. Peak and instantaneous peak values may be approximated by calibrating the Lissajous pattern.

Making and Using Test Tapes

Standard test tapes are available for use with commercial flutter meters in order to measure flutter content of tape machines. Another method is to record your own flutter test tapes.

Recording a test tape, rewinding, and then playing it back on the same machine for wow and flutter measurements provides data which is certainly a reflection of the machine's performance. However, the readings obtained are a result of the random summing of two wow and flutter patterns, record and playback, and they therefore are not a reflection of the performance of the machine in an absolute sense. Consider, for example, that sooner or later one peak deviation which occurred during recording must arrive at the playback head just as a peak playback deviation occurs. The peak deviation measured would be the sum of the two, and if they both happened to be in the same direction it would be increased. If they were equal and opposite they would cancel (the playback would have to be slightly less in percentage).

The effects of the presence of recording wow and flutter can largely be reduced by using a test tape recorded at a much higher tape speed in relation to the playback speed. For example, a tape recorded at a speed of 120 in/s with a 192-kHz signal will provide a 3-kHz tone at 1⅞ in/s and will reduce the wow and flutter frequencies of the recording transport by a factor of 64. Thus, a flutter frequency of 16 Hz at 120 in/s becomes ¼ Hz at 1⅞ in/s. The use of such a test tape will provide precise and accurate data relating to the machine's performance in an absolute sense, except for the customary instrumentation errors.

Wow and flutter measurements made by recording and playing back the test signal simultaneously may be very misleading, because of the relationship between tape speed and the spacing between the record and playback heads. Fig. 3 shows that for a tape speed of 3¾ in/s and a one-inch spacing between heads, an error of 20% will result at a wow frequency of 0.55 Hz. This is true because the frequency starts at the recording head with zero deviation irrespective of tape-speed variations, and can change only an amount allowed by the time lapse which occurs as the tape travels to the playback head. Accurate measurements are possible for very few frequencies when the tone is recorded and played back simultaneously. These frequencies may be determined by first dividing the distance between heads by the tape speed, which will give the time of travel between heads. Accurate measurements will be possible when the time between heads equals ¼ or ¾ the time period of the flutter frequency, or multiples thereof.

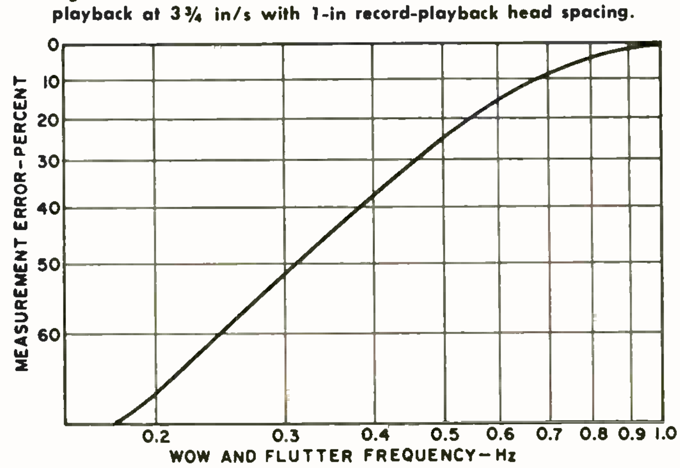
Effects of Tape Drives

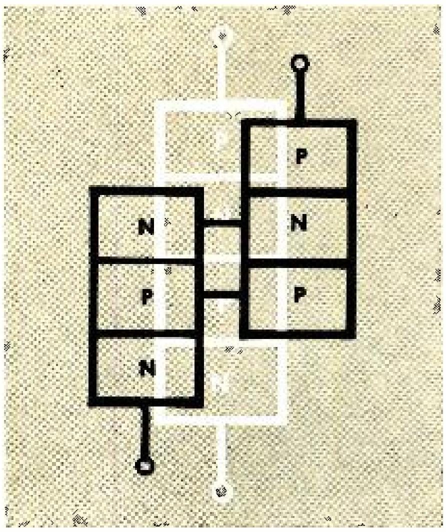
The majority of home model tape transports depend upon the stability of the frequency and amplitude of the power line for control of wow and flutter.

For most home applications the induction motor is used to drive a system of pulleys and belts or smooth-surface rubber gears (friction wheels). The control of wow and flutter in such machines is highly dependent upon the roundness of wheels, smooth bearings, and clean running surfaces, as well as stable commercial power.

Various other systems have evolved to reduce the variations in tape speed, the most effective of which employs the synchronous motor, which depends upon the frequency stability of the driving power and tends to ignore voltage amplitude variations. In cases where the available power is not adequate, the synchronous motor is driven by an audio power amplifier which is excited by a precision tuning fork, or other frequency standard. When tape speed as well as wow and flutter are especially critical, a closed servo loop is sometimes used, wherein the capstan speed is monitored and compared with some frequency (*Continued on page* 58)

Fig. 3. Measurement error due to simultaneous record and playback at 3¾ in/s with 1-in record-playback head spacing.





Using Transistors as Negative-Resistance Devices

By WESLEY A. VINCENT / Advanced Development Section
Government Electronics Div., Motorola Inc.

By using simple transistor-resistor combinations, characteristics of four-layer diodes, SCR's, and UJT's may be readily simulated.

SEVERAL rather unusual negative-resistance devices have become available to the circuit enthusiast during the past few years. These devices include four-layer diodes, silicon controlled rectifiers (SCR's), and unijunction transistors (UJT's) to name a few of the most popular. Industrial competition and improved manufacturing and production techniques have resulted in price reductions, allowing those with limited budgets to use them in circuit projects. However, ordinary transistors are more likely to be readily available for circuit experiments. By using the simple transistor-resistor combinations presented in this article, the characteristics of four-layer diodes, SCR's, and UJT's may be simulated.

A relaxation oscillator using the analog circuit of the unijunction transistor, which is quite similar in operation to the unijunction relaxation oscillator, is also described. Although the test results presented were obtained using silicon transistors, low-leakage germanium transistors may be substituted.

An advantage gained in simulating these negative-resistance devices is that the more important device parameters may be determined by selecting transistors and resistors used in the substitute combinations. The basic building block for the circuits discussed is based on the operation and theory of the four-layer or *p-n-p-n* diode. The SCR and UJT are then presented as extensions of the four-layer diode in theory and in synthesizing their characteristics, using transistor-resistor combinations.

Four-Layer Diode Theory

A four-layer diode consists of four alternate regions of *p-* and *n*-doped semiconductor, as shown in Fig. 1A. The *p*-region terminal is called the anode while the *n*-terminal is referred to as the cathode. The V-I characteristics and parameter definitions associated with the device are shown in Fig. 1B. With the anode biased positively with respect to the cathode, a negative-resistance (current increases as the voltage decreases) region exists. The four-layer diode may also be represented by a regenerative transistor feedback arrangement consisting of a *p-n-p* and *n-p-n* transistor, as shown in Fig. 1C.

Using this model, the mathematical expression for the terminal current I_E, may be expressed in terms of the transistor parameters as follows:

$$I_E = \frac{M_p I_{cop} + M_n I_{con}}{1 - (M_p \alpha_p + M_n \alpha_n)}$$

where: α_p and α_n are the common-base current gains; I_{cop} and I_{con} are the collector-to-base leakage currents; M_p and

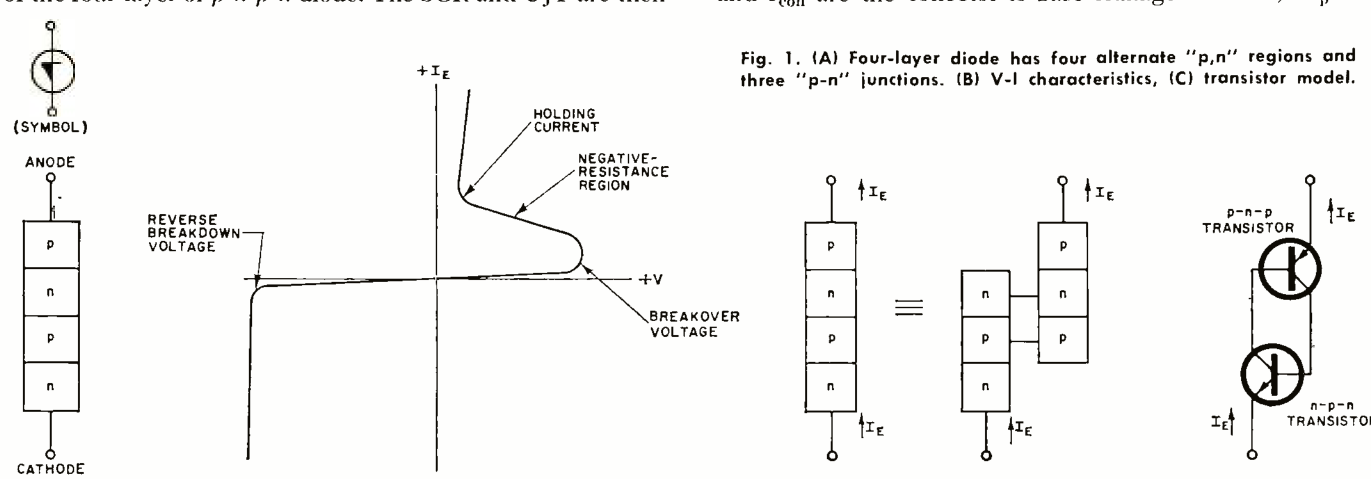


Fig. 1. (A) Four-layer diode has four alternate "p,n" regions and three "p-n" junctions. (B) V-I characteristics, (C) transistor model.

M_n are the multiplication factors which account for carriers created by impact ionization in a reverse-biased junction during breakdown.

The p and n subscripts refer to the parameters associated with the *p-n-p* and *n-p-n* transistors, respectively, in Fig. 1C. Usually M_p and M_n are assumed to be equal and are designated simply as M. If the leakage terms are combined, the previous equation may be expressed in a slightly more simplified form as:

$$I_E = \frac{M\ I_{co}}{1 - M\ (\alpha_p + \alpha_n)}$$

This expression may be used to briefly explain the forward V-I characteristics of the four-layer diode as follows: For anode-to-cathode voltage less than the breakover voltage, only a small leakage current flows. The current-gain parameters α_p and α_n are complex functions of injection efficiency, the base transport factor, and surface conditions. For small anode-to-cathode voltages, the combined values of α_p and α_n are much less than 1. Since no multiplication takes place at low voltages, M is equal to unity. The denominator in the above expression is only slightly less than unity so that I_E is approximately equal to I_{co}.

The current gains α_p and α_n increase with increasing current as the forward voltage is increased. Thus, the forward current increases slightly with increasing voltage. As the forward voltage is continually increased, the condition occurs where $M\ (\alpha_p + \alpha_n) = 1$. When this occurs, the current increases sharply over the previous small leakage current as shown in Fig. 1B. This voltage is known as the breakover voltage. At the breakover voltage, multiplication (M) is greater than unity since avalanche breakdown is occurring in the reverse-bias junctions. Therefore, the combined value of α_p and α_n is less than 1.

As the current increases beyond the breakover current, α_p and α_n increase due to their current dependence. A lower multiplication (M) is then required to maintain the breakover voltage. As a result, the forward bias across the diode begins to decrease with a negative-resistance region occurring. The current increases and voltage decreases until the holes injected at the anode of the *p-n-p* transistor equal the electrons injected at the emitter of the *n-p-n* transistor. This is a result of current continuity conditions and results in forward bias of the center junction of the four-layer diode. The transistors in the model are then in their "on" or saturated state.

In the reverse operating mode, the four-layer diode acts like two reverse-biased diodes in series. A small reverse current exists until the breakdown condition finally takes place.

Equivalent Circuit for Four-Layer Diode

When silicon transistors are connected in the manner shown in Fig. 1C, the forward V-I characteristics resemble those of an ordinary *p-n* junction rather than those of a four-layer diode. This occurs because the discrete transistor current gains are much higher than the current gains in a four-layer diode. The breakover condition of $M\ (\alpha_p + \alpha_n) = 1$ is reached at a few tenths of a volt when current injection for the transistor begins.

Large transistor leakage currents can also cause low breakover voltages. One method of reducing the transistor current gain is to place a resistor between its base and emitter terminals. A shunt path exists for the emitter current with the result that very little injection takes place until the voltage across the shunt resistor begins to forward-bias the base-emitter junction.

In the transistor equivalent model shown in Fig. 1C, several possibilities exist for reducing the combined values of α_p and α_n. Resistors can be inserted between the base and emitter of the *p-n-p* or *n-p-n*, or both, transistors. Shown in Figs. 2A and 2B are the forward V-I characteristics for a transistor-resistor equivalent circuit with a 1000-ohm resistor inserted between the base and emitter of the *n-p-n* transistor. It can be seen from these curve-tracer photographs that the forward V-I characteristics are similar to those of the four-layer diode.

In the configurations shown, the breakover voltage is determined by the BV_{CEO} parameter of the *p-n-p* transistor. In general, the breakover voltage will be determined by the transistor with the lower breakdown parameter. Shunt resistors, used to reduce either α_p or α_n, will increase the transistor breakdown voltage from BV_{CEO} to BV_{CER}. In Figs. 2A and 2B, BV_{CEO} for the *n-p-n* transistor is approximately 50 V. However, with the shunt resistor of 1000 ohms, the BV_{CER} voltage is greater than 100 volts; hence, the breakover voltage for the circuit is determined by the *p-n-p* transistors with BV_{CEO} voltages of 54 and 64 volts, respectively.

For breakover voltages less than the BV_{CEO} voltage of the transistors, either the *p-n-p* or *n-p-n* transistor may be operated in an inverted mode. Results for such a circuit are shown in Fig. 2C where the *n-p-n* transistor has been inverted. Even though *alpha* for an inverted transistor is severely reduced, it is still necessary to reduce the *alpha* of either the *n-p-n* or *p-n-p* transistor with a shunt resistor. As with the previous circuit, the breakover voltage is determined by the lower breakdown of the two devices. In this configuration the

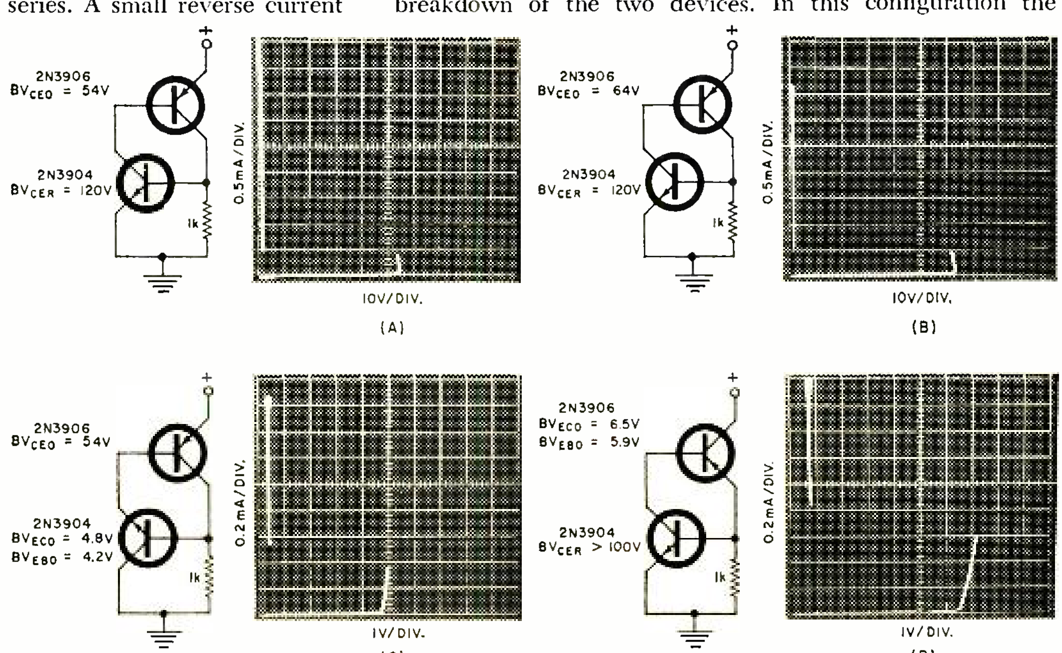


Fig. 2. (A, B) The transistor-resistor equivalent circuit for a four-layer diode. (C) Same but with inverted "n-p-n" transistor and (D) with an inverted "p-n-p" transistor.

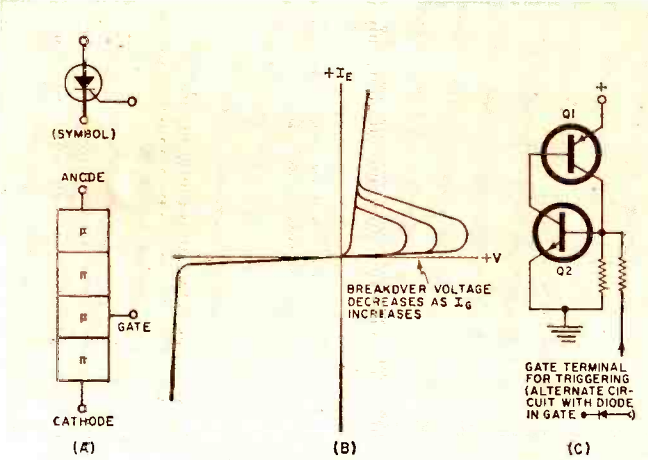


Fig. 3. (A) An SCR is four-layer diode with gate terminal. (B) V-I characteristics, and (C) equivalent circuit for SCR.

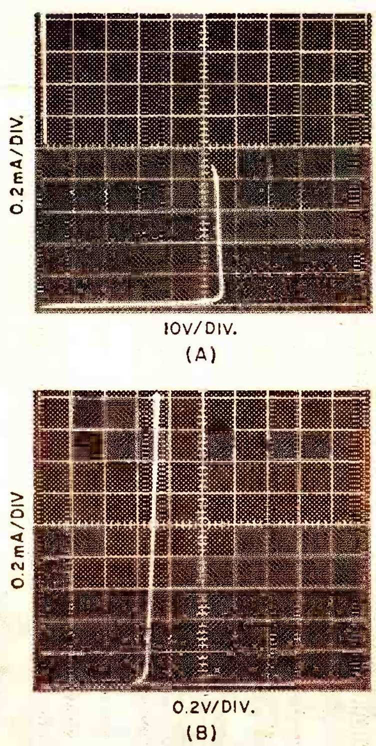
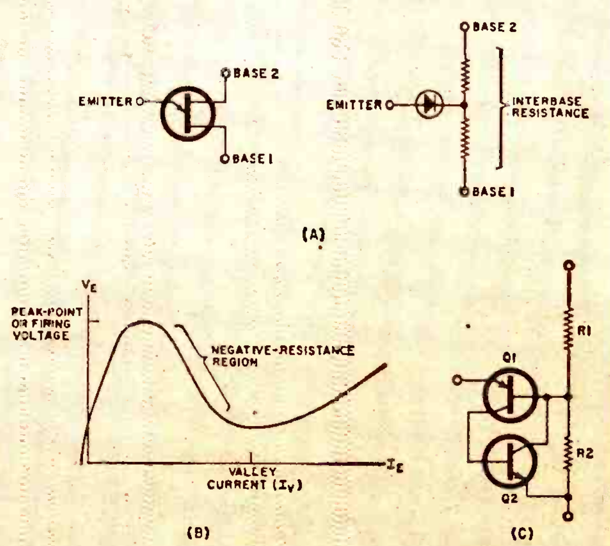


Fig. 4. Characteristics of simulated SCR shown here (A) in blocking state and (B) in "on" state due to 1 V on gate.

Fig. 5. (A) Symbol and circuit used to explain operation of UJT. (B) Forward V-I characteristics. (C) Equivalent circuit.



breakover point is determined by the BV_{ECO} voltage of the *n-p-n* transistor. (A close approximation of the breakover voltage is obtained by knowing the more commonly specified BV_{EBO} voltage of the *n-p-n* transistor.)

Another four-layer diode equivalent circuit with its forward V-I characteristics is shown in Fig. 2D, where the *p-n-p* transistor has been inverted. The BV_{ECO} voltage of the *p-n-p* transistor determining the breakover voltage is 6.5 volts.

By selecting the transistor breakdown voltage, the experimenter can simulate four-layer diode characteristics with a breakover voltage of 5 to 100 volts or more.

