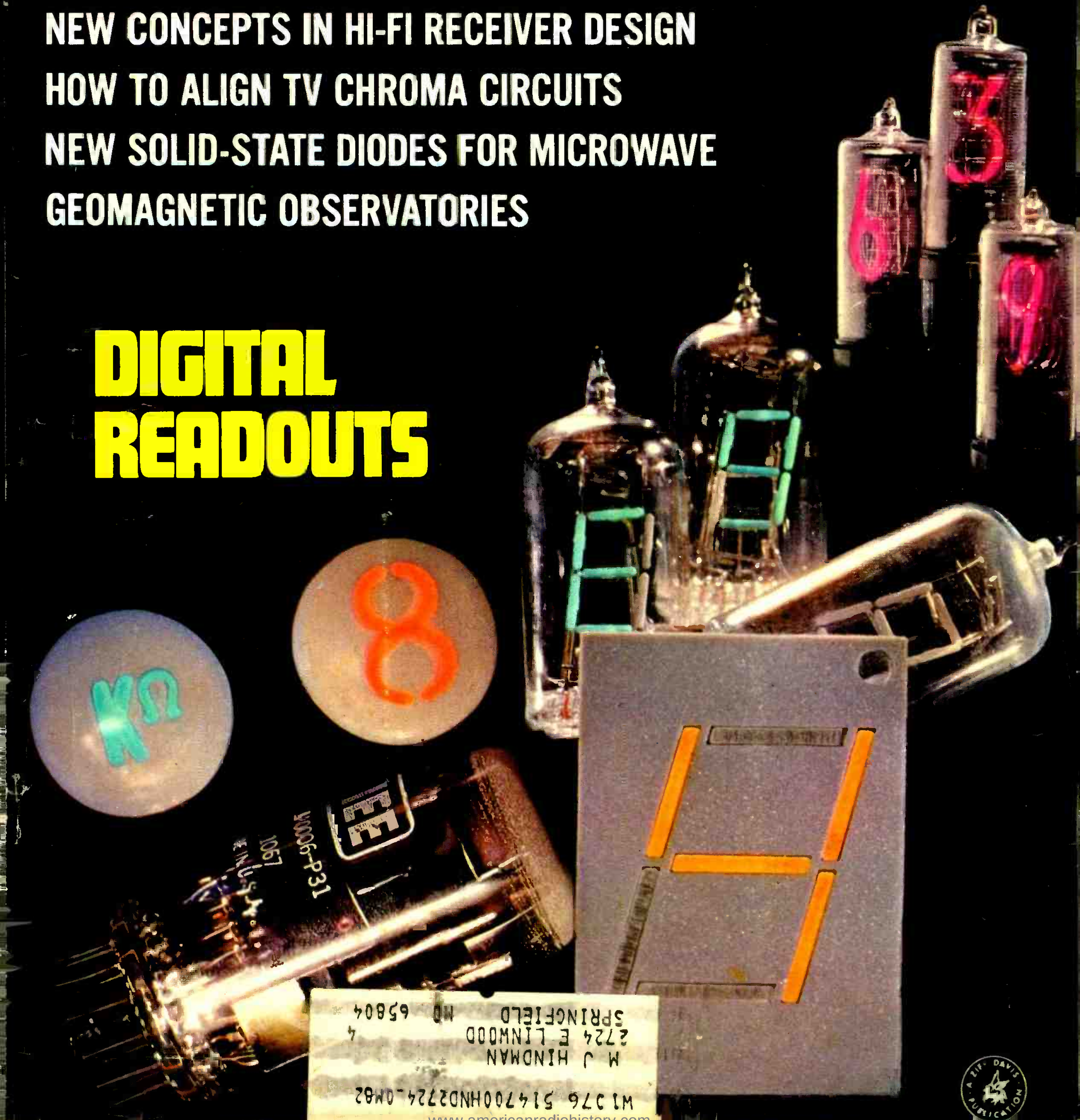
Electronics World

FEBRUARY, 1969
60 CENTS

NEW CONCEPTS IN HI-FI RECEIVER DESIGN
HOW TO ALIGN TV CHROMA CIRCUITS
NEW SOLID-STATE DIODES FOR MICROWAVE
GEOMAGNETIC OBSERVATORIES

DIGITAL READOUTS



A ZIFF-DAVIS PUBLICATION

Every Hour of Every Day

Magnecord tape recorders run hour after hour, every day, under the toughest broadcast conditions. The die-cast mainplate assures permanent mechanical alignment. Timing accuracy is constant with the hysteresis synchronous capstan tape drive. Payout and take up reels have their own heavy duty split-capacitor motors. In short, solid state Magnecords are built to take it, day after day. You can depend on it.

The quality of a Magnecord does not vary from model to model. Features do:

MODEL 1021. Monaural broadcast unit. Inputs: Mixing bridge and choice of Lo-Z microphone or balanced bridge or unbalanced bridge. Cue Speaker. Monitor Amplifier. Two speeds. Balanced 150/600 ohm output.

MODEL 1022. Studio or broadcast stereo unit. Inputs Per Channel: Auxiliary bridge and choice of Lo-Z microphone or balanced bridge or unbalanced bridge. Separate Playback and Record/Gain Controls for each channel. Master Playback and Record/Gain Controls. Balanced 150/600 ohm output. Choice of speeds and head configurations. Full remote option.

MODEL 1024. Commercial or personal stereo unit. Inputs Per Channel: Hi-Z microphone, mixing bridge, auxiliary bridge. Full mixing facilities. 1K ohm emitter follower output. Choice of speeds and head configurations.

Write for the full story on a Magnecord tape recorder. You can depend on a prompt answer.

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CIRCLE NO. 90 ON READER SERVICE CARD

Here's a new, complete ICS course in TV Servicing that costs less than $100.

With the first two texts, you can repair 70 percent of all TV troubles.

You need no previous experience to take this complete, practical course in TV Repairing.

You don't even have to know a vacuum tube from a resistor. Yet in a matter of months, you can be doing troubleshooting on color sets!

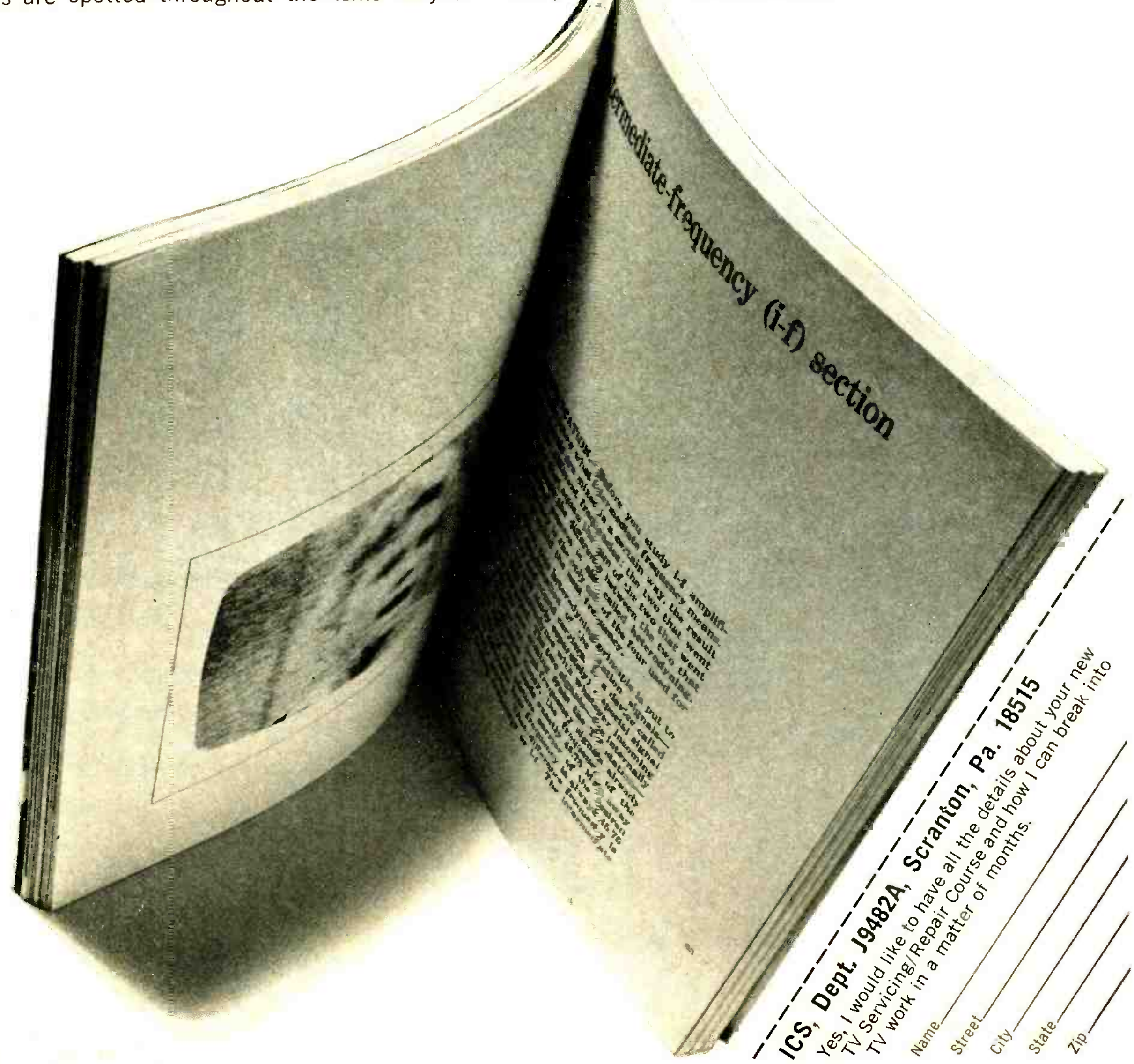
Course consists of 6 texts to bring you along quickly and easily. 936 pages of concise, easy-to-follow instruction, plus 329 detailed illustrations. You also receive a dictionary of TV terms geared directly to course material so you'll understand even the most technical terms. The dictionary will come in handy even after you've finished your course.