The holding current for these configurations is determined by the transistor current gains and shunt resistors. The holding current may be selected from a few microamps to 10 or 20 mA or more. Decreasing the value of the shunt resistor (and hence decreasing the transistor current gain) increases the holding current.

The reverse breakdown voltage for the four-layer diode equivalent circuit is similar to that of a four-layer diode and is determined by the junction breakdown of the transistors in the specific configuration. Note that if shunt resistors are used to reduce both α_p and α_n, the reverse breakdown voltage will be only approximately 0.65 volt, the voltage of one forward-biased diode.

The most noticeable temperature effect for these configurations is that the holding current decreases with increasing temperature. If the transistor *alphas* are not reduced sufficiently by shunt resistors, it is possible for premature firing to occur with increasing temperature as α_p and α_n increase with temperature.

The test results are not unique for any particular transistor type. Similar results have been obtained using other silicon and low-leakage germanium transistors.

Simulation of SCR Characteristics

The SCR consists basically of a four-layer diode with the addition of a third terminal called the gate. The gate is usually attached to the *p*-region near the cathode, as shown in Fig. 3A. The gate terminal is used to switch the SCR from the blocking or "off" state to a low-impedance or "on" state. As the gate current increases, the breakover voltage decreases, as shown in Fig. 3B.

With a minimum gate current, which is dependent on the particular SCR construction, the negative-resistance region no longer occurs and the V-I characteristics resemble those of an ordinary *p-n* diode. In theory, the gate current causes the individual current gains α_n and α_p to increase so that the condition for breakover, $M\ (\alpha_p + \alpha_n) = 1$, occurs prior to four-layer junction breakdown.

The transistor-resistor equivalent circuit for the four-layer diode may be adapted to obtain SCR characteristics by simply adding the gate terminal with a series resistor to the base of the *n-p-n* transistor shown in Fig. 3C. The series gate resistor insures that the collector current of *Q*1 causes *Q*2 to turn on, leading to regenerative action and the low-impedance state. Otherwise the collector current (electron current) of *Q*1 would flow into the gate terminal. A diode may also be used to replace the series gate resistor in Fig. 3C.

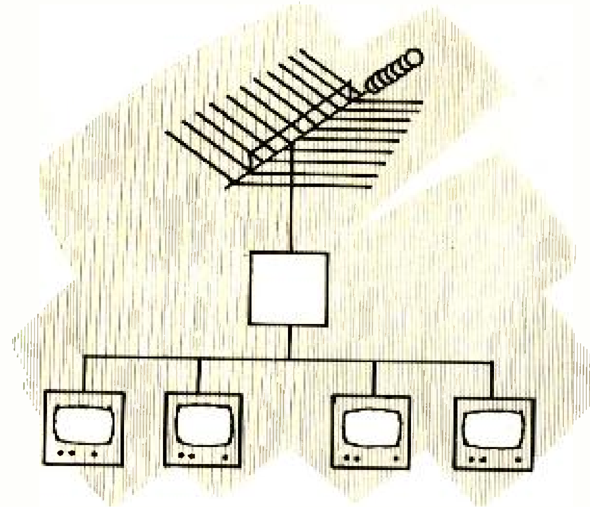
Curve-tracer results for the simulated SCR are shown in Fig. 4, where *Q*1 and *Q*2 were 2N3906 and 2N3904, respectively. Both resistors used in the equivalent circuit were 1000 ohms.

Fig. 4B shows the equivalent SCR turned "on" by an applied gate voltage of 1 volt. The exact gate voltage and current necessary for switching the simulated SCR will depend on the transistors and resistors used in the equivalent circuit. A gate current of 1 milliamp should be sufficient to switch silicon or germanium combinations.

Simulation of the Unijunction Transistor

The unijunction transistor is another device with negative-resistance characteristics. It is used (*Continued on page* 62)

Installing a Home Master Antenna TV System



By JIM SARAYIOTES / JFD Electronics Co.

Passive and active multi-set couplers make it simple to use a single antenna for several TV receivers. Some of the installation problems are covered here.

A GOOD color-TV picture is harder to receive than black-and-white. Therefore, when a family buys a new color set, they are quite likely to buy a good outdoor TV antenna to go with it.

But most people who buy a color set already own one or more black-and-white receivers and many also have FM-stereo receivers. It seems logical for all of these sets to be hooked up to the new outdoor antenna. Thus, many TV technicians find that it pays to sell-up to a complete home master antenna system when they are called in to make a color-antenna installation.

Multi-Set Couplers and Signal Splitters

The easiest way to feed a number of sets from a single antenna is with a multi-set coupler, as shown in Fig. 1A. A coupler matches the single 300-ohm input from the antenna to two, three, or four 300-ohm outputs. In addition, it provides isolation between TV receivers, so that they do not interfere with each other.

In choosing the coupler, there are several factors to consider:

1. *What is its frequency range?* Until a few years ago, almost all couplers passed only v.h.f. and FM frequencies. Most modern couplers also pass u.h.f. Generally, it pays to use an 82-channel coupler even if your antenna only picks up v.h.f. The cost difference is minimal, and an 82-channel unit will not become obsolete.

2. *What type of circuit is used?* Resistive-type circuits cost less but they do cause a great deal of loss. They should be used only in very strong signal areas. Inductive or transformer-type circuits, especially hybrids, are best for most applications.

3. *How much loss will the coupler cause?* This, of course, is a function of the circuit used.

Actually the term loss, as generally applied to couplers, is a misleading term. Loss is specified as the difference, in dB, between the input and any of the outputs. However, this is not all loss. For example, a theoretically perfect two-way coupler would divide the antenna signal into two equal outputs. Each output would have exactly half the signal power, therefore the signal in each output would be 3-dB down from the input signal.

This theoretically perfect coupler actually causes no loss at all, yet its loss would be specified at 3 dB. A practical two-way splitter would absorb part of the signal, causing an actual loss of 0.5 to 3 dB.

Thus, a coupler with a specified loss of 3.5 dB causes only 0.5 dB of actual loss, plus 3 dB of splitting loss. All other factors being equal, the lower the loss the better the coupler.

4. *How much isolation does it provide?* Connect two sets directly together, tune them to different channels, and

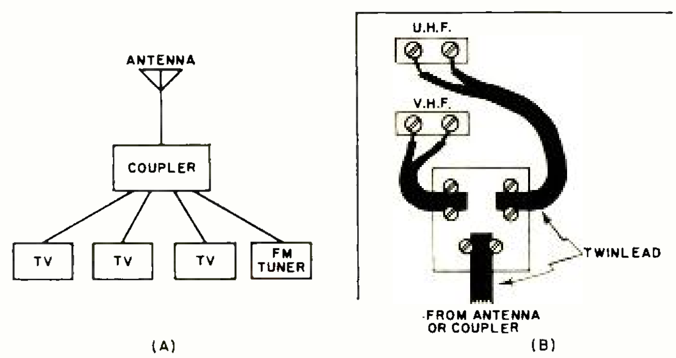
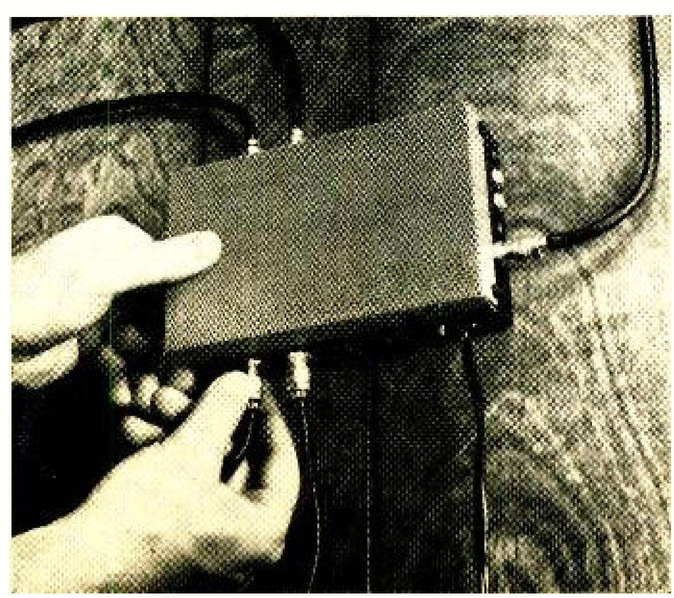


Fig. 1. (A) Use of a multi-set coupler permits a single antenna to be employed for several receivers. (B) A signal splitter is used to separate the u.h.f. and v.h.f. signals for TV receiver.

Fig. 2. A typical amplified coupler, the JFD Program Center, provides some gain along with isolation between TV receivers.



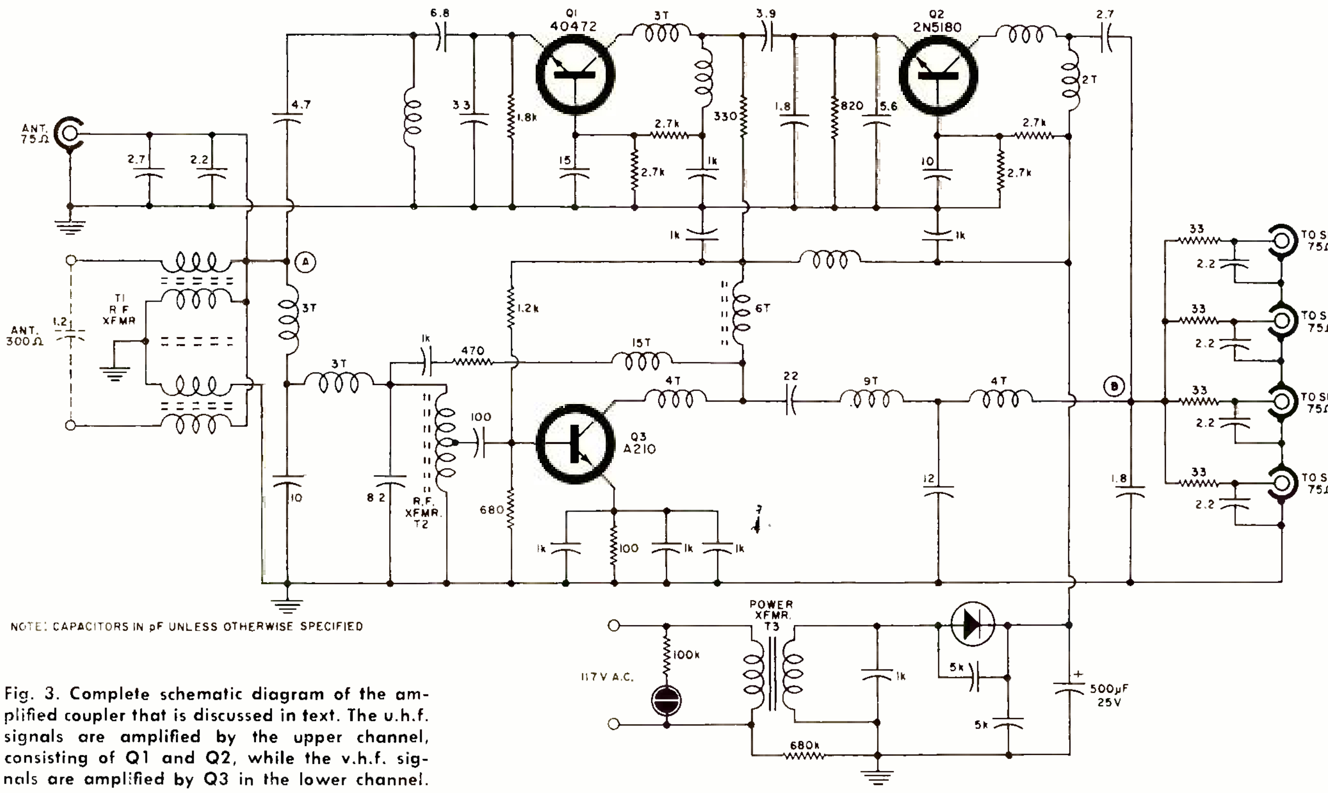


Fig. 3. Complete schematic diagram of the amplified coupler that is discussed in text. The u.h.f. signals are amplified by the upper channel, consisting of Q1 and Q2, while the v.h.f. signals are amplified by Q3 in the lower channel.

you'll see a lot of interference on both screens. With a good coupler there should be at least 12-dB isolation.

If the antenna and coupler carry both u.h.f. and v.h.f. signals, you run into a slight problem at the TV set. All current TV receiver models use separate u.h.f. and v.h.f. tuners, with separate antenna inputs to each. Therefore, you have to split the signals, as shown in Fig. 1B, sending u.h.f. signals to the u.h.f. tuner and v.h.f. signals to the v.h.f. tuner. Some signal splitters also provide a separate output for an FM tuner.

Amplified Couplers

In many areas, splitting loss can be a problem. Reduce the antenna signal by 7 dB or so with a 4-way coupler and you may get "snow" (noise in the picture), loss of color, or both.

Newly developed amplified couplers overcome this problem. Amplified couplers do the same job as passive couplers, but they provide amplification rather than causing losses. Each output of the amplified coupler shown in Fig. 2, for example, is 6 dB greater than the input at v.h.f. and 6.5 dB greater at u.h.f. Table 1 lists a variety of amplified couplers currently available, and includes some of their characteristics.

Let's take a close look at a typical amplified coupler to see why it makes home master antenna TV systems so easy to install.

Fig. 3 is the schematic of the *JFD* Model PC4782 CD Program Center, which incorporates a number of interesting features. It offers the advantage of both 300-ohm and 75-ohm inputs, with 75-ohm outputs. While older units required a switch to go from 300 to 75 ohms, this unit uses an all-channel balun, built around transformer T1, to match the 300- and 75-ohm inputs. At point A, the impedance is 75 ohms. Therefore the 75-ohm input is connected directly to point A, with the 2.7 and 2.2-pF capacitors acting as

Table 1. Listing of currently available amplified couplers. The models that are grouped together horizontally have fairly similar characteristics. Most of the indoor units have outputs for several receivers, while outdoor units have single output.

FREQUENCY	OUT. IMPEDANCE	BLONDER TONGUE	CHANNEL MASTER	JERROLD	JFD	WINEGARD
INDOOR AMPLIFIED COUPLERS						
VHF	300Ω	PS4-300 DA-4V-300	0024-0017	TA-24, TA-66A	PC4312	BC-208
VHF	75Ω	HVB-3P DA-4V-75	0016	TC-88	PC4712	BC-274
VHF & UHF	300Ω	DA-4U/V-300	--	--	PC4382	BC-382
VHF & UHF	75Ω	--	--	TAC-4	PC4782	BC-782
OUTDOOR AMPLIFIED COUPLERS						
VHF	300Ω	VAMP-2	0023, 0026, 0027, 0028, 0031	ADM-106L, SPM-106L	SP2300	AC-223, RD300, AP220
VHF	75Ω	VAMP-2-75	0041, 0043, 7060	SPC-107-L	SP2700	AC-295
VHF	75Ω	--	--	SPC-132A-L	SP2730	--
VHF & UHF	300Ω	COLORAMP U/V	0062	--	SP2382	AC-823
VHF & UHF	75Ω	--	7264	ACP-105L	SP2782	AC-895
UHF	300Ω	ABLE-U2	--	UPM-104, ULP-104	SP2314	AC-423

Note: Most V.H.F. units are suitable for FM band.

filters. Equally important, the coupler handles all u.h.f. and v.h.f. channels.

At point *A*, u.h.f. and v.h.f. signals are combined, and beyond this point they are split. The v.h.f. signals go through another transformer (*T*2) to match the input of v.h.f. transistor *Q*3. The u.h.f. signals are sent through *Q*1 and *Q*2.

Two stages of u.h.f. amplification are required, compared to only one stage of v.h.f. amplification. This is because u.h.f. signals are, in general, weaker and harder to amplify in a single stage.

One of the most serious problems with older solid-state home TV antenna amplifiers was that they overloaded in the presence of strong signals. For example, if most of the signals in the area are relatively weak, but there is one strong local v.h.f. channel, it can drive most transistors into distortion. The viewer sees lines moving across the screen (known as "windshield wiper effect") or loss of sync on the TV screen. Peculiarly, the interference is seen on every channel *except* the one causing the overload.

In this amplified coupler the problem of overload is solved by using a transistor (*Q*3) with very high signal-handling capability. Thus, the unit will not overload unless it is within a very few miles of a local transmitter. Overload is no problem at u.h.f., since signals are generally much weaker in that band.

The u.h.f. and v.h.f. signals are recombined at the output of the amplifier (point *B*), where they are split into four different 75-ohm outputs. A resistive network is used to insure good inter-set isolation. Yet gain of the unit is high enough to overcome the losses of the resistive output splitter network. The unit provides 6 dB v.h.f. and 6.5 dB u.h.f. gain at each of its four 75-ohm outputs. Response is flat, to assure good color fidelity.

In use, the input of the amplified coupler is connected to a 300-ohm or 75-ohm antenna. Then, each output is connected to a TV set or FM receiver. Of course, a matching transformer is required to match the 75-ohm output cables to 300-ohm set inputs.

Also, a signal splitter is required to provide separate u.h.f. and v.h.f. inputs to all-channel TV sets. Generally, the matching and u.h.f./v.h.f. splitting functions are combined into a single unit such as the one shown in Fig. 4.

Running Twinlead or Cable

Whether you use a passive or an amplified coupler, all you have to do is connect the antenna to the input and a set to each output. You don't have to terminate unused outputs. The only practical problem comes in running the wires to the various receivers.

First, you have to decide between coaxial cable and twinlead. The comparative characteristics of coax *vs* twinlead have been debated widely (see "Coax vs Twinlead", July 1965; "New Shielded Twinlead for Color-TV and U.H.F.", October 1965; and "New Low-Loss Coax for TV", August 1966, all in this magazine), but it is safe to make a few generalizations:

1. Unshielded twinlead costs less.
2. Coax keeps out interference better than unshielded twinlead.
3. Twinlead causes less signal loss, if carefully installed.
4. Coax can be run near metal, electrical wires, and almost anywhere without ill effects.

Many installers prefer coax for metropolitan areas where interference and ignition pickup cause problems, and twinlead for fringe areas where you have to fight for every dB of signal you can get.

If you decide to use unshielded twinlead, be sure to run it carefully. Proximity to metal changes the impedance of twinlead, causing color smears. Therefore, you must be careful to keep twinlead away from all metal objects including gutters, pipes, ducts, window frames, and a.c. wiring. In fact, twinlead should even be kept away from wood and shingles which may get wet. However, new foam-type twinleads are much more resistant to moisture and shielded twinlead is completely immune to moisture.

To avoid proximity to metal and to simplify the job, many installers prefer to run twinlead outdoors as much as possible. They simply put the coupler under an eave where it is protected from the weather to some degree, or mount it on the antenna mast. Then, they run the output wires around the house and in through the windows closest to the TV sets.

Twinlead run outdoors should be twisted about once a foot, to minimize interference pickup. Also, it should be run vertically, rather than horizontally (where possible) to avoid direct signal pickup. Finally, it should be kept away from the house exterior by means of standoff insulators.

Be careful *not* to crimp a metal-ring-type standoff insulator tightly around twinlead. This is a sure way to cause standing waves. If possible, use the type of standoff that encircles the twinlead with plastic rather than metal.

You may want to take twinlead into the house through a convenient window. If the window frame is wood, this is fine. Just carefully cut out a channel in the wooden windowsill and run the twinlead through it.

If the window is aluminum, you have a problem. However, if you drill the hole oversized and keep the twinlead from touching metal by wrapping it thickly with plastic tape, it usually works pretty well. The same method can be used for French or casement-type windows. Caulk the hole to prevent water leakage.

No matter how you take the twinlead into the house, be sure to use a drip loop. This is merely a small down loop in the leadin just before the twinlead enters the house. Water collected on the twinlead will then drip off to the ground rather than run into the house.

Indoors, twinlead is generally stapled to the baseboard, run through closets and walls, or under rugs. Avoid too many staples since they, too, may upset impedance match. Staples should be placed in the plastic insulation, parallel to the two conductors and midway between them.