Instruction is simple, very easy to grasp. Photos show you what a TV screen looks like when everything is normal, and what it looks like when trouble fouls it up. The texts tell you how to remedy the problem, and why that remedy is best.

Quizzes are spotted throughout the texts so you can check your progress. At the end of the course, you take a final examination. Then you get the coveted ICS® diploma, plus membership in the ICS TV Repairman Association.

By the time you've finished the course, you should be able to handle tough, multiple TV problems, on color sets as well as black and white.

This new TV Servicing and Repair Course has been approved by National Electronic Associations for use in their Apprenticeship program. Because of its completeness, practicality and price, it is the talk of the industry. The cost is less than $100—just slightly over ½ the price of any comparable course on the market today. Remember, the sooner you get started on your course, the sooner you'll be turning your spare time into real money. Fill out the coupon today. And we will rush to you all information, no obligation.



ICS, Dept. J9482A, Scranton, Pa. 18515

Yes, I would like to have all the details about your new TV Servicing/Repair Course and how I can break into TV work in a matter of months.

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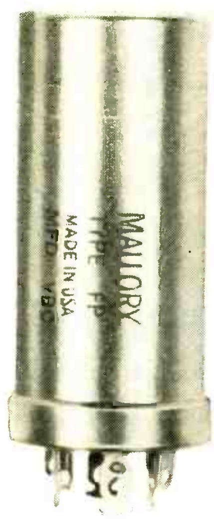
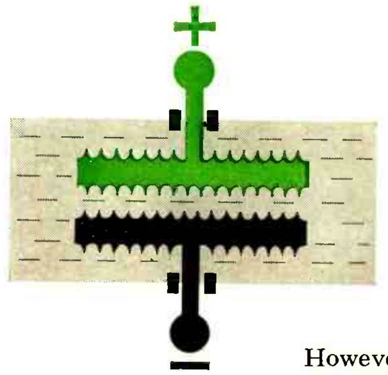
MALLORY **Tips for Technicians**

Why some filter capacitors develop hum... and some don't





Aluminum electrolytic capacitors are widely used as filters in DC Power Supplies. This is because of their large capacitance in relatively small size. All in all, they do an efficient job of reducing ripple (hum) to acceptable levels.

However, all electrolytic capacitors are not alike. This is often why some types seem to allow hum to rise to objectionable levels more quickly than do others. In order to understand why, we must investigate actual construction methods.

As you know, electrolytics are basically made by depositing a film of aluminum oxide on aluminum foil to form the positive anode. The oxide is the dielectric. A semi-liquid electrolyte surrounds the anode and is actually the negative cathode. In order to connect this semi-liquid cathode to a terminal, a second piece of aluminum foil is used. This is often *called* the cathode, but it is not. It is actually only the *cathodic connection.* (The preceding describes a "polarized" electrolytic capacitor.)

When high ripple currents are applied to polarized electrolytics, a thin oxide film forms on the so-called "cathode". It begins to assume the characteristics of a second anode. This in turn, has the same effect as placing two capacitors in series. Consequently, overall capacitance is reduced. Inevitably hum increases.

This action is especially noticeable in electrolytics which use plain foil as the "cathode". This is simply because the oxide builds up over a relatively small area.

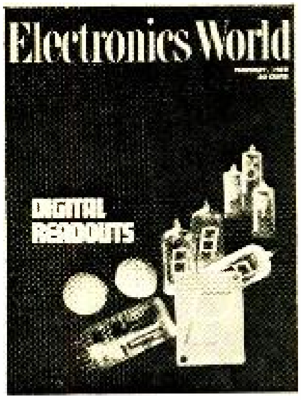
Mallory avoids this problem by etching the "cathode" on electrolytics. As a result, oxide build-up is spread over a vastly increased area. Therefore, ripple currents are maintained at very low levels for very long time periods.

Of course etched "cathodes" cost a lot more to make. But you get them from Malloy at *no extra cost.*

Meanwhile, see your local Franchised Mallory Distributor for capacitors, resistors, controls, switches, semiconductors, and batteries. Or write 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?"*

CIRCLE NO. 91 ON READER SERVICE CARD



THIS MONTH'S COVER shows a few of the new generation of digital readouts available for computer and general instrumentation use. IEE has developed a single-plane vacuum-tube readout (lower left). It combines the display characteristics of a CRT with the character generation philosophy of a rear-projection readout. The newest segmented readout available is Tung-Sol's Digivac S/G (center). This unit comes in a standard 9-pin envelope and is able to form 23 alphanumeric symbols. Unlike many readouts, very low voltage and power are required. Dialco's single-plane incandescent readout is also new. It uses filament lamps or neon bulbs and light pipes to form symbols. The B-5750 is the latest Nixie available. It displays numbers 0-9 and has two independently operable decimal points inside the tube. Cover photo by Dirone-Denner.

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CONTENTS

MONTHLY FEATURES

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COMING NEXT MONTH

SPECIAL FEATURE ARTICLE:

LOUDSPEAKERS

Can we measure what we hear? Cymbals, drums, and triangle sounds may make the hi-fi enthusiast happy, but usually tests are needed for proof of sound-reproduction quality. In next month's feature story, Victor Brociner of the H. H. Scott Co. discusses a reverberant-room technique which gives valid measurements.

STRAIN GAGES
Strain gages have changed their looks while growing in technology. Today, they are being used in a world of new applications. This article will discuss how strain-gage measurements are made.

50-MHz DIGITAL COUNTER
Once, you could expect a counter that measured frequency to FCC standards to cost a fortune. But here is a counter design that uses inexpensive integrated circuits to slash the price to under $400.00.

THERMOLUMINESCENCE: LIGHT FROM HEAT
Certain materials emit light that depends on previous radiation dosage. This effect is used for archaeological dating, dosimetry, and solid-state research.

BANDWIDTH COMPRESSION TECHNIQUES
Digital communications are rapidly replacing analog systems. Here is a discussion of some compression methods which improve reliability and promote information security.

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

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Radio & Television news

By FOREST H. BELT / Contributing Editor

News About Electronic Video Recording

Electronic video recording (EVR) may beat out classic video tape recording for home use. *CBS Laboratories, Inc.* decided to go ahead with its monochrome EVR, rather than wait until a color version is ready, probably some time next year. The company is trying for deals with set manufacturers to put the system into future home TV sets.

Motorola has just announced that next year it will be marketing an industrial-type EVR playback unit for schools, hospitals, and industry training programs. The unit will sell for around $800 and its output is simply clipped to the antenna terminals of a black-and-white TV set. Also, *The New York Times* will produce about 50 programs for elementary and secondary schools, using the new medium.

The EVR system uses film, not magnetic tape or discs. The film, about 5⁄16″ wide, contains two separate tracks of optical images (10 per inch) along with two separate magnetic tracks for accompanying audio. The film is sensitized by an electron beam instead of light. After the film is developed, a cartridge (actually an open reel) about 7 inches in diameter and less than ⅜-in thick holds a 26-minute color show or a 52-minute black-and-white program. Although the system is intended first for educational and industrial monochrome TV, the cost—once production begins—makes it feasible for home viewing some time in the future. At a recent demonstration of the system, picture quality was seen to be excellent.