One difficulty with running (*Continued on page* 72)

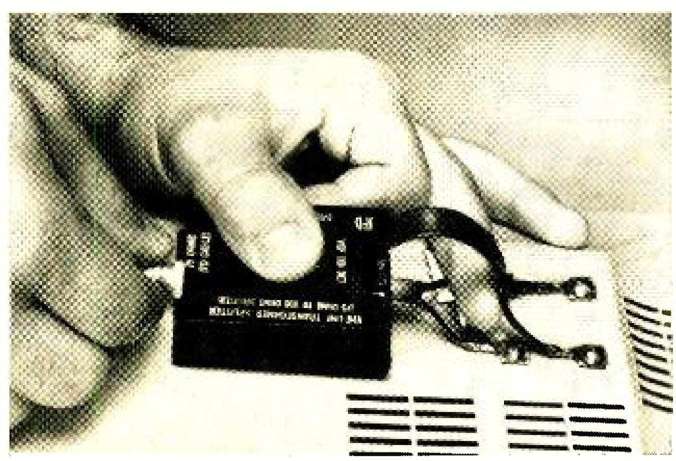
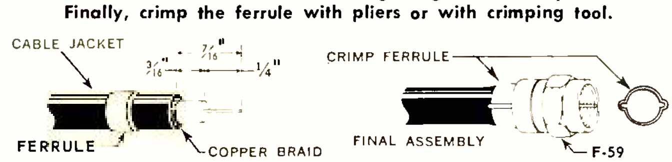
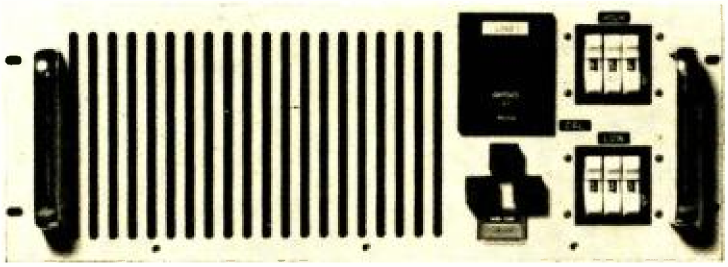


Fig. 4. Both impedance matching from 75 to 300 ohms and u.h.f./v.h.f. splitting are accomplished in this single unit.

Fig. 5. Proper method of installing coax connector. First, strip cable to dimensions shown. Note that the cable jacket and copper braid are flush. Slide ferrule over cable jacket. Second, push connector into cable, between shield and the dielectric. Be sure connector is tight against cable jacket. Finally, crimp the ferrule with pliers or with crimping tool.





ELECTRONIC LOADBANK–
Tests Power Supplies Dynamically

By LUTZ H. BENGNER /Associate Manufacturing Engineer, IBM Systems Manufacturing Div.

Test loads for some power supplies are bigger and as complex as the systems they simulate. Here is a versatile test load that makes power-supply testing easy.

ALL electronic circuits have a common requirement—they must have power to operate. And because electronic circuits can be very simple or extremely complex, they have created a need for a wide variety of precision power supplies; each so different from the other in their characteristics that they, in turn, have made necessary power-supply test apparatus of unprecedented flexibility and precision. To satisfy this demand, engineers at *IBM's Systems Manufacturing Division* developed a programmable electronic load capable of modulation up to 100 kHz for dynamic loading tests. This test load is capable of:

100 amps at 1.2 volts to 10 amps at 100 volts continuous d.c. power.

A programmable current range from 1 amp to 100 amps in 100-milliampere steps.

Load regulation of one percent.

Modulation by an external source of up to 100 kHz.

Undervoltage protection that is adjustable from 0.5 to 1.5 volts.

Overpower protection to protect load circuitry.

It has been common practice to use resistive loads for power-supply tests, but adjusting these loads (remotely) to fit a supply's requirements can be difficult. Resistors require continuous readjustment to maintain constant current under varying voltage conditions. And, at high currents, internal heating causes load resistances to change value.

There is also the problem of space. Accommodating a load which ranges from 100 amps at 1.2 volts to 10 amps at 100 volts in 100-milliampere steps requires about five cubic feet of space. In addition, dynamic loading at frequencies up to 100 kHz is extremely difficult with resistive loads.

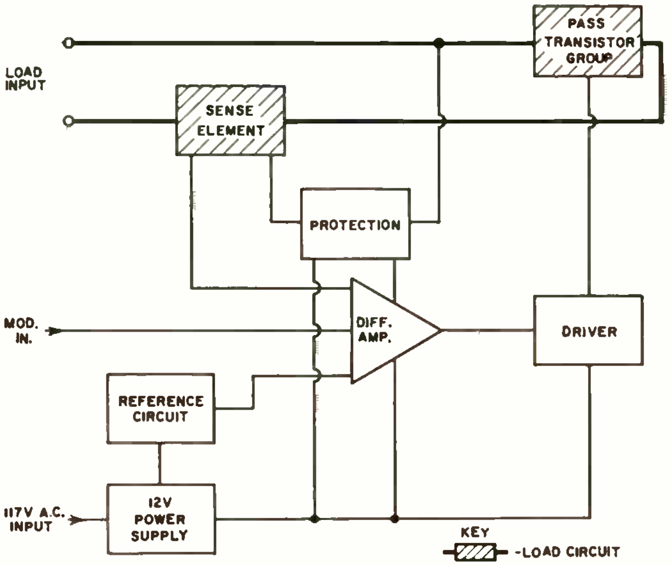
Basic Design

The basic loadbank design is a pass-transistor group regulated by a programmable differential amplifier. To provide a constant current independent of input voltage, it is necessary to keep the voltage across the sense element constant (Fig. 1). Therefore, the differential amplifier acts as a voltage regulator, regulating the voltage across the sense element by controlling the conduction of the pass-transistor group.

Since the requirements of this load are 10 amps at 100 volts and 100 amps at 1.2 volts, voltage drops within the load circuit had to be minimized, and the transistors in the pass-transistor group had to have extremely low saturation resistance. At the same time, they had to be able to withstand more than the 100-V collector-to-emitter voltage. The value of the emitter resistors (in this group) also had to be kept low, but they had to be large enough to provide efficient matching of the pass transistors. Power transistors of the 2N2771 type were found to meet load requirements and 21 of them were chosen for the pass section, in conjunction with 100-milliohm emitter resistors.

In the electronic loadbank, the sense element is used to

Fig. 1. Sense element monitors current flowing through pass transistors and acts as protective device for load.



monitor current flowing through the pass transistor group. To keep its voltage drop low, its resistance is limited to 2 milliohms.

However, when a sense element of only 2 milliohms is used, the voltage across the element is extremely small as compared to average voltage regulators. In the worst case (1 amp), the sense element output is 2 millivolts. In addition, to regulate the element's output to 1 percent (20 microvolts), the temperature stability of the differential amplifier is very important. The average discrete-component differential amplifier has a stability of approximately 20-30 μV per degree centigrade and is too unstable for this application due to the wide range of temperature variations.

In view of this, a *Fairchild* μ726 temperature-compensated integrated-circuit differential amplifier module was chosen. This amplifier has a stability of better than 0.2 μV per °C, permitting tolerance requirements to be met under the temperature conditions of the loadbank.

The Reference Source

The high stability of the reference source was achieved with a constant-current driver (Fig. 2A). Zener diode *D*1 and resistor *R*1 are connected across the output of the 12-volt stabilized power supply' (Fig. 1). This provides a constant voltage at the base of transistor *Q*1. Since the current at the base is constant, a constant voltage drop is present across *R*2. Zener diode *D*2 provides additional stabilization for reference-load changes. A portion of *R*2 is used as a reference voltage divider for current programming.

Current Programming

Current programming is accomplished by adding resistance to the programming voltage divider, part of *R*2. The amount of resistance added is proportional to the increase in the base current of transistor *Q*1. Therefore, the current through the reference voltage divider remains the same and provides programming linearity. The load is programmed by three decades of 1-2-4-8 BCD resistor trees used in conjunction with reed relays. This allows local manual programming with a switch, and remote programming by a computer. In local programming, two different load levels can be pre-set and manually switched from one to the other.

Loadbank Protection

In the operation of the loadbank, undervoltage and overpower protection are provided.

Undervoltage protection is necessary because, in the absence of an input voltage (with a certain current programmed), the load tries to approach the programmed current and forces the driver sections to exceed their safe operating limits. In this case, an important design consideration for the undervoltage protection circuit was that it remain in an "off" condition from zero to approximately 500 millivolts, then turn "on" and withstand up to 100 volts (Fig. 2B).

With no input voltage, the voltage divider (*R*1 and *R*2) is loaded by *R*3 through *D*1. This keeps *Q*1 turned off, knocking out the programming. When the input voltage exceeds 0.5 volt, *Q*1 turns on and *D*1 stops conducting. This makes the load available for programming. The "threshold" voltage, exceeding 0.5 volt, is adjustable from 0.4 to 1.5 volts, enabling the test load to operate below the saturation limit (Fig. 3).

In an overpower situation, excessive power dissipated by the pass-transistor section will result in transistor damage due to overheating. Therefore, overpower protection is a necessity. The circuit acts quickly to keep the semiconductors from being damaged. Thus, the overpower circuit is not designed to turn the load off at a fixed wattage, but rather to follow the safe operating curve of the load, allowing for the maximum use of the pass-transistor performance under all voltage conditions.

To accomplish this, a balanced differential amplifier, made up of *Q*1, *Q*2, and resistors *R*1, *R*2, *R*3, *R*4, and *R*5 (Fig. 4), is used to add voltage and sense current to determine when the load should be shut off.

The differential amplifier is followed by voltage and current drivers. Its main design parameter, high gain and high power, was a consideration of the worst-case working voltage of the pass-transistor group. Under operating conditions, this voltage can be as low as 1.2 volts.

Since the safe-operation curve has non-linear characteristics, the voltage signal which varies from 0.5 to 100 volts is sensed by a non-linear silicon-carbide device in conjunction with the zener diode. The differential amplifier disables the programming when the safe-operation curve is exceeded. When this is the case, the disabling action "locks up" the loadbank so that it remains off. Otherwise, it would turn "on" and "off" repeatedly as the overpower condition changes. The loadbank is designed to be reset only after the overpower condition has been corrected.

Mechanical Design

While the unique electrical design of the loadbank had to meet exacting requirements, (*Continued on page* 64)

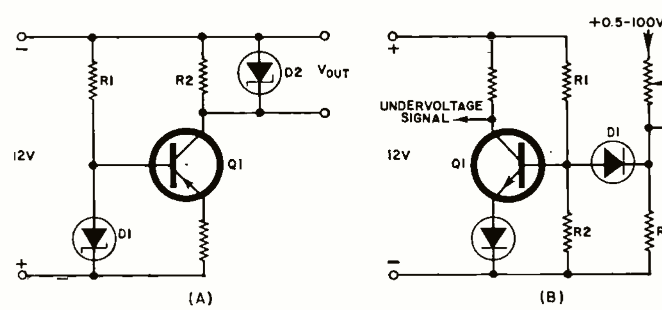


Fig. 2. Constant-current driver makes reference circuit (A) stable. Undervoltage-protection circuit is shown in (B).

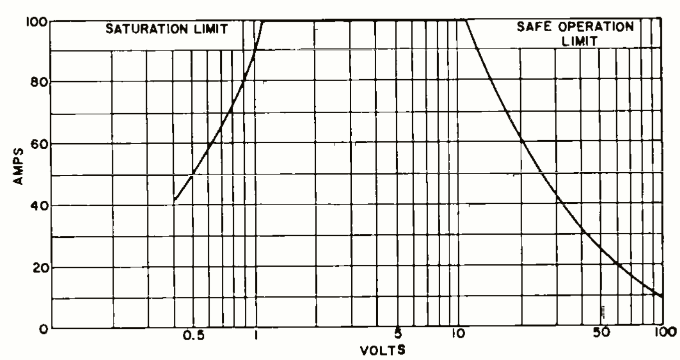
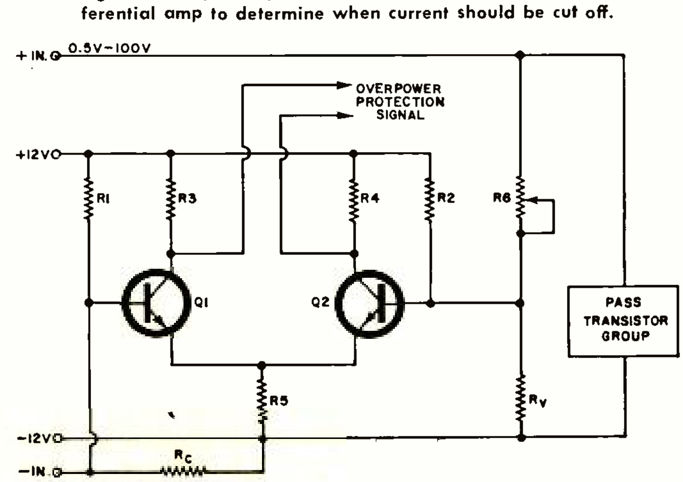
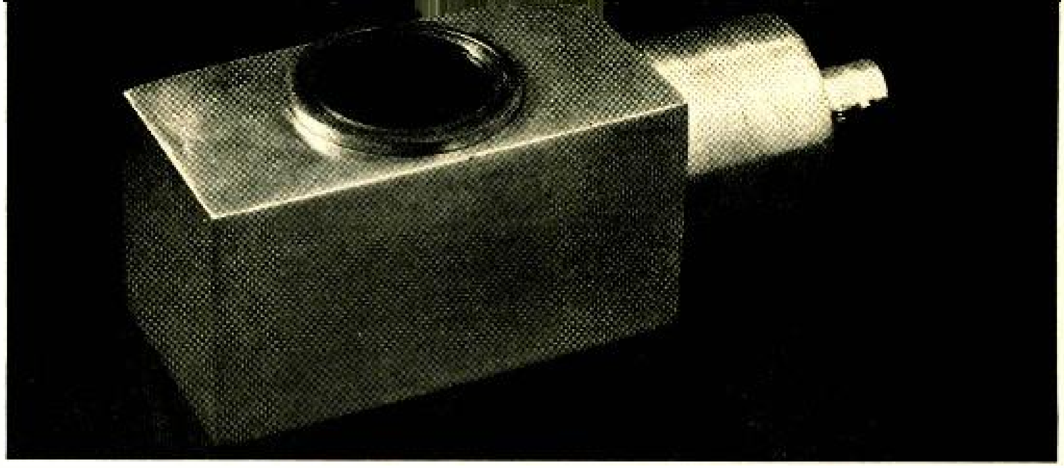


Fig. 3. The performance curve for the electronic loadbank.

Fig. 4. Overpower-protection circuit uses balanced differential amp to determine when current should be cut off.





A typical proportional counter made by LND, Inc. Radioactive particles entering the circular window ionize the atoms of a gas to give an output that is proportional to the tube's voltage.

(Editor's Note: In Part 1 of this series, we introduced some of the elementary concepts of atomic radiation and discussed the basic units used to measure nuclear emanations. This article examines nuclear detection methods and equipment.)

NUCLEAR radiation is detectable because the radioactivity interacts with matter. Charged particles (α-particles, β-rays, etc.) interact with matter by ionizing the atoms as the radiation passes through. Each ionization uses up to 50 eV of energy, depending upon the element being irradiated. Hence, the number of electrons "knocked loose" (atoms ionized) is a measure of the energy of the incident particle. For silicon, the ionization energy is 3.5 eV; for germanium, 2.8 eV. This is the energy required to produce one ion/electron pair. For a gas mixture of 90% argon and 10% methane, the energy loss is 25 eV. In gases, some of the energy is used in the disassociation (breaking up) of the gas molecules.

Neutral particles (neutrons) interact with matter in a manner analogous to billiard-ball collisions. Here the "billiard balls" are the nuclei of matter and the incoming neutron particle. The recoiling nucleus interacts with other nuclei to produce electron/ion pairs.

In the case of *gamma* (γ) *radiation*, incident energy either ionizes the atom, excites an electron into a higher energy condition, or interacts with an atom to produce an electron and a *positron* (positive electron). Electrons which are initially ionized can also ionize other atoms, giving rise to *secondary* electrons.

Hence in any of the mechanisms just outlined, the final result of the interactions is the production of electrons. With this in mind, we now turn to an examination of the principal types of nuclear radiation detectors used to exploit this phenomenon.

Gas-Filled Detectors

Perhaps the simplest radiation detector is an electric field between two surfaces. Generally, the surfaces are concentric, and if a thin wire is used as the center conductor and a thin-walled cylinder as the other electrode, the device is as shown in Fig. 1. Depending on the potential difference (voltage bias) between the electrodes, and the nature and pressure of the gas between them, several different types of detectors can be made.

Fig. 1. An elementary gas-filled detector. The output is dependent on potential between electrodes, and gas pressure.

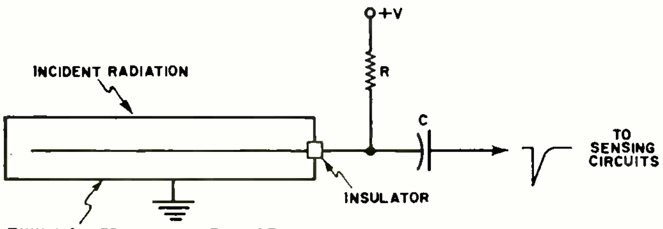


Fig. 2 shows several distinct regions of operation of this primitive detector. On the Y axis, the number of ions collected (note the logarithmic scale) is plotted as a function of bias voltage. Depending on the type of radiation, several curves can be drawn, each characteristic of the incident radiation. While examining in detail the various regions shown in Fig. 2, the nature of the interaction between the incoming radiation and the gas molecules must be considered.

The steep portion of the curve marked "Region A" is not generally useful as a detector. In this region the bias voltage is not high enough to collect the majority of ions and electrons (ions to cathode, electrons to anode) before recombination occurs. Recombination is the opposite of ionization, that is, electrons and ions unite to form an uncharged atom.

As the bias voltage is increased, the ions and electrons are swept to the electrodes at an increasing velocity and rate, and thus there is less time for recombination to occur.

Further bias increase causes the detector to operate in the ionization region, creating an ionization chamber, shown by "Region B" of the diagram. These detectors are normally operated at pressures of up to 50 pounds per square inch and have a bias of several hundred volts. These conditions allow efficient collection of the ions/electrons, but the energy imparted to the particles by the bias is not high enough to generate secondary ions and electrons. The output current of the ionization chamber is directly related to the total energy of the particles which arrive over a given time interval. Since one ampere is one coulomb of charge flowing in one second, for a *constant* current I flowing over time T, the total charge is $Q = I \times T$. Then at either electrode the charge collected is just $\pm Ne$, where N is the number of particles and e is the charge on the electron (1.6×10^{-19} coulomb). The appropriate sign ($\pm$) is taken at the electrode of interest.

To gain an insight into the level of the signals we expect to exist under these conditions, assume that 10^6 ion/electron pairs are collected in one microsecond (10^{-6} second). Then if a rectangular pulse of current I exists, $I = (Q/T) = (Ne/T)$, thus, $I = (10^6 \times 1.6 \times 10^{-19})/10^{-6} = 1.6 \times 10^{-7}$ A or 0.16 microamp. The equation $v = Q/C$ is used to find the amplitude of the voltage pulse. If C is 100 pF (the total capacitance of the system), then $v = (1.6 \times 10^{-19} \times 10^6)/10^{-10} = 1.6 \times 10^{-3}$ volt or 1.6 millivolts. Hence, we see that signal levels are very low, even for a million (10^6) electrons arriving in one microsecond. These low-level signals are difficult to amplify and process in the presence of noise.

Another distinct disadvantage of the ionization chamber is that particle identity (α, β, γ, etc.) cannot be determined, nor can the energy of a particle be resolved. We have only a measure of the *total* incident particle energy.

The next region of interest occurs when the bias is raised high enough to produce secondary electrons/ions. The number of secondary particles generated is proportional to the

ATOMIC RADIATION: Detection Methods

By JOSEPH H. WUJEK, Jr.

Part 2. You can't see it, and you probably won't know it's around until too late. But here's what you use to detect presence of dangerous radioactivity.

bias voltage, hence "Region C" is termed the *proportional region* and a detector which operates in the region is called a *proportional counter*.

A proportional counter is a considerable improvement over the ionization chamber in that the amplitude of the output pulse is proportional to the energy of the incoming radiation which caused the pulse. Hence, energy-sorting or pulse-height analysis can be performed. By means of appropriate particle shielding, the radiation which finally "sees" the detector can be of a particular type. For example, it's easy to shield against α and β particles, leaving only x-rays and γ-rays to be detected. Notice also that the number of particles collected has increased several decades over the number collected in the ionization region. Thus, signal processing becomes less of a problem due to the increase in amplitude of the detector output.

The last region of interest, "Region D", is the Geiger region. This is the region where the Geiger tube or Geiger-Mueller (G-M) detector, used by many prospectors and radiation safety personnel, operates. In the G-M detector, a discharge occurs between electrodes when a stream of ions/electrons bridges the inter-electrode gap. These pulse are rather long in duration, but the addition of a "quench" gas can shorten the pulse length to tens of μsec. However, at high counting rates the G-M detector is useless. As with the ionization chamber, no energy sorting or particle identification is possible, although α and β particles may be distinguished by the use of shields. The G-M counter is popular because it furnishes a gross measure of radiation level and only simple circuitry is needed to monitor the tube output. These devices can be built to withstand rugged use in the field and are relatively inexpensive as compared to the more sophisticated detection devices.

The Scintillator/PM Tube

Certain materials exhibit an interesting and useful property when exposed to radiation. In some materials, incoming radiation excites electrons to new energy states within the atom. When the electrons return to their original energy state, the absorbed energy is converted to a pulse of light. These pulses may last only a fraction of a nanosecond or as long as a few milliseconds, depending upon the material. The material is said to "scintillate" and the material is a *scintillator*. In theory, at least, we should be able to "see" the excitation of an individual electron, but of course the light energy emitted is at an extremely low level. In order to amplify the light and at the same time convert the light energy into electrical energy, a *photomultiplier* (PM) tube is employed.

Fig. 3 illustrates the arrangement of the scintillator and PM tube. The PM tube consists of a photo-cathode and a series of electrodes called dynodes, usually tied together by a resistance divider as shown. When the light emitted by the scintillator strikes the cathode, electrons are "kicked

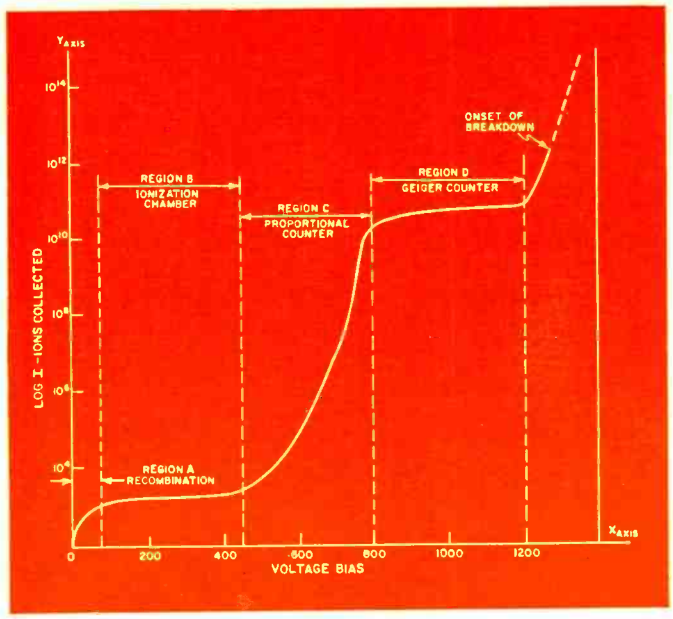
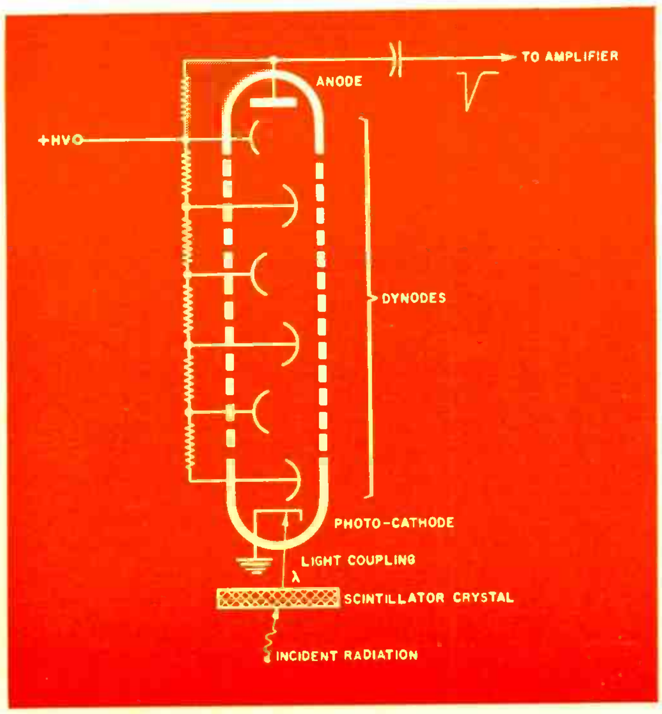


Fig. 2. The response of the hypothetical detector shown in Fig. 1 for a given radiation and gas pressure. See text.

Fig. 3. Scintillator crystal and photo-multiplier tube as used in scintillation counter to detect electron excitation.



This Eberline & Associates meter is used in systems where it is necessary to continuously monitor high radiation levels.

out" from the cathode by the photoelectric effect. Since the first dynode is more positive than the cathode, it attracts the electrons. Upon impact with the first dynode, additional electrons are generated which head toward the second dynode. This action continues from dynode to dynode due to the increase in electron energy caused by the potential difference between the successive electrodes. Hence, a multiplying, or avalanche, effect (of electrons) is created as the stream proceeds. At the final dynode, or anode, the resulting current pulse is coupled to the detector circuitry. The net effect is to multiply the electrons and achieve a current gain of 10^7 or more. It requires several tens of nanoseconds for the electron to traverse a PM tube.

The scintillator/PM tube output pulse is proportional to energy, hence pulse-height analysis may be performed. The resolving time of these detectors depends upon the time required for the light pulse to decay after excitation. This decay time varies from less than 10 nanoseconds for a stilbene crystal to about 0.2 microsecond for a sodium-iodide scintillator. A wide variety of scintillator crystals are used in nuclear detection work, the principal parameters of interest being the decay time and the sensitivity to incoming particles. As in any of the detectors we have discussed, noise is also a fundamental limitation of the useful range of the device.

Solid-State Detectors

The solid-state detector may be thought of as an ionizing device where the ionization medium is a crystal lattice rather than a gas as was the case with the detectors of Figs. 1 and 2. As previously noted, the ionization energy for silicon and germanium is 3.5 eV and 2.8 eV, respectively.

Several important types of solid-state detectors are in use: diffused-junction, surface-barrier, lithium-drifted, and totally depleted junction, among them.

Although important differences exist in the physics and technology of the four device types mentioned, some similarities are also present. Each of the devices has, as the principal means of detection, a *p-n* semiconductor junction that is operated under reverse bias. Incoming radioactive particles produce ion/electron pairs in proportion to the energy of the particles and the physical constants of the material.

The diffused-junction detector is not unlike a diffused-junction semiconductor diode, although an optimum design of large surface area (hence more sensitivity) *vs* low capacitance is the ideal. These detectors have a sensitive region and capacitance which is strongly voltage-dependent, therefore a charge amplifier is used as the detector's first stage rather than the usual voltage amplifier.

The surface-barrier detector has a very thin sensitive region upon which a thin-film metallic (usually gold) electrode is deposited. The carriers may be thought to reside principally at the interface between the gold layer and the crystal. Like the diffused-junction device, capacitance is strongly dependent upon bias voltage.

If lithium ions are present in the semiconductor material, it is possible to fabricate detectors having a sensitive region far thicker than the diffused-junction (DJ) or surface-barrier (SB) types. The capacitance of a lithium-drift device is nearly independent of bias voltage. This permits use of a voltage amplifier as the input stage.

The extra thickness of sensitive region of the lithium-drift device permits its use as a detector of higher energy particles than the DJ or SB types. With thin sensitive regions, high-energy particles have a high probability of passing through a zone without interacting with the crystal. This is analogous to throwing a small ball through a chicken-wire fence. If a single thickness of wire fence is used, the chance of hitting the fence is smaller than if several unaligned layers were used.

The totally depleted detector has a thick sensitive region and makes use of any or all of the three technologies previously outlined. These detectors are inherently lower in noise and generally faster in output rise-time than the DJ, SB, or lithium-drift types. The totally depleted device will exhibit higher capacitance than the other three types, although *C* is largely independent of voltage.

The solid-state detectors discussed will yield rise times from less than 10 nsec to several hundred nanoseconds, depending upon the material, geometry, and type of device. Circuits are often the limiter, rather than the detector. Frequency response, noise, and input sensitivity can also limit the value of high-quality detectors (see Fig. 4).

Other Detectors

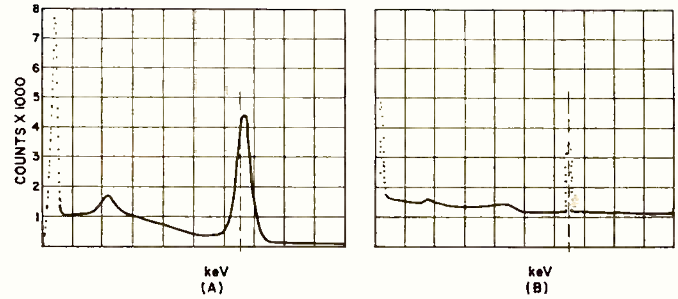
The *calorimeter* is an instrument for measuring heat rise and may be used to measure radiation. In high-energy, high-flux levels, radiation will cause materials to heat. Energy sorting may be accomplished by collimators and/or shielding. The temperature rise of the calorimeter may be measured by monitoring resistance change with temperature, or by using thermocouple junctions. One form of collimator consists of a narrow slit milled through shielding material. Particles of a wavelength equal to the slit are passed, others are blocked.

The *spark-chamber* consists of parallel electrodes maintained at several hundred volts' potential. An incoming particle causes gas ionization in its path, triggering a spark. Photographs furnish the record of direction and the length of the spark path is a measure of the particle energy.

Other schemes, some of which are non-electronic in nature, exist for the detection of nuclear radiation. The most important devices have been discussed in this article. In the final article, we will discuss some of the circuits and systems used to process the signals generated by these detectors.

(Concluded Next Month)

Fig. 4. (A) Gamma radiation from a cesium-137 sample peaks at 662 keV. Sodium-iodide scintillator with a PM tube is used. (B) Better resolution is obtained when a lithium-drifted germanium detector at 77°K is used. The samples are the same.



JOHN FRYE

Perhaps TV manufacturers should recognize cable-TV is here to stay and start building receivers for use with it.

DESIGNING A RECEIVER FOR CABLE-TV

BARNEY came in out of the hot and humid June day, parked his tube caddy on the service bench, and stood appreciatively with arms akimbo in front of the cool output of the shop air conditioner.

"Man, summer is here!" he announced to Mac, his employer; "but I licked that interference problem," he added with satisfaction.

"What was it?" Mac asked.

"You'd never guess. Remember we were getting complaints of a vertical bar that kept sliding across the screen of a black-and-white set. Sometimes the interference was present; other times it wasn't. But it was very much in evidence during the popular evening shows. I only got a glimpse of it one time a couple of weeks ago, and then it looked like a Barkhausen oscillation that *moved!* It consisted of two narrow vertical lines that were about a half-inch apart, but instead of standing still at the left side of the screen as proper Barkhausen lines should, these kept moving across the screen from left to right. Before I had a chance to touch the set, the lines disappeared. I noted, though, that this customer was using an outside antenna, while most of his neighbors were on cable. None of them was having any interference problems at all.

"The difficulty was really pinned down by another customer of ours, one to whom we sold a new color set last Christmas. A couple of days ago he and the black-and-white customer, who lives directly across the street, were talking about the interference; and it came out the interference began just about the time the new color set was installed. The two neighbors did a little experimenting on their own, and sure enough the bars appeared on the black-and-white set every time the color set was turned on and disappeared when it was turned off. To add to the confusion, the color set was on the cable and so had no antenna to radiate any signal it was producing."

"Hm-m-m-m, that *is* strange. When you first started talking, I thought vertical sync bars from the cable signal were being radiated from a long run of twin-lead used on an unauthorized installation. We've both run into that one several times."

"That was my thought, too, but I'm glad to have company in my ignorance. Anyway, I started checking out the color set and found a damper tube that was not seated well in its socket. I pushed it down, and that cleared up the trouble immediately. I suppose other receivers in the vicinity were not bothered because they were on the cable. The combination of strong signal from the cable plus reduced pickup of external signals made these sets relatively immune to the interference. In fact, the color set itself did not pick up the interference it was producing; yet the receiver on an outside antenna, at least two hundred feet away, suffered bad interference."

"And the lines moved because of the slight difference in the sync frequencies of a color set and those of a black-and-white receiver," Mac suggested. "Ordinarily we only see interference from a short-ranging Barkhausen oscillation on the screen of the set producing the oscillation and timing it with the set's own sweep circuits; in which case, of course, the bars stand still."

"Yeah, I was mulling all that over while I was driving back, and I concluded I was darned lucky those neighboring customers of ours were on speaking terms. That situation had all the ingredients of a really nasty service problem. But it would probably never have happened if our black-and-white customer had been on the cable."

"True, and that reminds me of something I've been thinking about the last few days. I read an article put out by the National Cable Television Association in which it was stated that about three million of the TV sets in this country, or roughly 6%, are operating on cable now. Some 2200 CATV systems are in operation, and about the same number are franchised or are under actual construction. It is estimated that by the next presidential election in 1972 some twenty-two million more people will be watching TV *via* the cable and that within ten years 85% of all sets in the country will be cable-connected."

"So what?"

"So it seems to me it is not a bit too early for TV manufacturers to take cognizance of this fact and start redesigning their receivers for optimum performance on cable."

"I think I see what you're driving at. Up until CATV came along, the major requirements of a good TV set designed to operate in either a fringe area or near a transmitter have been such things as"—and Barney ticked off on his fingers—"a low-noise front end and good sensitivity; a stable sync as immune as possible to ignition noise, airplane flutter, and other types of interference that would cause a weak-signal picture to jump and jitter; an a.g.c. system that will permit the set to handle a very wide range of signal strength so as to provide maximum sensitivity on weak signals without overloading on strong signals; and, of course, sufficient bandwidth to provide good picture detail."

"So far so good," Mac said approvingly. "Now let's consider what is needed for a set operating off the cable. To start, a low-noise front end and good sensitivity are no longer of paramount importance. The signal delivered by the cable is usually around a thousand microvolts across 72 ohms on all channels provided by the cable. The hot front end is required in the cable front-end receivers, not in the TV set."

"The same thing goes for the a.g.c. system," Barney suggested. "The a.g.c. in those front-end receivers and in the line amplifiers is designed to hold the signal level delivered to cable-connected sets within comparatively narrow limits under all receiving conditions. As a result, the TV set's a.g.c. system has very little to do. What's more, the sync signal going along the cable is relatively noise-free. If the receiver's input is protected from interference emanating outside the cable, much less emphasis need be placed on sync-stabilizing circuitry."

"That brings up an important point," Mac interrupted. "I was thinking that the conventional length of 300-ohm line running from antenna terminals on the back cover of the TV receiver to the tuner should be replaced with coax that could be connected directly to the cable and so shield the input of

Every minute is longer up there.

You can save as many as 20 or 30 of those long minutes when you put up one of our larger antennas, because they're pre-assembled. Our snap-joints take only seconds to lock in place.

Sylvania antennas are equipped with a double boom (for strength and rigidity).

All have strong, seamless, half-inch tubular elements (not rolled-over strips of aluminum).

All aluminum parts are gold-alodized inside and out (not sprayed, but dipped).

Even more care goes into the electronics.

We've peaked our antennas for flat response over the entire 6 MHz bandwidth of each TV channel. Flat response is absolutely necessary for good color reception. Otherwise, color rendition may be lost.

You also need high gain—that's obvious. But coupled with high directivity to knock out interference. Polar patterns from our antennas show almost complete rejection of signals from the rear and sides.

We designed our antennas so you wouldn't have to (1) climb back up there or (2) fiddle around up there.

We know that the fiddler on the roof is just fiddling his own money away.

For more information on our line of antennas see your Sylvania distributor.

SYLVANIA
GENERAL TELEPHONE & ELECTRONICS

the receiver completely from outside interference. Under the present arrangement, in which an impedance-matching transformer must be used between the single-ended 72-ohm output of the cable and the 300-ohm balanced input of the receiver, that length of twin-lead between the antenna terminals and the tuner provides plenty of pickup for strong signals or interference. What's more, in some cases we have both seen, it permits radiation of the cable signal into nearby receivers working off their own built-in antennas or off outside antennas."

"I know you're right," Barney said with a nod. "We don't have the problem here because there is no nearby TV transmitter; but boys working on cable installations in a city where there is a powerful transmitter tell me one of their most annoying problems comes from the direct reception of a strong signal by that length of twin-lead interfering with the same signal delivered by the cable. They say you can get some dan-dan-dandy ghosts out of that arrangement. Complete shielding of the front end, as you suggest, would eliminate this."

"One requirement for both cable-connected sets and for those operating off an antenna remains the same," Mac continued. "I refer to the adequate bandwidth requirement. And that brings us squarely up against a serious problem. Cable operation of TV receivers presents those receivers with a problem they were never designed to handle. I refer to the reception of equally strong signals on adjacent channels. In the beginning, the FCC went to great lengths to avoid assigning adjacent channels to TV stations operating in the same area so receivers would not have to contend with this problem; and, in general, they were successful. Only receivers operating in fringe-areas where overlapping signals from equally distant stations had trouble with this particular kind of interference.

"But it is a different story on cable. Here, on many CATV systems, the receiver has to receive a station on one channel while equally strong signals are present on both sides of it. Receivers for use on cable, therefore, should have provision for better adjacent-channel rejection. We both know cable systems try to help this situation by considerably reducing the audio level of a channel below its respective video level, but this is still not enough to prevent interference with many receivers. The i.f. response curves of the receiver must be made to coincide more nearly with the perfect curve shown in the textbooks—and never seen on our scopes. I realize this is not going to be easy to do because greater reduction of adjacent channel signals tends to narrow the bandwidth of the i.f. system; but I am sure our TV design engineers have whipped much tougher problems than this."

"Perhaps the manufacturers can use some of the money they now have to spend on other sections of the receiver—sections that will not be so important in cable reception—on improving this adjacent-channel rejection," Barney suggested.

"That's my thought, too. But it seems to me the most important thing right now is for the CATV people and the TV set manufacturers to get together and work out their mutual problems—and they *are* mutual problems. It certainly will be to the advantage of both that good reception be had off the cable in the future when the majority of sets are going to be working off the cable."

"They can use a little cooperation," Barney offered. "As things stand now, the CATV people are inclined to blame less-than-perfect reception on the receivers, and the service technicians for the dealers blame the cable for poor reception. The poor customer is caught in the middle. Perhaps both factions should remember how the TV transmitter manufacturers and the receiver manufacturers had to work together in the beginning when TV was getting off the ground. If they hadn't, most of us would probably still be gathered around the console radio in the living room instead of the color-TV set." ▲

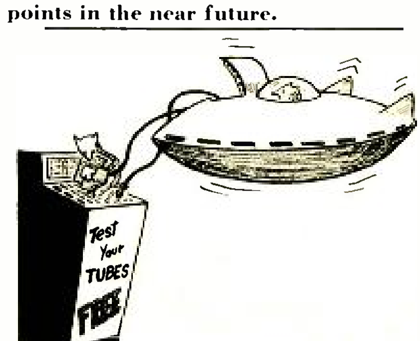
EXECUTIVE "HOT LINE"

A private "Hot Line" for businessmen, between New York City and San Juan, P.R., has been developed by RCA Global Communications, Inc. as part of a major expansion of international communications services tailored to the needs of industry.

The "Hot Line", an international voice/data service, permits a businessman in New York to establish immediate contact with a business associate in San Juan by merely lifting his telephone handset. Dialing or placing calls through switchboards is thus eliminated.

In addition to voice communications, the new service can accommodate various forms of high-speed data communications. Information input/output devices such as computer data terminals, teleprinters, and equipment for transmitting facsimile material can be interconnected to the system by merely pushing a button on the phone.