Year's Big Show Event

For a while, it looked as if the Consumer Electronics Show, annual exposition of the Consumer Products Division of EIA, might be discontinued—or at least it might not have EIA sponsorship. The doubts are past, at least for this year. The show is to be at the New York Hilton and Americana hotels in New York City, June 15 through 18.

It seems a good thing the Show wasn't canceled; available exhibit space is already sold out. There were 158 exhibitors last year, and almost the same number this year. The first CES was in 1967, and CES has become *the* show to attend if you're in home-entertainment electronics.

NEA Expands Certification

If you don't already know about Certified Electronic Technicians, you soon will. The program is spreading all over the U.S. (and outside, too). National Electronic Associations (NEA) administers a rather stringent exam to service technicians who want it; those who pass, and who have at least four years of servicing experience, become Certified Electronic Technicians, and earn the right to the put trademarked initials CET after their names. Every CET is registered with NEA, and any technician's claim of being a CET can be easily checked.

New administrator for the CET program is NEA's secretary, Leon Howland. You can get information about CET's and about when exams are held in your area by writing him at 4622 East 10th Street, Indianapolis, Ind. 46201. An exam can be arranged anywhere in the country and some cities have them scheduled on a regular basis.

Old Service Shops Just Fade Away

It's no wonder owners of TV sets and other home-electronic instruments are starting to worry how they can keep them going. Repair shops are disappearing.

In a survey of one metropolitan area with a half-million people, we found an astonishing attrition rate among TV shops. In 1964, that city had over 250 service businesses. At the end of 1968, only 103 of those were still in business and only 53 new ones had commenced operation.

Dealers Have Similar Problem

The National Appliance and Radio-TV Dealers Association (NARDA) said not long ago that 5% of the nation's appliance-TV dealers go out of business each year. New ones make only a 3% increase, leaving a net loss of 2% per year. That's not as heavy a mortality as for service businesses, but Jules Steinberg, executive vp of NARDA, estimates it could virtually wipe out independent dealers within 20 years. In fact, NARDA is considering expanding membership to include dealers in other types of home furnishings.

Who Cares About Customers?

In view of so many business foldups, we can't help wincing when someone says (as one shop owner did lately), "Why should I be nice to customers? They act like I'm a crook, when they're really chiselers themselves. And they believe whatever bad they hear or read about service technicians. If they treat me like that, I say stick 'em for whatever I can. If they don't like it, let 'em go somewhere else."

It seems impossible to convince a guy who feels that way that he's committing business suicide. He can't see how his antagonism shows to every customer he meets. Yet, he admits he's worried; business isn't very good. His repeat business is practically nil.

At a time when most shops have more than they can do, why should anyone go broke? Customers will pay almost any price, even more than they think is reasonable, for good service from a friendly technician. The independent service dealer has the best opportunity he ever had to create a likeable image. And if he doesn't, do you know who will? Larger companies, that's who. They'll teach their employees to show customers that technicians are good guys, interested in doing a good job. And every time another little shop closes down, one that didn't care what a customer thinks—that big-company shop will gladly snap up the customers.

End of CB Slump?

Maybe it wasn't exactly a slump, but sales of class-D Citizens Band radios leveled off more than a year ago. Some slackening can be laid to the poliferation of "Part 15" transceivers—100-mW sets that don't need a license. And some can be blamed on channel-crowding in some localities, which gave the effect of saturation. And, too, some of the early glamour merely wore off.

Reports say sales are picking up again. There's no big upsurge in new licenses, but some of the thousands and thousands of sets bought during the peak are nearing replacement age. Users sometimes get tired of a model in 3 or 4 years and trade it in for a newer version. *E. F. Johnson*, maker of its own and some private-label CB units, reports interest by auto manufacturers in custom-installed CB. *Raytheon* and *Ford* tried that a few years ago, with little success; but the sets were not part of the car like a car radio is. New FCC Rules have eased congestion a little, freeing certain channels for business use.

Tape Pen-Pals

You've heard of computer dating? Now you can have a pen-pal selected by computer. And you don't even have to write a letter . . . you do that part with cassette tapes. Tape-A-Letter League, called TALL for short, collects personal data from applicants and matches them with data from other applicants. Your taped letters don't go straight to your correspondent, though, unless you wish it. Tapes sent to TALL headquarters are duplicated and the last name and address taken off; that way, no one gets unwanted tapes. What a way to mix cassettes and computers!