Plans are underway to extend the "Hot Line" service to other major overseas points in the near future. ▲



Communications System Aids Ohio Police in War on Crime

A BANK of computers in Columbus, Ohio is now helping law enforcement agencies patrol thousands of miles of highways and back roads across the state through a new communications network designed for the Department of Highway Safety-Division State Highway Patrol, by *Western Union*. The 136th station of the 208-station network has been put into operation.

The new network, called LEADS, for Law Enforcement Automated Data System, links police, sheriff, and state highway patrol posts responsible for law enforcement, with two *IBM* 260/40 computer systems at Columbus by over 5700 miles of *Western Union* data channels.

LEADS works this way: An officer on patrol stops a car for speeding. The driver claims he left the car registration at home and is hurrying to work because he is late.

Unconvinced, the patrolman calls his radio dispatcher over his car radio with whatever data he has, such as the stopped car's license plate number and vehicle description, and the driver's license number.

From his office, the dispatcher, using a *WU* Model 33 teleprinter connected by communications line to the computer center, immediately queries the computer for any pertinent data in its memory.

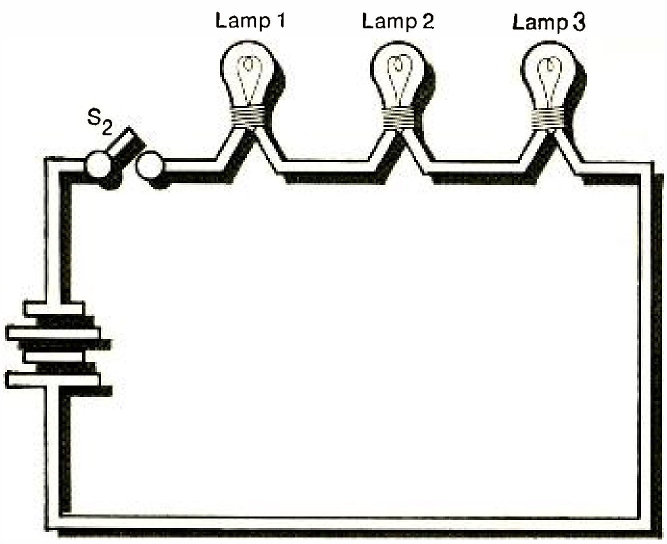
The computer searches its memory and sends back any relevant information it may have. In this case, it might transmit that the car has been reported stolen, and the driver is wanted for some serious violation. Now the officer has substantial grounds on which to make an arrest and hold the suspect.

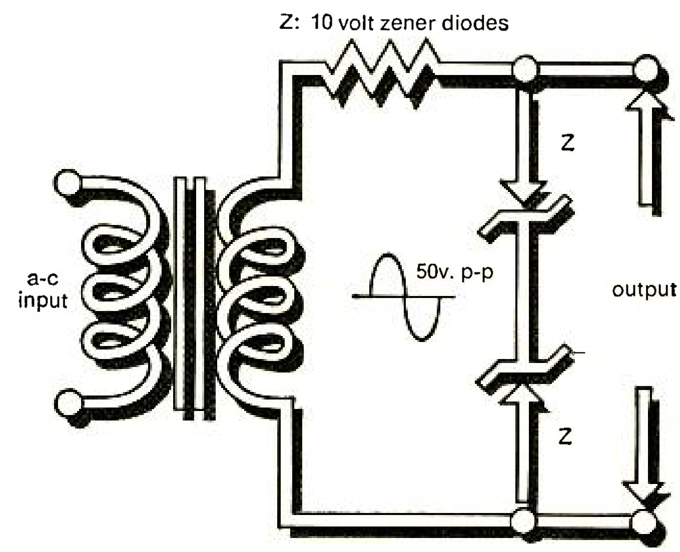
"One of the most important benefits of LEADS to the community is that the police will be able to identify and apprehend individuals wanted for serious offences, such as homicide and grand larceny, simply because they were noticed for traffic violations," said Col. Robert M. Chiaramonte, Superintendent of the Highway Patrol.

LEADS is interconnected with the FBI National Crime Information Center communications network, also designed by *Western Union*, which maintains a huge computer file of law-enforcement intelligence, and with the police information networks in the neighboring states of Kentucky, West Virginia, and Michigan.

The various police units participating in the LEADS network can feed information into the computer files at Columbus as easily as taking it out. Files are updated periodically to keep intelligence timely. ▲

Can you solve these two basic problems in electronics?





This one is relatively simple:

When Switch S_2 is closed, which lamp bulbs light up?

Note: If you had completed only the first lesson of any of the RCA Institutes Home Study programs, you could have solved this problem.

This one's a little more difficult:

What is the output voltage (p–p)?

Note: If you had completed the first lesson in the new courses in Solid State Electronics, you could have easily solved this problem.

These new courses include the latest findings and techniques in this field. *Information you must have if you are to service today's expanding multitude of solid state instruments and devices used in Television, Digital, and Communications Equipment.*

If you had completed an entire RCA Institutes Home Study Course in Semiconductor Electronics, Digital Electronics, or Solid State Electronics, you should now be qualified for a good paying position in the field you choose. Send for complete information. Take that first essential step now by mailing the attached card.

ANSWERS: Problem 1—they all light up
Problem 2—20 Volts (p–p)

Tape-Recorder Flutter

(*Continued from page 37*)

standard; as the standard varies so varies the speed of the transport.

What the Ears Hear

Timbre, which is the overtone pattern of sound, is virtually unaffected by wow and flutter, as the frequencies involved are each changed a like percentage. The amplitude changes in loudness are not usually detected by the ear, and tests have shown that the degree of amplitude changes involved are not particularly annoying even subliminally. As additional research is performed we may learn that timbre and loudness, as affected by wow and flutter, do contribute significantly to listener fatigue. In the meantime, we know that *pitch*, determined by frequency, is certainly changed, and that such change can be annoying to the listener.

Some individuals have the ability to correctly name a particular tone heard and some have the ability to reproduce a specific tone without reference to another. The abilities are sometimes referred to as "absolute pitch" and are not common. One does not have to have absolute pitch to detect a wow. It has been shown that even those individuals who are rather insensitive to pitch are easily able to detect wow and flutter frequency changes and, for this reason, each person is probably the best authority on how much wow is good and how much is bad.

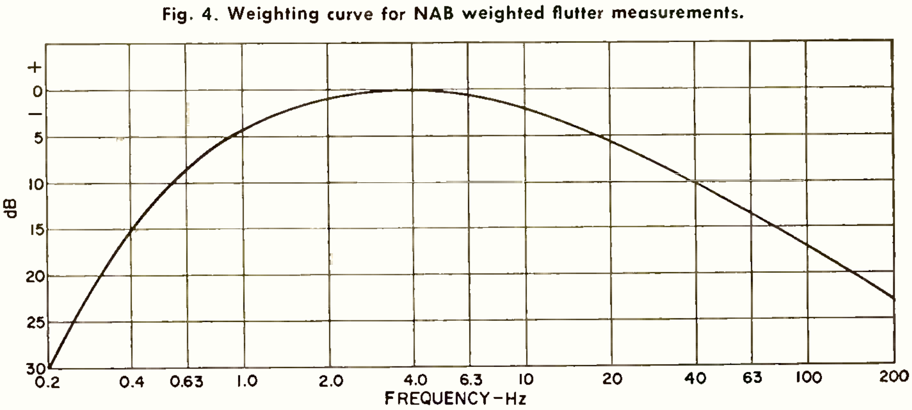
The sound of a particular piece of program material may not be an accurate indication of the performance of a particular machine, as the program material for the home machine usually involves one tape being made from another. This means that the effects of speed changes from one machine will add to or subtract from the effects of another and eventually to or from those of the home machine.

This interaction of one machine upon another will always result in an increase in the peak amount of frequency deviation, and so with multiple serial tape duplication the chances of wow and flutter effects becoming offensive to the ear are increased. For the most part, commercial duplicating work and studio recording are done at fairly high tape speeds, and this tends to place the duplicating wow and flutter components low in the playback spectrum. Duplicate tapes made from other home playback machines or from air transmissions are very likely to result in audible wow and flutter; not because of poor transmission or recording quality, but because of wow and flutter accumulation.

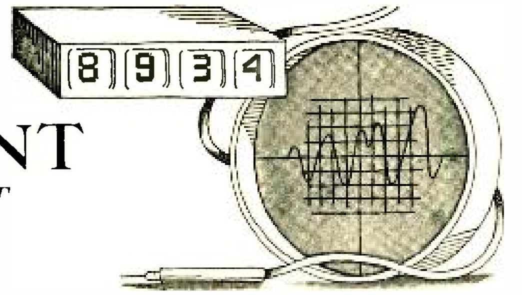
The problems associated with wow and flutter will become more difficult in the near future because of reduced tape speeds, and the increased number of multiple serial duplicate tapes in circulation. No matter how the problems are solved, a wow or flutter now and then may be a small price to pay for the many other benefits to be derived from a magnetic tape recorder. ▲

Editor's Note: Readers of this article will be interested in what the National Association of Broadcasters has to say about the flutter of playback tape machines for broadcast use. According to an NAB Standard, at a recorded frequency of 3000 Hz and a tape speed of 7½ in/s, the r.m.s. flutter should not exceed 0.20%; at 3¾ in/s, it should not exceed 0.25%. Measurements are taken over a frequency range from 0.5 to 200 Hz using an indicating meter with the dynamics of the Standard Volume Indicator and calibrated to read r.m.s. values of a sine wave. These figures are the unweighted *flutter content. The NAB also specifies a* weighted *flutter measurement that is more in line with the sensitivity of the human ear to flutter variations. To make this weighted measurement, a circuit having a response as shown in Fig. 4 is inserted ahead of the above meter. The maximum weighted flutter content is specified as 0.07% for 7½ in/s and 0.10% for 3¾ in/s.*

Fig. 4. Weighting curve for NAB weighted flutter measurements.



TEST EQUIPMENT
PRODUCT REPORT



Heath Model IG-18 Sine/Square-Wave Audio Generator

For copy of manufacturer's brochure, circle No. 25 on Reader Service Card.

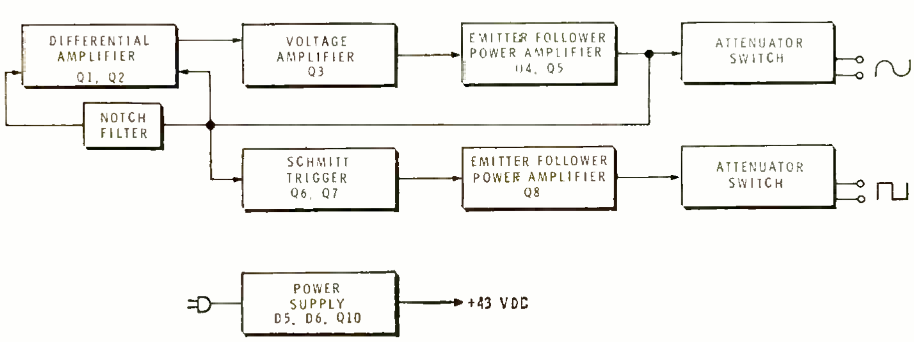
THE new *Heath* Model IG-18 is a low-distortion audio generator that will produce both sine and square-wave output at frequencies far exceeding the normal audio band. Sine waves are available from 1 Hz to 100 kHz at outputs from 0.003 to 10 volts (r.m.s.) and square waves from 5 Hz up to 100 kHz at a level of up to 10 volts (p-p). The generator has been designed for service and testing as well as for laboratory use. With pure sine-wave output, the generator can be used to check the gain and frequency response of audio amplifiers, can serve as a signal source for harmonic-distortion measurements, or as an external modulator for an r.f. signal generator. The square waves provide a fast way of checking response.

The output frequency produced is switch-selectable by means of three front-panel switches. Most audio generators that use this method of frequency selection have the disadvantage of not allowing the user to sweep his generator through a given frequency range (as when you're trying to find the exact frequencies of the two peaks in a bass-reflex speaker enclosure that you're trying to tune, for example). *Heath* solves this problem nicely by adding a vernier control of frequency that permits any setting between those determined by the fixed switch positions.

Separate level controls and output terminals are provided for sine and square waves so that these signals may be used at the same time or independently. A switch-selected 600-ohm internal load is provided for ranges up to 1 volt; for higher outputs the generator should operate into higher-impedance loads (such as 10,000 ohms or more). A front-panel meter is used to monitor the sine-wave output level.

The sine wave is produced by a pair of transistors (Q1 and Q2 in the block diagram) connected as a differential amplifier with an *RC* notch filter inserted in the feedback loop. Component values in the filter are changed by the front-panel controls which adjust output frequency. After voltage and power amplification (Q3, Q4, and Q5), the sine wave is applied to the attenuator switch and metering circuit. Some positive feedback is also taken from the output stage to the oscillator through a lamp that acts to keep the output constant.

The sine waves are also applied to a



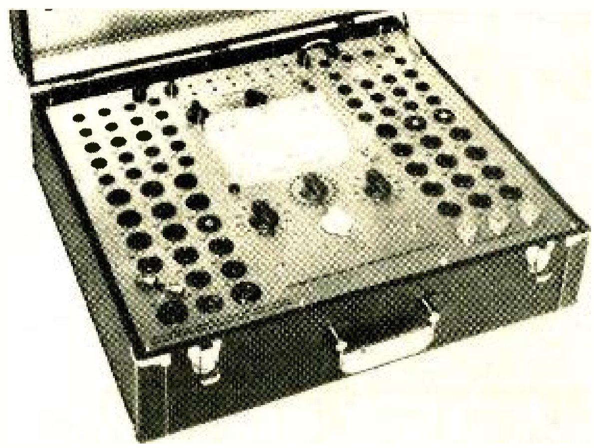
Schmitt trigger (Q6, Q7), which converts them into fast risetime square waves. These square waves are applied to emitter-follower Q8 and then to the output attenuator switch. The power supply, which can be wired to operate from either the 120-V or 240-V a.c. line, uses a pair of diodes for rectification along with a series transistor (Q10) and a zener to regulate the 43-volt output.

After we finished constructing the kit, we were curious to find out just how low in distortion our sine-wave output was. After all, if the generator is to be used for harmonic-distortion measurements, it should not itself introduce an undue amount of distortion. *Heath* rates the distortion as less than 0.1% from 10 Hz to 20 kHz. We checked the distortion at 1000 Hz and found only 0.05% distortion at 1-V output and 0.06% distortion at 2-V output. At 50 Hz, distortion measured 0.045% and 0.05%, respectively, at these two outputs, and at 10 kHz, we measured 0.07% and 0.08% at 1 V and 2 V. Hence, the generator meets its distortion spec nicely.

The *Heath* IG-18 measures about 13 by 5 by 7 inches deep and is priced at $67.50 in kit form. ▲

Sylvania CB2400 Tube Tester/Color-Bar Generator

For copy of manufacturer's brochure, circle No. 26 on Reader Service Card.



HERE'S a unique combination test instrument for the TV service technician. When the unit is closed, it looks like an attractive attaché case. When the cover is opened, it looks like a tube tester but with the roll chart built into the cover of the case. But if you look a little closer you see that at the top center of the tester are the controls for a color-bar generator.

The color-bar generator circuitry is completely independent of the tube checker except that it does derive its power from the instrument's power transformer. This transformer, incidentally, is not a conventional power transformer but is a regulator type whose output voltages are kept to within 1 percent at all times. Hence, both tube-tester meter indications and color-bar patterns are highly stable. What's more, the transformer is self-limiting so that a line fuse is not needed for protection.

The color generator uses conventional bipolar and unijunction transistors in the countdown chain for good stability. Crystal control of the master oscillator is used. The generator produces six patterns for color-set adjustment. These are a clear raster, conventional color bars, ten vertical lines, thirteen horizontal lines, dots, and crosshatch. Color-killer switches are included along with a control for adjusting the thickness of the vertical lines.

The tube-testing function is very simple. Instead of using a lot of setup switches and controls, the instrument uses a large number of differently wired sockets. There are no less than 73 such sockets to accommodate just about all tube types. Three tests are performed on the tube being checked. These are what the manufacturer calls "dynamic cathode power output," shorts and leakage, and test for gas. This first test is actually a type of a.c. emission test.

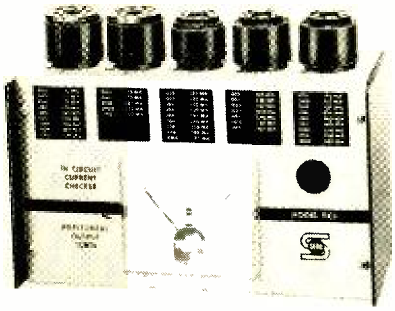
In addition to these, the instrument can also be used as a continuity tester as well as an auto-vibrator tester.

The combination instrument weighs 27 lbs, measures 20¼ by 18½ by 8¼ inches, and comes in a portable, heavy-duty solid-wall case covered with non-scuff plasticized cloth. The *Sylvania* CB2400 is priced at $299.95. ▲

Seco Model HC-8 In-Circuit Current Checker

For copy of manufacturer's brochure, circle No. 27 on Reader Service Card.

THIS is another unusual piece of test equipment for the TV service technician. The manufacturer of the *Seco* Model HC-8 feels that resonating or

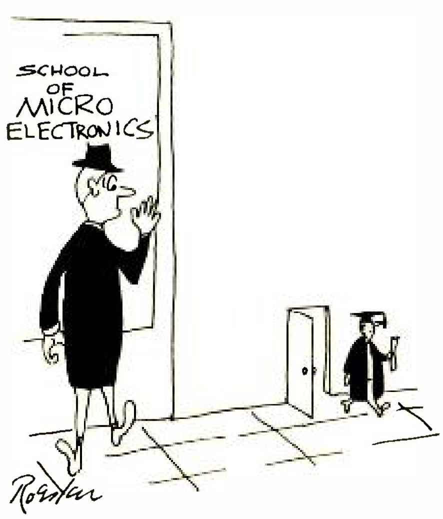


tuning the horizontal tank circuit of the horizontal-output stage in a TV set is just as important as tuning an i.f. transformer or adjusting the final of a transmitter. So they have recently come out with a special instrument that allows you to conveniently measure the cathode current of the horizontal-output tube in a color or black-and-white TV set.

The technician simply inserts the appropriate adapter into the output-tube socket, inserts the tube into the adapter socket, and reads the cathode current on the front-panel milliammeter. The horizontal drive and linearity coil are adjusted for close to minimum cathode current in a black-and-white set and the linearity or efficiency coil is adjusted for minimum cathode current in a color-TV set. Before attempting to converge a color set, it's a good idea to make sure that the cathode current is "dipped" to insure maximum operating efficiency of the output stage.

Five adapters are supplied with the checker in order to accommodate just about any horizontal-output tube. Printed below each adapter is a listing of the tubes with which the adapter is to be used, along with the maximum cathode currents for these tubes. Currents range from a low of 75 mA for tubes such as the 6BQ6 to 260 mA for the 6KN6. The milliammeter on the checker has a range of up to 300 mA.

The *Seco* Model HC-8 sells for $34.50. ▲



Negative-Resistance Devices

(*Continued from page 40*)

in oscillators, timing circuits, pulse and sawtooth generators, and special triggering applications. The unijunction equivalent circuit can be considered to be a resistive *n*-type silicon bar with a *p-n* junction formed between the terminals, as shown in Fig. 5A. The end terminals of the bar are referred to as *bases* while the anode of the *p-n* junction is called the *emitter*. The resistance between the two bases is known as the *interbase resistance*. The geometry of the first unijunctions consisted of the bar structure although newer UJT's include cube, planar, and *p*-base complementary structures.

In operation, the interbase resistors form a voltage divider with the voltage applied between base terminals. When the voltage at the emitter forward-biases the *p-n* junction, the unijunction enters the negative-resistance region. Forward V-I characteristics for the unijunction, showing the negative-resistance region, are illustrated in Fig. 5B.

The unijunction transistor can be considered to be a four-layer diode with the addition of biasing resistors as shown in Fig. 5C. The biasing resistors replace the interbase resistors of the unijunction and are used to set the breakover point. However, in unijunction terminology, this voltage is known as the *peak-point voltage*. Also, the minimum holding current is referred to as the *valley current* (I_V) for the unijunction.

For commercially available UJT's, the ratio of interbase resistors setting the peak-point voltage is determined by the semiconductor manufacturer. Using the transistor-resistor equivalent circuit in Fig. 5C, the peak-point voltage may be selected by choosing the appropriate resistive dividers, *R*1 and *R*2.

A relaxation oscillator is one of the most common applications for the UJT. The basic configuration appears in Fig. 6A. A positive pulse appears at base 1, a negative pulse at base 2, and a sawtooth waveform at the emitter. The frequency of oscillation is controlled by the *R*1*C*1 time constant; *R*2 is selected for minimum frequency change over a given temperature range, and *R*3 limits the capacitor discharge current.

The basic operation of the relaxation oscillator is as follows: When "B+" is applied, all of this voltage immediately appears across the timing resistor, *R*1. The voltage across *C*1 then increases at a rate determined by the time constant *R*1*C*1 as *C*1 begins to charge toward the applied voltage. When the voltage across the capacitor increases to the emitter firing voltage, the emitter-base 1 junction becomes forward-biased and the UJT enters the negative-resistance region. *C*1 then discharges through *R*3 and the emitter of the unijunction; this continues until the voltage across *C*1 falls sufficiently and causes the UJT to turn off. When the UJT turns off, the applied voltage minus the turn-off voltage appears across *R*1. The capacitor begins to charge again and the cycle is repeated. Positive and negative output pulses are produced, as shown on the diagram, as a result of the pulse of current flow through the UJT. During firing, negative resistance occurs between the emitter and base 1 due to carriers injected across the junction. This mechanism is known as conductivity modulation of the bulk silicon.

The configuration of the equivalent-circuit relaxation oscillator and its similarity to the UJT oscillator are shown in Fig. 6B. The operation is similar to the unijunction oscillator except that the capacitor is discharged through the low impedance, resulting from the four-layer action of *Q*1 and *Q*2 when firing occurs. Component values in Fig. 6B are for an oscillator with a frequency of approximately 1 kHz.

The firing point for this circuit is:

$$\frac{(R3 + R4)\ (B+)}{R2 + R3 + R4} + V_{BE}$$

or approximately $5.5 + 0.6 = 6.1$ volts. A positive pulse can be obtained by dividing *R*2 into two separate resistors and taking the output between them.

In summary then, we have shown that it is possible to simulate the characteristics of four-layer diodes, SCR's, and UJT's by simply wiring together a pair of transistors and some resistors. ▲

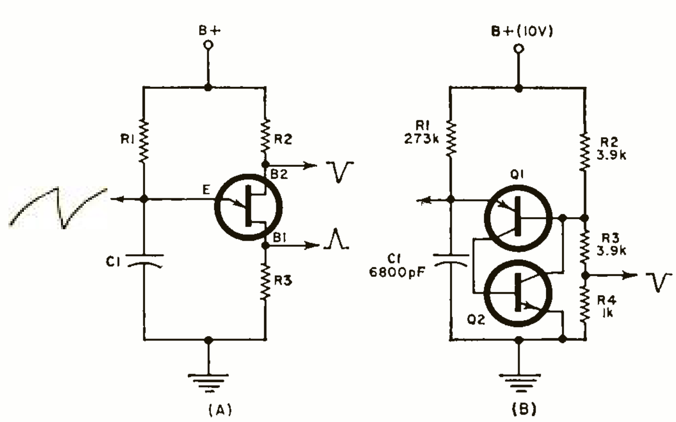


Fig. 6. (A) UJT oscillator. (B) Equivalent-circuit version.

Electronic Loadbank

(*Continued from page 45*)

the mechanical considerations for housing the load were equally important.

In the mechanical design (Fig. 5), emphasis was placed on the load's ability to dissipate approximately 1500 watts in the pass-transistor section, while keeping the control circuitry at or near ambient temperature.

These requirements meant the loadbank had to be made in two main sections: one section to house the pass-transistor group and the cooling fans; and the other section to contain the control circuitry, programming, and readout devices.

The pass-transistor group (A) consists of 21 transistors and three drivers, mounted on 24 individual heatsinks. The heatsinks are linked mechanically and electrically in two groups of 12 by tie bars.

Two temperature-controlled, high-velocity fans (B) blow a maximum of 500 cubic feet per minute across the loadbank for cooling. Air is drawn in through a grille on the front panel over the heat sinks and forced out by the fans at the rear.

A sheet-metal cover (C) encloses the pass-transistor section. This provides a "tunnel" effect to make the cooling more efficient and thermally isolate the pass-transistor group from the control circuitry.

Located in the rear corner of the right section is the main bias power supply (D), capable of 12 volts at 6 amps. The control circuitry (E) is mounted on plug-in PC cards in front of the bias supply.

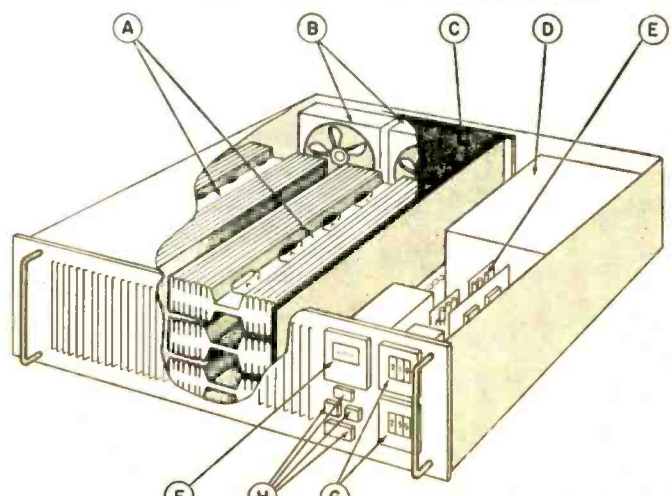
The ammeter (F) on the front panel has a projected moving scale with an effective scale length of 8 inches. The scale resolution is one amp and accuracy is one percent.

Programming controls (G) and the control switches (H) are also located on the front panel. In the case of the programming controls, each digital control is numbered from one to nine to accommodate dialing the desired load current. The rectangular button at the base of the loadbank's front panel is for changing the load from high to low current or *vice versa*. The remote programming feature allows an infinite number of load setups to be programmed and changed with the flip of a switch.

The entire loadbank is 7 inches high by 23 inches deep and can be mounted in a standard 19-inch rack.

Because of its size, current regulation, and programmability, this loadbank should be of wide interest to engineers who design power supplies, testing organizations who perform quality and production tests, as well as maintenance technicians. ▲

Fig. 5. Component layout of electronic loadbank. See text.



COMMERCIAL TV HELPS NBS' STANDARDS BROADCASTS

UPGRADING the accuracy and precision of its time and frequency broadcasts is a continuing preoccupation of the men at the National Bureau of Standards. Their latest improvement involves ideas borrowed from commercial television in Denver and from Czechoslovakian know-how.

Television broadcasts from Denver TV stations are now a key element in a chain of controls for precision and accuracy of the nation's time and frequency broadcasts. With this new system, the clock that controls the broadcasts from station WWV in Fort Collins, Colo. may be kept within a millionth of a second (1 μs) of the atomic clock in Boulder.

With this new technique, a TV synchronizing pulse on the TV carrier wave is used. The system was adapted from a Czech experiment and put into operation by John Milton of the Bureau's Frequency and Time Broadcast Services Section in Boulder, which operates four NBS radio stations.

The system works this way. A commercial table-model TV set is operated at the NBS atomic clock end in Boulder and another at the NBS broadcast station end in Fort Collins. Both TV sets are tuned to the same Denver TV channel so that both receive the same program.

Both TV sets are connected to sensitive electronic equipment which records the arrival of periodic pulses on the carrier wave. The sync pulses are a known distance apart and are easily identified by electronic devices which "tag" them as they arrive at the location of each recording device. In the present case, the distance from crest to crest of succeeding pulses is about 11.8 miles.

The equipment records the time of arrival of these pulses at the atomic clock in Boulder and at the radio stations in Fort Collins. The time delay between the TV transmitter near Denver and the Boulder and Fort Collins receivers is accurately known to a tenth of a microsecond. From this information, NBS scientists calculate the time difference between two clocks — the atomic clock in Boulder and the one at Fort Collins which controls the radio broadcasts. Once the difference is known, even if it is only a few microseconds, corrections may be made to synchronize the two clocks.

The absolute accuracy of the measurement is conservatively set at $\pm 1\ \mu s$, but the day-to-day precision often approaches $\pm 0.1\ \mu s$. ▲

GM Research Labs New Sponsor of REACT

With emphasis on reporting of road disasters, volunteer CB service group changes backers.

NATIONAL sponsorship of REACT, the 40,000-member national association of Citizens Band radio operators who provide emergency communications to their local communities, was taken over March 15th by the *General Motors Research Laboratories*, according to the joint announcement from Arthur F. Underwood of *GM* and Henry B. Kreer, National Director of REACT.

The organization was set up in 1963 by *Hallicrafters* and has been nationally sponsored by the firm. Under *Hallicrafters'* aegis, REACT grew to more than 1300 teams throughout the U.S. With more than 70% of the teams' communications related to highway safety problems, it was felt that continued growth and development of the organization could best be achieved through sponsorship by a member of the auto industry.

Individual members are public-spirited citizens who operate CB equipment in their cars as well as in their homes, offices, or places of business. Through a 24-hour-per-day monitor system, REACT members are able to report *via* radio a wide variety of local emergencies such as automobile accidents, fires, and suspicious actions to a central station. The central monitor post then relays the information to the proper authority, such as the police department, highway department, hospital, or service station.

Many of the teams are highly organized, some with membership as high as 200. Such teams also perform organized communications services during parades, conventions, and civic affairs, and for major emergencies such as searches for missing persons, floods, and tornadoes. No charge is made for such services, and members serve on an entirely voluntary basis.

Over 35% of REACT teams are officially affiliated with Civil Defense, police, or fire authorities in their communities.

Under the new sponsorship, the network of emergency teams will be expanded and strengthened.

According to Mr. Underwood, "Because of our concern for an involvement in the development of promising systems for increasing highway safety, our research group has watched with great interest the fine experiment in public service that has been conducted by this outstanding group of citizens. It is obvious that the rapidly increasing availability of CB radios in the U.S. offers a tremendous potential for improving safety and saving lives on the highway. *GM's* objective is to support and encourage, on an organized basis, this very promising technique for utilizing such resources in the public interest."

REACT headquarters estimate that in 1968, their teams alone will have reported to authorities over 1,200,000 automotive emergencies, 27% of which were accidents.

National Headquarters has been moved to new offices at 205 West Wacker Drive, Chicago, Illinois 60606. ▲

Vitally interested in the new GM sponsorship of REACT and plans for its expansion are, left to right, Edward Weller and Richard Thompson of GMRL, H.B. Kreer of REACT.

EW Lab Tests Cassettes

(*Continued from page 27*)

able speakers form a cover for the deck. A covered compartment on the deck conceals the input and output connectors, all the cables, and the stereo microphone with its small tripod stand. The transport appears to be identical to that of the *Norelco* although we measured some differences in performance which may have reflected normal production tolerances. Its speakers appear to be about the same size as those of the *Norelco* (5" to 6" diameter) and sounded fairly similar to us. The power rating of 20 watts for the *Ampex* seems a trifle optimistic, since we measured 4.5 watts (continuous power per channel) at the clipping level. Presumably the 20-watt figure is combined peak music-power output. At any rate, it played loud and sounded as good as could be expected from such speakers. Like the *Norelco*, its amplifiers always included the equalization, so were of limited usefulness for playing any other external program source.

Most of the connectors on the *Ampex* were European DIN types. The instructions were lacking in specifics as to how the machine could be connected to an external tuner and amplifier. The inclusion of two cables, for input and output connections, which appeared to be identical but actually were not, added to the confusion.

The *Ampex* and *Norelco* machines sounded pleasant when played through their own speakers. However, it was most revealing, when they were connected to a good external system, to find a couple of octaves of bass on many cassettes which gave no hint of their presence through the small speakers. As with reel-to-reel recorders of any price, the speakers with these small cassette machines are not nearly good enough to reveal the true performance potential of the cassettes.

Although these four machines appear to be competitive, albeit with some differences in performance, one must look deeper. The *Norelco* and *Ampex* machines are complete systems, and seem to be directed toward a less critical market, where they would be used for casual recording or listening. The *Sony* TC-125, on the other hand, must be used with an external amplifier and speakers, and will give sonic results commensurate with the quality of the external components. It has the virtue of extreme simplicity and a really foolproof design, without compromise in performance. The *Harman-Kardon* CAD-4 is the best of the group in performance, although it requires a bit more attention from the user. It, not surprisingly, is also the most expensive (considered as a deck only).

All of them sound good. Given the proper program and listening conditions, they are "hi-fi", even though their frequency response, distortion, and flutter do not yet match reel-to-reel recorders operating at 7½ in/s. One must not forget that these cassette machines operate at 1⅞ in/s, and very few comparably priced recorders at 3¾ in/s can match them in performance. ▲

How to get into

One of the hottest money-making fields in electronics today—servicing two-way radios!

HE'S FLYING HIGH. Before he got his CIE training and FCC License, Ed Dulaney's only professional skill was as a commercial pilot engaged in crop dusting. Today he has his own two-way radio company, with seven full-time employees. "I am much better off financially, and really enjoy my work," he says. Read here how you can break into this profitable field.

More than 5 million two-way transmitters have skyrocketed the demand for service men and field, system, and R&D engineers. Topnotch licensed experts can earn $12,000 a year or more. You can be your own boss, build your own company. And you don't need a college education to break in.

How would you like to start collecting your share of the big money being made in electronics today? To start earning $5 to $7 an hour... $200 to $300 a week... $10,000 to $15,000 a year?

Your best bet today, especially if you don't have a college education, is probably in the field of two-way radio.

Two-way radio is booming. Today there are more than *five million* two-way transmitters for police cars, fire department vehicles, taxis, trucks, boats, planes, etc. and Citizen's Band uses—and the number is still growing at the rate of 80,000 new transmitters per month.

This wildfire boom presents a solid gold opportunity for trained two-way radio service experts. Many of them are earning $5,000 to $10,000 a year *more* than the average radio-TV repair man.

Why You'll Earn Top Pay

One reason is that the United States Government doesn't permit anyone to service two-way radio systems unless he is *licensed* by the Federal Communications Commission. And there simply aren't enough licensed electronics experts to go around.

Another reason two-way radio men earn so much more than radio-TV service men is that they are needed more often and more desperately. A home radio or television set may need repair only once every year or two, and there's no real emergency when it does. But a two-way radio user must keep those transmitters operating at all times, and *must* have their frequency modulation and plate power input checked at regular intervals by licensed personnel to meet FCC requirements.

This means that the available licensed experts can "write their own ticket" when it comes to earnings. Some work by the hour and usually charge at least $5.00 per hour, $7.50 on evenings and Sundays, plus travel expenses. A more common arrangement is to be paid a monthly retainer fee by each customer. Although rates vary widely, this fixed charge might be $20 a month for the base station and $7.50 for each mobile station. A survey showed that one man can easily maintain at least 100 stations, averaging 15 base stations and 85 mobiles. This would add up to at least $12,000 a year.

Be Your Own Boss

There are other advantages too. You can become your own boss—work entirely by yourself or gradually build your own fully staffed service company. Instead of being chained to a workbench, machine, or desk all day, you'll move around, see lots of action, rub shoulders with important police and fire officials and business executives who depend on two-way radio for their daily operations. You may even be tapped for a big job working for one of the two-way radio manufacturers in field service, factory quality control, or laboratory research and development.

How To Get Started

How do you break into the ranks of the big-money earners in two-way radio? This is probably the best way:

1. Without quitting your present job, learn enough about electronics fundamentals to pass the Government FCC Exam and get your Commercial FCC License.
2. Then get a job in a two-way radio service shop and "learn the ropes" of the business.
3. As soon as you've earned a reputation as an expert, there are several ways you can go. You can move *out* and start signing up and servicing your own customers. You might become a franchised service representative of a big manufacturer and then start getting into two-way radio sales, where one sales contract might net you $5,000. Or you may even be invited to move *up* into a high-prestige salaried job with one of the major manufacturers either in the plant or out in the field.

The first step—mastering the fundamentals of Electronics in your spare time and getting your FCC License—can be easier than you think.

Cleveland Institute of Electronics has been successfully teaching electronics by mail for over thirty years. Right at home, in your spare time, you learn electronics step by step. Our AUTO-PROGRAMMED® lessons and coaching by expert instructors make everything clear and easy, even for men who thought they were "poor learners." You'll learn not only the fundamentals that apply to all electronics design and servicing, but also the specific procedures for installing, troubleshooting, and maintaining two-way mobile equipment.

Get Your FCC License . . . or Your Money Back!

By the time you've finished your CIE course, you'll be able to pass the FCC License Exam with ease. Better than nine out of ten CIE-trained men pass the FCC Exam the first time they try, even though two out of three non-CIE men fail. This startling record of achievement makes possible the famous CIE warranty: you'll pass the FCC Exam upon completion of your course or your tuition will be refunded in full.

Ed Dulaney is an outstanding example of the success possible through CIE training. Before he studied with CIE, Dulaney was a crop duster. Today he owns the Dulaney Communications Service, with seven people working for him repairing and manufacturing two-way equipment. Says Dulaney: "I found the CIE training thorough and the lessons easy to understand. No question about it—the CIE course was the best investment I ever made."

Find out more about how to get ahead in all fields of electronics, including two-way radio. Mail the bound-in postpaid reply card for two FREE books, "How To Get A Commercial FCC License" and "How To Succeed In Electronics." If card has been removed, just mail the coupon below.

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.

Home MATV System

(*Continued from page 43*)

coaxial cable is that it must be terminated properly. It is important that coaxial connectors be installed correctly with no loose strands causing shorts. Fig. 5 shows the proper method for connecting the common "F"-type connector.

You can run coax cable anywhere without problems, but there are two important precautions:

1. Don't bend coax sharply. Keep the bending radius greater than six inches. A sharp bend collapses the coax dielectric, bringing the shield too close to the center conductor and ruining impedance match.

2. Don't crush coax. This also upsets the impedance match.

Coaxial cable can be taped to the mast and stapled directly to the side of the house. A gun that fires rounded crown staples is ideal for this purpose.

Coaxial cable can be taken into the house in the same ways as twinlead. Be sure to leave a drip loop and to caulk the entry hole.

Installers often put the active or passive coupler in the basement. In this case, they take the antenna downlead into the basement, through a wall or window, and send the outputs of the coupler up behind the television sets through holes in the floor.

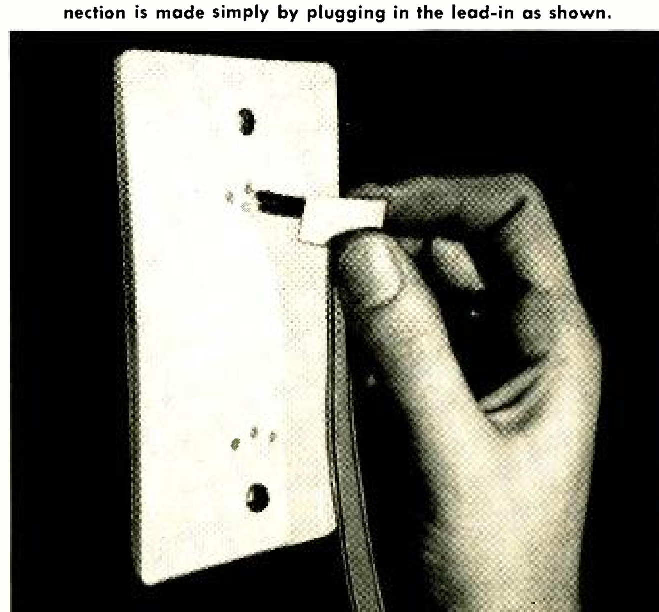
In other homes, it is more convenient to mount the coupler in the attic. Most attics have louvers through which you can run the lead without drilling.

Once you have the signal inside the attic you have to figure out how to get it to the TV sets. You may find it easiest to run the downleads outdoors. Often, you can drill down into closets. It's easy to run the lead-in wire down through heating or air-conditioning ducts or next to pipes or a.c. wires, but this cannot be done with twinlead without affecting the performance somewhat.

It's a good idea to coil up about three feet of coax and fasten it loosely behind the TV set. This makes it easy for the lady of the house to move the set when she wants to clean. You should not coil twinlead behind the set, but you should leave as much slack as possible.