Flat-Screen Color-TV—Not Again!

Every time we turn around, there's something new being discovered that might apply to flat-screen TV. The newest idea might permit flat-screen color. It's a light-filtering gadget developed by *Sandia Laboratories* of Albuquerque. A tiny flake of ferroelectric ceramic is sandwiched between two light-polarizing transparent filters. Crystals in the flake have the quality of bi-refringence, meaning that they refract light in two directions. When voltage pulses are applied, the character of the pulses changes the orientation of the crystals. With white light applied, the crystals allow only certain colors to pass through. As usual, there is still a ways to go before we can use them for color-TV.

Flashes in the Big Picture

Two well-known companies have quit making TV sets: *Hoffman* and *Westinghouse*. *Hoffman* will neither build nor sell sets but *Westinghouse* will continue to sell small-screen black-and-white and color receivers which they will import. . . . Subsidiary of *ABC* is distributing 4-inch minirecord in vending machines. . . . Corporation for Public Broadcasting finally got $5-million from Congress, but still no permanent financing. . . . *RCA* has new low-cost color-TV camera, suited for ETV; uses only one vidicon, with dichroic mirrors to separate colors. . . . *Howard W. Sams & Co., Inc.* just passed milestone with publication of Photofact Set 1000; starts new format with Set 1002. ▲

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It's the turntable the experts invariably choose for their own systems. (And we're including the independent reviewers whose reviews you'll be reading in our literature. Most of them decided to buy a 1019 after they'd put it through their tests.)

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But send for their exact words.

They tell the Dual story in a much more convincing way than we ever could.

(You know we're prejudiced.)

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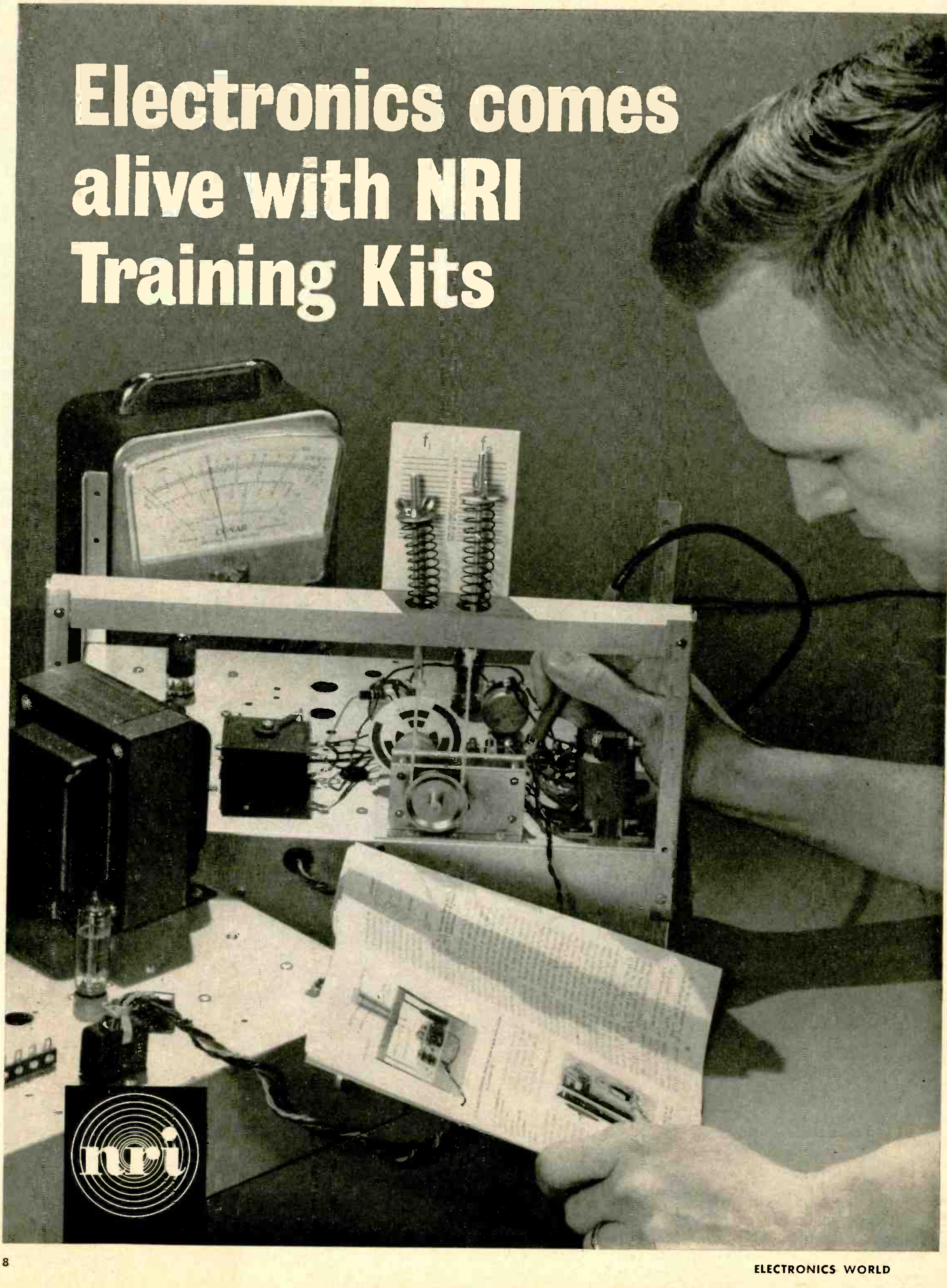
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*You must pass your FCC License exams (any Communications course) or NRI refunds in full the tuition you have paid.