For more professional systems, some installers prefer to use wallplates into which a TV or FM set can be plugged at the convenience of the householder. A typical wallplate is shown in Fig. 6. ▲

Fig. 6. By using a wallplate such as this, unsightly loose lead-in wire can be avoided. The TV receiver's antenna connection is made simply by plugging in the lead-in as shown.



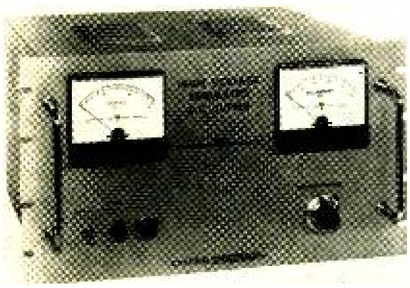
NEW PRODUCTS & LITERATURE

Additional information on the items covered in this section is available from the manufacturers. Each item is identified by a code number. To obtain further details, fill in coupon on the Reader Service Card.

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

LAB POWER SUPPLIES

Del Electronics Corp., 250 E. Sandford Blvd., Mount Vernon, New York 10550 has announced a new series of high-voltage laboratory power supplies, the LHRM series. Available in adjustable



outputs from 1200 volts, models are available for various output currents up to 50,000 volts.

The rack-mountable units feature full voltage control to a 0.01% resolution, by means of a 10-turn pot, with 0.03% line and load regulation. Fully metered, they are essential in laboratory development and testing of high-voltage equipment such as high-resolution CRT displays.

Circle No. 126 on Reader Service Card

TV TUBE BRIGHTENER

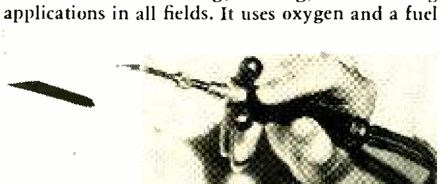
A new TV tube brightener for use with the miniature base (7G4) tubes used in personal portable TV sets is now available. The Model C-414 "Vu-Brite" can be used to brighten faded pictures on series-wired TV sets with 4.5- and 6.3-volt picture tubes. Applicable tube numbers include 114P4, 12BFP4, 12BMP4, 12CDP4, 12CFP4, 12CMP4, 12CNP4, 16CFP4, 16CQP4, etc.

The unit is designed to be used on a.c.-operated sets. It cannot be used on battery-operated sets with 12-volt tubes. Perma-Power

Circle No. 1 on Reader Service Card

MINIATURE WELDING TORCH

A tiny torch which welds metals smaller than 0.002" wire and up to 16 gauge steel has been introduced as the "Little Torch." The unit can be used for heat bonding, welding, and soldering applications in all fields. It uses oxygen and a fuel



gas (acetylene, hydrogen, LP-gas, or natural gas) to produce flame temperature at 6300° F. It operates at pressures of 2 to 4 psi, and uses gas at a rate of 0.023 to 2.54 cfh.

The torch comes with five different sized tips which swivel 360° for complete handling ease. The two smallest tips (#1, #2) have sapphire jeweled orifices for extra durability and precision performance. These jeweled orifices prevent oxide contamination in the joint. Tescom

Circle No. 2 on Reader Service Card

ALL-CHANNEL TV ANTENNAS

A new series of television antennas which the company claims provide improved color and black-and-white reception on all TV channels has been released.

The new "VUfinder Plus" antennas feature an improved electronic design. An optional extra "Power Zoom" u.h.f. element can be used to increase gain an average of 35% on difficult channels.

The five models in the series, available for direct 300-ohm installation and instantly convertible to 75-ohm operation by means of snap-on transformers, are for use in areas classified from "local" to "deep fringe" in signal strength. The antennas are compact, lightweight, and come completely factory preassembled. Jerrold

Circle No. 3 on Reader Service Card

RESISTANCE DECADE UNIT

A resistance decade with high-power dissipation capabilities has been developed by the Advanced Engineering Department of Dale Electronics, Inc., Box 609, Columbus, Nebraska 68601.

According to the company, the new unit is believed to be the only one commercially available with the capability of dissipating 50 watts continuous power and up to 100 watts intermittent

power. When used at lower power levels it can perform with a high degree of accuracy.

Three units with four decades each are provided in the following ranges: 1 ohm to 9999 ohms, 10 ohms to 99,990 ohms, and 100 ohms to 999,900 ohms. Resistance accuracy is ±1% and dielectric strength is 2000 volts.

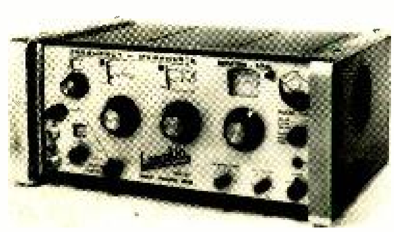
Circle No. 127 on Reader Service Card

DIGITAL FREQUENCY METER

The Type 107 digital frequency meter has been specially designed for mobile-radio servicing. It is both a frequency meter and a signal generator. It has universal frequency coverage, is all solid-state, and has a dual power supply—either 12 volts d.c. or 115 volts a.c. at option. The accuracy is ample for the newest 0.00025% transmitter tolerances.

The DFM is unique in that the generated frequency can be varied in calibrated amounts about center frequency, up to ±50 parts per million. Resettability is better than 0.2 part per million.

The frequency can be set, directly on digital dials, to five significant figures (7 above 100 MHz). The frequency range is from below 10



kHz to above 500 MHz, continuous without bands or gaps.

The instrument measures 7⅜" high x 17⅜" wide x 11" deep. Without the carrying handles, it is 6 15/16" high to fit in standard relay racks. It weighs 22.3 pounds. Lampkin

Circle No. 4 on Reader Service Card

HAND-HELD TRANSCEIVER

A 23-channel, hand-held CB transceiver has recently been introduced as the "Clipper 23." The completely portable unit has full 5-watt power with an effective inland range of 10 miles, depending on the terrain. Over-water operation increases the range substantially.

The all solid-state unit weighs less than 5 pounds but provides good voice reproduction through a 2¾" PM dynamic speaker. All crystals are included for transmission and reception on all 23 CB channels. The circuit includes a variable squelch, built-in range expander, and automatic noise limiter. It features a full complement of jacks for p.a. systems, external earphone/speaker, antenna, microphone, and power connection.

Available accessories include a solid-state, transformer-regulated a.c. power supply/recharger which makes it possible to use the unit as a base station; a cigarette-lighter adapter cord for operation from a 12-V auto lighter; an external power pack for "D" cells; and an external antenna adapter. Courier

Circle No. 5 on Reader Service Card

CONTROLLED-IMPEDANCE SPEAKER

The Model S-20 is a controlled-impedance speaker system which has been specifically designed for use with solid-state components.

The system's unique Mediterranean styling features an antiqued pecan finish with ornate scrollwork grille. A Flamenco red grille cloth is supplied with the speaker but other colors may be substituted by the user.

The system consists of a 10" woofer and a 5" dual-cone midrange/tweeter in a 22¾" x 11¾" x 11" enclosure. H.H. Scott

Circle No. 6 on Reader Service Card

EMI/EMC FILTERS

A new FSR-X series of EMI/EMC "Powerline" filters is now available for 5, 10, and 15 ampere applications as well as 25 to 200 amperes. Designed for use in secure communications areas and shielded rooms, the new filters provide 100 dB attenuation as follows: 14 kHz to 10 GHz measured in accordance with MIL-STD-220A; full-load condition from 14 kHz to 20 MHz with extended-range buffer networks.

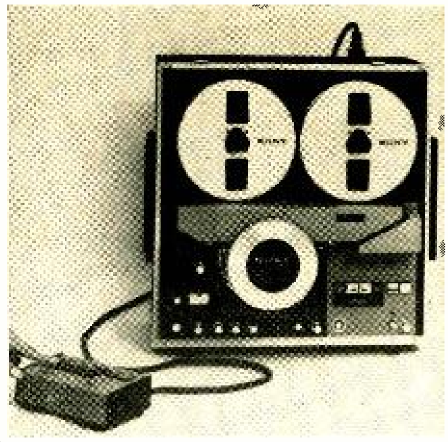
Forty-eight different standard models are available. Standard filters are rated for 0-60 Hz powerline frequencies; filters for 400-Hz power can be supplied on special order. Complete specs on this new series will be forwarded on request. Filtron

Circle No. 7 on Reader Service Card

VIDEO TAPE RECORDER

A compact, portable one-inch-format video tape recorder which is especially suited to applications in education, training, and CATV distribution is available as the Model EV-310 "Videocorder."

The unit uses one-inch video tape and records any composite TV signal with a 60-field frequency, including random-interlace signals. Video recording is accomplished through a rotary, two-head scan system. Recording time is 60 minutes on a 2400-ft reel of tape. Tapes are inter-



changeable among the firm's EV-310, EV-210, and EV-200 series Videocorders.

Standard features of the EV-310 are two-channel audio, editing and slow motion, and stop action in the playback mode. The playback picture is continuously variable from still frame to one-fifth of normal speed. Audio may be dubbed on channel 2 after video has been recorded. Automatic shut-off occurs when the tape reaches the end of the reel.

Prices and full specifications on the Model EV-310 are available on request. Sony Corporation

Circle No. 8 on Reader Service Card

BLUE LATERAL/PURITY ASSEMBLY

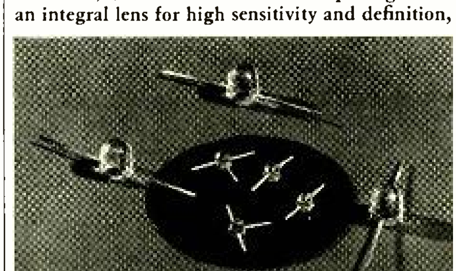
A new single-unit, blue lateral and purity assembly, which is a replacement for similar assemblies on any size American rectangular color picture tube, has been introduced as the #7604. The assembly registers blue, red, and green beams simultaneously within 0.06". A single wheel rotates two magnetic rings in opposite directions to provide blue beam lateral convergence.

Purity correction is accomplished by individual adjustment of the two purity rings. The magnets compensate for misregistration up to 0.005" in any direction. J.W. Miller

Circle No. 9 on Reader Service Card

PLASTIC PHOTOTRANSISTORS

A series of low-cost phototransistors in molded plastic packages are the newest items in the company's line of optoelectronics. One, the MRD450, is in a two-lead "Mini-T" package with an integral lens for high sensitivity and definition,



while the others, MRD100 and MRD150, are in subminiature "Micro-T" packages for applications that require high-density mounting.

The new devices are the only available plastic phototransistors with homogeneous molded cases. The clear plastic is molded under pressure to form a solid, single-piece package of high uniformity, repeatability, and stability.

Among the applications for these inexpensive components are in automobiles to sense various conditions of the road and car, in home security alarms and automatic lighting controls, and in automatic electric, water, and gas meter reading. Motorola Semiconductor

Circle No. 10 on Reader Service Card

HORN TWEETER

The high-power tweeter, Model 1000-12, has been specifically designed for musical-instrument applications. In addition to supplementing high-frequency response, the horn features a ruggedized high-power construction to insure reliability at power levels many times higher than conventional units. The 30-watt r.m.s. continuous rating will normally permit safe operation with amplifiers up to 100 watts, with the recommended network.

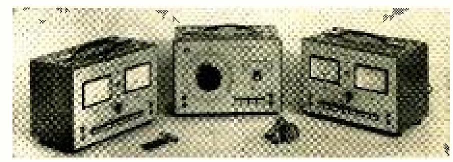
Frequency response is 700-13,000 Hz, impedance is 8 ohms, and the unit measures 8⅞" over-all depth x 3½" x 8" mouth. It is supplied in two-tone gray or as specified. Cleveland Electronics

Circle No. 11 on Reader Service Card

AUDIO FLUTTER METERS

Three solid-state units, two of which are flutter meters and the third a precision wave analyzer, are now available in the U.S. Made by Woelke of West Germany, both flutter meters feature separate instruments for the indication of drift, which is the deviation from correct speed, and flutter content in ±%. Both instruments have self-contained 3150-Hz oscillators which permit recording of the test signal as well as calibration of the metering section.

Both weighted and unweighted measurements can be made and both meters feature a unique



input circuit which allows use of any input level above 30 mV without the necessity for level adjustment. A relay in the ME-102b also provides switching between 3000 and 3150 Hz to accommodate both international and U.S. frequency standards. Flutter between 1 Hz and 315 Hz is metered.

The companion ME-301 wave analyzer provides precision continuous tuning between 1 and 330 Hz, making possible exact diagnosis of the source of flutter. Filter steepness of more than 40 dB/octave, a self-contained amplifier for loss-free operation, and a means for self calibration are also features of this unit. Gotham Audio

Circle No. 12 on Reader Service Card

MOBILE ANTENNAS

Two new high-performance mobile antennas, "Racer 4" and "Racer 6," are now available. Each model has a stainless steel tip incorporating a tuning device. Tuning is accomplished by simple adjustment of the tip length for minimum s.w.r. The tip is then locked into place for maximum radiated power.

The Racer 4 has a 48" shaft and Racer 6 a 72" shaft of rugged fiber glass that is impervious to moisture and corrosion and has extremely high impact resistance. The shafts are white with a printed checkered flag pattern at the base. The chrome-plated threaded brass ferrule permits easy installation in any standard mounting bracket.

Frequency range is 26.6 to 27.3 MHz and power handling capability is 100 watts. Avanti

Circle No. 13 on Reader Service Card

140-WATT STEREO RECEIVER

The KR-100 AM-FM-stereo receiver provides 140 watts of music power (IHF) at 4 ohms and 110 watts at 8 ohms.

The circuit is all solid-state and features four IC's, two FET's, and a four-gang tuning capacitor in a sensitive front-end.

Push-buttons regulate interstation muting, loudness control, tape monitor, and low and high filters. The front panel has a dubbing/tape recording jack and a stereo headphone jack. There

is input for two record players and 300- and 75-ohm FM antenna inputs. A patented power transistor protection circuit is included. Center-channel output is also provided.

A simulated walnut cabinet is included in the price of the receiver. Kenwood

Circle No. 14 on Reader Service Card

SOLDERING TOOL

The new "tempmatic" temperature-controlled soldering tool combines the advantages of a lightweight pencil-type soldering iron with a fast-

heating soldering gun for both light and heavy-duty soldering.

The heart of the new tool is the company's exclusive "Powerhead" containing the temperature controlled system. The integral points of the Powerhead have made over 30,000 solder connections in lab tests. The points have a special premium plating which extends life.

Two Powerheads are available, a 700° F, 3/16" chisel point and an optional 600° F, 1/8" conical point. A convenient ejector button makes switching the heads easy.

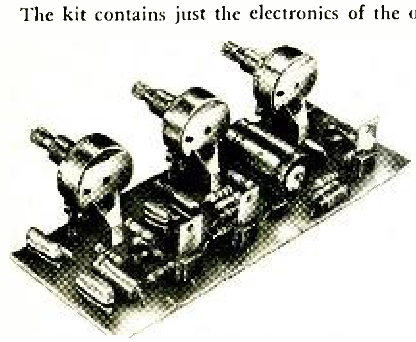
The tools weighs only 7 ounces. Its trigger turns heat "on" and "off." The stainless steel barrel has a long reach. Weller

Circle No. 15 on Reader Service Card

COLOR-ORGAN ELECTRONICS KIT

An easy-to-assemble kit that contains the electronics for a color organ is now available as the Model 103. The kit uses frequency-selective networks to divide the audio spectrum into three channels. Each channel has its own intensity control plus an SCR which controls the intensity of the lamp connected at the output terminals of the circuit.

The kit contains just the electronics of the or-



gan but the manufacturer provides instructions on how to add the filament transformer, line cord, switch, and light box (none of which is supplied).

Input sensitivity is 300 mV, impedance is 3000 ohms, input power to the lamps is 16 V a.c. at 3 amps, and 11 V a.c. at 20 mA; the output load current is 1 amp maximum per SCR. The over-all size, assembled, is 5⅝" x 3" x 1½". Science Workshop

Circle No. 16 on Reader Service Card

LOW-COST INTERCOMS

A new line of low-cost intercom systems which includes wireless, battery-operated, and a.c.-operated types is now available for distribution.

The CW1 is a complete 2-station wireless system that requires no installation. It is fully portable and can be moved from room to room. Hum and noise are minimized by a built-in squelch circuit.

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The Model CBI is a battery-operated 2-station system. It can be used indoors or outdoors and is especially suited for monitoring nurseries. It operates on a standard 9-volt battery in the master cabinet, which is connected to the remote by a 50-foot plug-in cable that comes with the unit. Battery power is conserved by a call-signal circuit that permits master and remote units to signal each other even when the system is turned off.

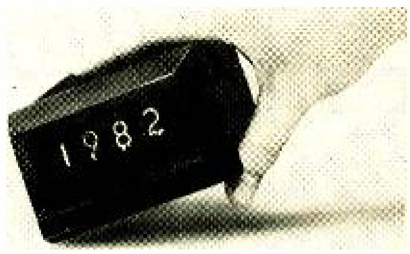
The Model CAI operates from 117-volt a.c. and comes with a 50-foot cable and the special call-signal circuit. Courier Communications

Circle No. 17 on Reader Service Card

DIGITAL PANEL METERS

Ten versions of the company's 3-digit digital panel meters have been introduced recently.

Features of the new series include full-scale readings, 100% overrange, nonblinking display,



programmable decimal points, BCD outputs, 0.01/°C stability, an accuracy of 0.1% reading ±1 digit, and an operating temperature range of 0 to +60°C.

Range is 100 mV to 100 V and 1 μA to 100 mA. The 510 series measures 2.7" high x 5" wide x 4" deep. Power requirements are 5 watts at 117 V a.c., 50-400 Hz.

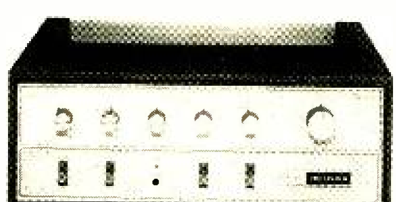
Additional information on available models will be supplied. Datascan

Circle No. 128 on Reader Service Card

MASTER CONTROL AMPLIFIER

The Model TX-50 master control amplifier is designed to deliver maximum power at 8 ohms. It is rated at 65 watts ±1 dB at 8 ohms; has full tape and phono facilities; main and remote speaker switches; headphone jacks; and loudness contour control.

Power bandwidth is 25-25,000 Hz and fre-



quency response is 30-15,000 Hz ±2 dB (phono low) and 20-20,000 Hz ±2 dB (aux.).

The amplifier measures 15½" wide x 4¹³⁄₁₆" high x 9" deep. An optional walnut cabinet (60-UW) is available at additional cost. Fisher

Circle No. 18 on Reader Service Card

MANUFACTURERS' LITERATURE

TAPE-RECORDER CATALOGUE

Applications, features, and specifications on a complete line of tape recorders are described in a new 1969 Tape Recorder Catalogue now available for distribution. The 4-color, 16-page illustrated catalogue covers portable cassette and reel-to-reel models; cassette, 8-track, and reel-to-reel tape decks; Radiocorders; and stereo tape systems. Concord

Circle No. 19 on Reader Service Card

TEST-EQUIPMENT DATA

A new 12-page catalogue describing the company's complete line of electronic test equipment for service and industry is now available as Form No. 458.

The publication features five completely new test instruments, including a sweep and marker generator, combination scope/vectorscope, color generator, and two transistor/FET testers.

Other units included are FET meters, tube testers, CRT testers, field-strength meter, and special-purpose instruments, all complete with performance data and prices. Sencore

Circle No. 20 on Reader Service Card

PROTOTYPE CHASSIS

An 8-page catalogue has been issued describing a laboratory and prototype chassis system and a line of terminal boards and terminals. More than 500 different chassis are included in the line, ranging from a 2" x 2" x 1" size to a 17" x 17" x 4" unit. There are three types of terminal boards in various sizes to fit the chassis and a series of self-threading and press-fit terminals to complete the system. Aracon

Circle No. 21 on Reader Service Card

DTL INTERCHANGEABILITY

A new DTL Interchangeability Chart which provides a comprehensive cross-reference between the company's DTL types and those of five other manufacturers is now available. Printed on heavy stock, the listings are divided into three sections by package type: 14-lead ceramic dual-in-line, 10-lead low-profile TO-5 type, and 14-lead ceramic flat packs.

A copy of this guide will be forwarded on request. ITT Semiconductors

Circle No. 129 on Reader Service Card

INFRARED HANDBOOK

A 36-page handbook covering a complete line of IR spectrophotometer cells and accessories has been issued by Barnes Engineering Company.

Hundreds of items illustrated include advanced designs in internal reflection and specular reflectance attachments; liquid cells; mull holders; gas cells; crystals of every size, shape, and transmission material; KBr die; GC fraction collector; pyrolyzer; beam condenser; attenuator; variable temperature chamber; chart paper; and pens.

Prices and parts numbers are given along with performance characteristics, spectra, and application data useful to spectroscopists.

The company will supply a copy of Catalogue No. 1969-BE on request.

Circle No. 130 on Reader Service Card

INSTRUMENT REFERENCE DATA

Instrument mechanisms, their principle, theory, and application, are the subject of a 42-page brochure recently prepared by Weston Instruments Division, 614 Frelinghusen Ave., Newark, N.J. 07114.

Entitled "The Instrument Sketch Book", it originated as a series of informal sketches and explanatory notes which were included as part of a series of educational lectures covering the instruments area. They have been prepared in present form for those interested in the principles of the art.

Comprehensive information, complete with performance curves and detailed drawings, are included on the subject of electrostatic and PM moving-coil mechanisms as well as application details on specific aspects of the technology.

A copy of the Sketch Book will be provided on request. Weston

Circle No. 131 on Reader Service Card

HARD-TO-FIND TOOLS

A new 24-page, fully illustrated catalogue of hard-to-find tools, with a detailed description of each tool and its application, has just been issued.

It contains a unique collection of useful tools rarely sold by industrial distributors or stores. Among the tools shown are electronic pliers and other tools, wood carving knives, jewelers' tools, sensitive drills, precision tools, flexible-shaft machines, unusual solders, soldering jigs, hard-wire cutters, screw and nut starters, glass drills, miniature files, rifflers, and reamers. Also a soldering machine, endless hacksaw, divider setter, diamond glass cutter, rust remover, and scores of other unusual hand and power tools are listed. Brookstone

Circle No. 22 on Reader Service Card

AUTO SPEAKER REPLACEMENTS

A listing of the company's line of automobile replacement speakers is now available. Printed in an easy-to-use 8½" x 11" format with universal punching, the new guide covers model years 1960 through 1969 inclusive. It lists replacement speakers for all American and foreign cars and is arranged to make it easy for the service technician to find the correct replacement model quickly. Jensen

Circle No. 23 on Reader Service Card

STROBOSCOPY

A booklet entitled "A Primer of Stroboscopy" that explains the fundamental concepts of stroboscopy is now available. This handy pocket-size booklet also describes accessories for the electronic stroboscope, how it can be used with a simple camera for high-speed photography, and a variety of other applications for the instrument.

The text is lavishly illustrated with clever cartoons to emphasize pertinent points in the text. General Radio

Circle No. 24 on Reader Service Card

WORLD TIME-ZONE CHART

The U.S. Naval Oceanographic Office has issued a colorful new standard time-zone chart which features not only brilliant colors for delineating the earth's different time zones but also "rules of thumb" for determining the time in various parts of the world.

Although designed to assist the mariner and the aviator, the new chart will find wide acceptance with travelers, transportation agents, educators, and students.

The chart is available from the Oceanographic Office, Suitland, Maryland 20390 or the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 for $1.00 a copy.

MATV MANUAL

A 30-page "MATV Planning Manual" has just been published by the Finney Company, 34 West Interstate Street, Bedford, Ohio 44146.

Priced at $1.00 a copy, the manual is written for technicians who want to educate themselves in the MATV business. It describes MATV system products and the fundamentals of system design and design calculations.

Also included in the manual are sample v.h.f. and all-channel systems, a dB-to-voltage multiplier chart, a coax cable and transmission line guide, TV channel assignments, and a glossary of most-used MATV terms.

SERVICING DATA INDEX

A "Master Index" to the company's publications covering servicing information on television and radio receivers is now available.

The listing is by manufacturer's name and model numbers and then the volume in which the servicing information appeared is listed—by number and year.

This new listing, which covers all sets up to 1969, is available for 25 cents. Orders for the Index should be addressed to Supreme Publications, 1760 Balsam Road, Highland Park, Illinois. ▲

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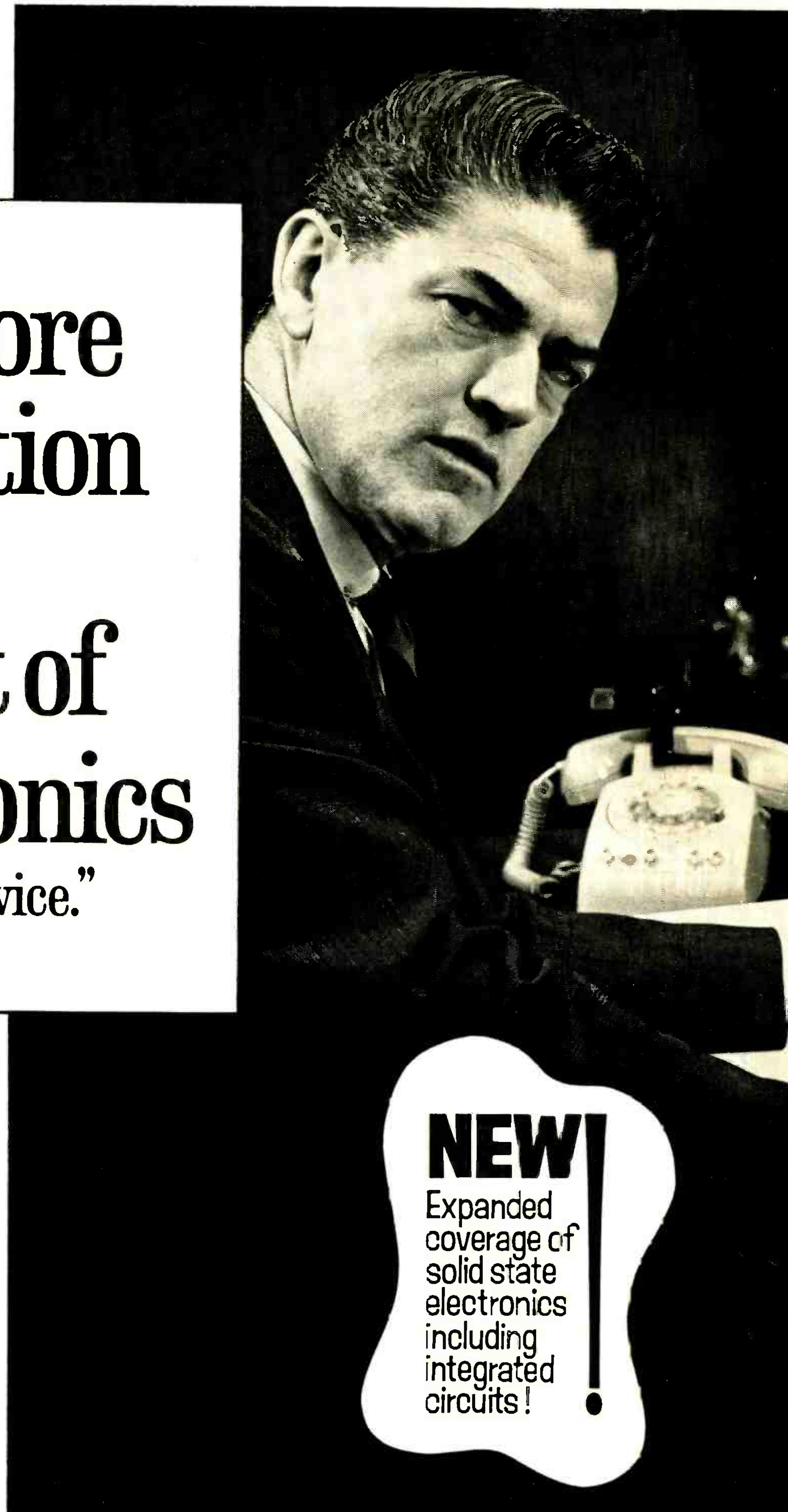

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The Power FET

(*Continued from page 35*)

because of extrinsic source resistance degeneration. This high ratio of transconductance-to-drain current gives potentially high voltage gain and low short-circuit noise at the input. As an illustration, the amplifier of Fig. 3 has an input noise level of less than 1.2 microvolts for a bandwidth of 10 Hz to 20 kHz while producing a voltage gain of 25 across a 1000-ohm load. Second-stage noise in this case would be negligible.

In r.f. applications, the FET is inherently more stable than the bipolar device. Used as an r.f. power amplifier or oscillator, the present power FET can put out 1 to 2 watts at frequencies up to a few hundred megahertz. It has been used successfully as a CATV distribution amplifier (see Fig. 4).

Its greatest advantage, however, is as a front-end device where its low noise figure and large dynamic range significantly improve receiver sensitivity and selectivity over that achieved with bipolars. The circuit of Fig. 5, covering 0.5 MHz to 40 MHz, is a good example. It has a broadband noise figure of less than 3 dB and handles signals of over 2 volts with little distortion. As with the small-signal FET, a.g.c. action in the power FET is obtained by varying G_m with operating current.

Used as a series regulator in power supplies, the power FET is short-circuit-proof because I_{DSS} is self-limiting. A bipolar will burn itself out trying to supply the load. As a switching regulator, the device is even more efficient than the bipolar owing to the low-power drive required and the fast switching speed. The power FET can be easily set for a maximum current below its I_{DSS} value in constant or controlled current supplies.

The power FET is similar to the small-signal device when it comes to figures of merit and selection criteria. The single, most meaningful figure of merit is the ratio of transconductance-to-drain-to-gate capacitance (G_m/C_{rs}). It determines cut-off frequency, switching time, high-frequency noise figure, power gain, and stability.

The gate of the power FET is tied to its can, like a tube having its grid tied to the tube shield. This, of course, necessitates special mounting hardware. With regard to derating and heat sinking, power FET requirements are the same as those of the bipolar.

The Future

The next developments to watch for are the multi-channel FET and gallium-arsenide devices. The first is more like a vacuum tube in design and should have increased G_m with shorter channels and lower capacitance, yielding a higher f_T than is possible with conventional channel structures. Multi-channel FET's have been built experimentally by several manufacturers, although many bugs have to be ironed out before they can be made production items. The high mobility of carriers in gallium arsenide will raise G_m and drain current by a factor of three if its performance can be made more predictable.

As for most power devices, there are no immediate plans to put the power FET into monolithic circuits, although it is possible to do so. It has, however, been used in several hybrid circuits. Monolithic circuits gain their advantage by using many small, low-current devices to accomplish specific functions. The necessarily large power chip is, itself, bigger than most monolithic structures. ▲

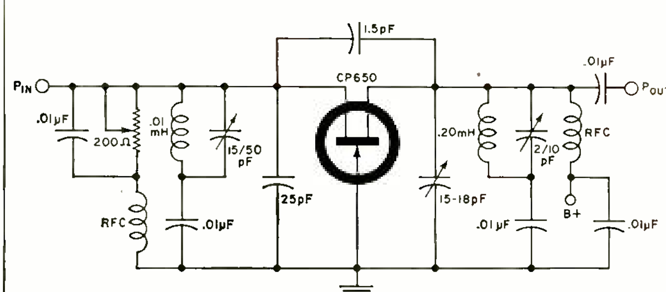


Fig. 4. An FET amplifier used as a CATV distribution amplifier.

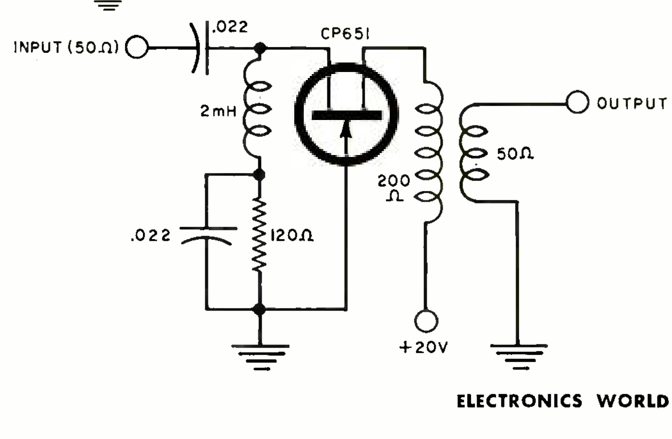


Fig. 5. Broadband noise figure of this unit is less than 3 dB.

FET Sine-Wave Oscillators

(*Continued from page 33*)

Minimum drain current indicates the point of adjustment of L1 where optimum phase shift is obtained between the transistor's drain and gate electrodes. Feedback is *via* the transistor's interelectrode capacitances which, in some applications, may be augmented by a small, fixed silver-mica or polystyrene capacitor.

Output may be obtained from a split drain-tank capacitor, as shown in Fig. 2A, or from a link on the drain inductor, as in Fig. 2B. Either method may be used at either frequency, depending on what is most appropriate.

Grounded-Drain Colpitts

The performance and output of the grounded-drain Colpitts FET circuits given in Fig. 3 are similar to those of the circuits in Fig. 2, but the grounded-drain oscillators have the tank (and thus the output) located in the transistor's low-impedance source circuit. In most applications, this makes them less susceptible to stray fields and capacitances. The mode of operations is different too and for this reason the source tank inductor is tuned to a frequency slightly lower than that of the crystal. Feedback is *via* the transistor's interelectrode capacitances which, as before, may be augmented by a small value of fixed capacitance.

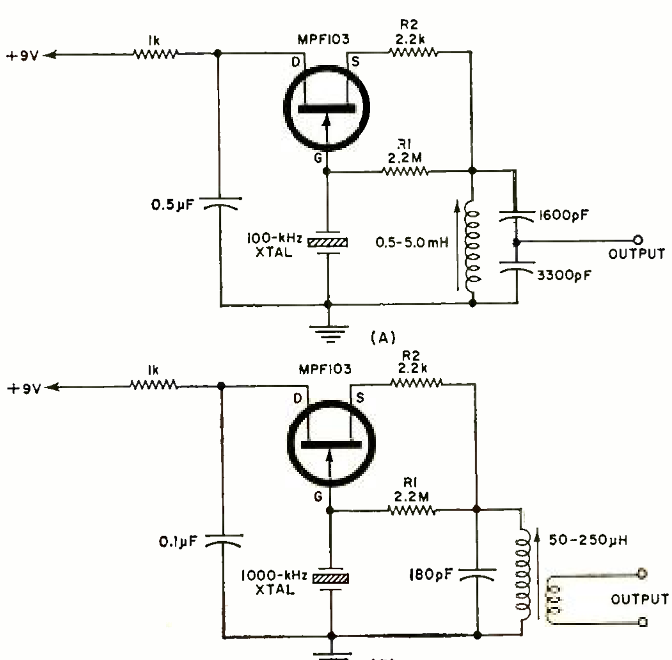
As with the operation of the previous circuits, optimum sine-wave output is obtained when the tank inductor is adjusted for minimum drain current.

Application

Frequency standards in the radio-frequency range are rarely used at the fundamental frequency. It is the harmonics which are useful. Since harmonics are not present in a sine wave, it is customary to feed the oscillator into an emitter- or source-follower (to decouple the oscillator and load it lightly) then into a harmonic generator or signal-squaring circuit, which clips the sine-wave heavily and produces a rectangular wave which contains harmonics at the frequency of interest to the designer.

(Engineers and technicians will also find circuits like these useful as signal sources for digital counter time-base generators.—Editor) ▲

Fig. 3. Performance of the Colpitts FET circuits (A and B) is similar to Fig. 2, except the output is a lower impedance.



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- **RCA UHF transistor type TV tuners, KRK-120 (long-shaft) cat. #UHF-20; KRK-120 (short-shaft), cat. #UHF-21, each $4.98.**
- **RCA VHF transistor type TV tuners, KRK-146, cat. #VHF-74, $9.99 each.**
- **Transistorized U.H.F. tuners used in 1965 to 1967 TV sets made by Admiral, RCA, Motorola, etc. Removable gearing may vary from one make to another. Need only 12 volts d.c. to function. No filament voltage needed. Easy replacement units. Cat. #UHF-567. $4.95.**
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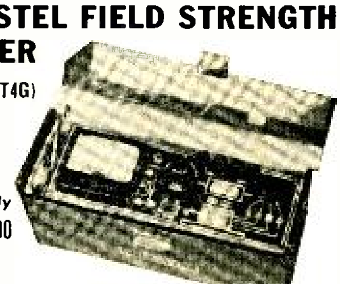

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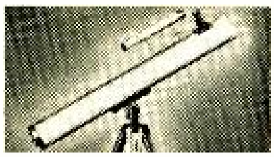

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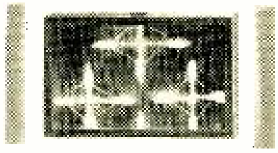

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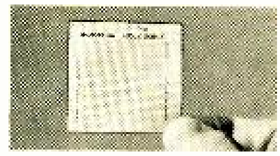

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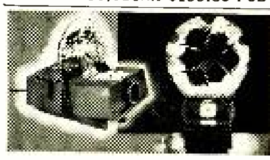

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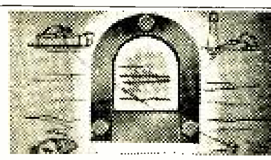

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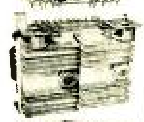

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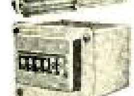

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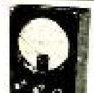

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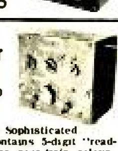

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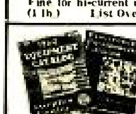

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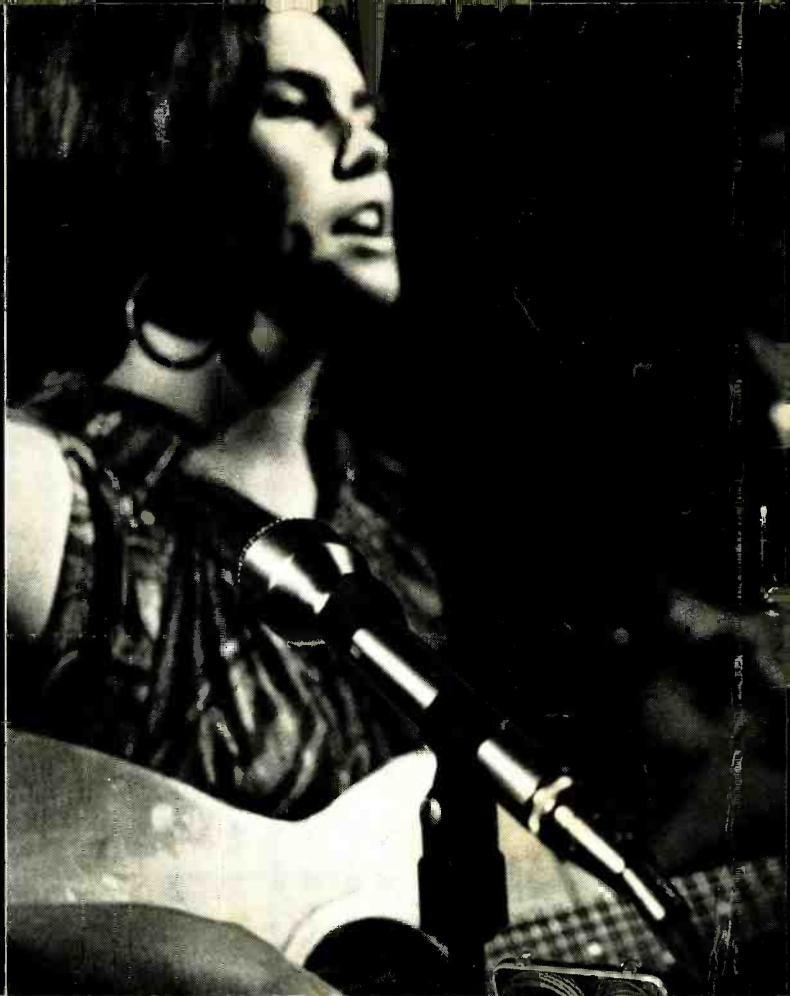

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