Reflections on the news

Transistors . . .

The entire semiconductor industry is changing its face. According to Dr. Robert C. Castor, Vice-President and General Manager of *Sylvania's* Semiconductor Division, "the future growth of the semiconductor industry lies in a major switch from the production of individual components to solid-state subsystems that can be used as building blocks in electronic designs." Dr. Castor, who is one of the most respected industry analysts, estimated the subsystem market could be as much as 50% of total industry sales by 1973, and at that time sales should reach a record $1.65 billion level.

Apollo Spacecraft . . .

whipping around the moon and earth are guided by a super inertial navigation system manufactured by the *AC Electronics Division* of *General Motors*. Working with a special digital computer developed by *Raytheon*, the system uses gyros and accelerometers to measure changes in the spacecraft's attitude and speed and uses the data to steer the ship to and from the moon. A sophisticated precision sextant and scanning telescope, produced by *Kollsman Instrument Corp.*, updates the inertial system in flight.

Less sophisticated, but perhaps more important to everyday, earthbound travelers, is the Carosel IV, which *AC* claims is the first inertial navigation system built as an integral part of a commercial aircraft's avionic subsystem. According to *AC*, the Carosel IV will provide the 490-passenger *Boeing* Jumbo Jet 747, with high-precision, fully automatic all-weather navigation between any number of points on earth. An earlier navigation system, the SGN-10 built by *Sperry Gyroscope Co.*, scheduled for installation aboard *Pan American* 707 aircraft, was scrapped when *Sperry* couldn't meet production schedules and *Pan Am* claimed the system was too unreliable as well as too inaccurate. *AC* says its system falls within the maximum FAA error limits 95% of the time—an acceptable standard.

Meanwhile, all the buzzing about the *AC* system is stirring up the old pilot-airline-FAA over ocean air-corridor controversy. The FAA and airlines would like to cut the space around the plane from 120 to 90, or even 60 miles. This allows more planes in the air at one time, a help during peak hours. *World Airlines Inc.* was fined $5000 for not having a precise navigation system on board one of its planes which strayed over Soviet territory and was forced down with 214 soldiers aboard. Perhaps an inertial system could have helped.

Batteries . . .

have been notoriously unreliable. Many units touted to be good for months. and even years, have failed after a few hours or days of operation. According to battery manufacturers, the big problem has been and, as a matter of fact still is, temperature changes or rather environmental changes. What happens is that batteries are tested in the lab to meet certain specifications (incidentally most military units are tested to the same specs as commercial devices) where they pass with flying colors. It's another matter when the battery is in the field—it fails.

Japan's *Matsushita Electric Industrial Co.* has developed a thermal battery which it claims has a storage life of five years compared to two-to-three years for ordinary batteries.

Here's what the company claims—operating temperature of $-54°$ to $+71°$ C compared to $-10°$ to $+60°$ for conventional batteries. The big news is that it is available for the commercial market. Heretofore, any batteries of this type have been earmarked strictly for military. The device has an open-circuit voltage of 38 volts. It measures 58 mm in diameter and 47 mm high, excluding terminals.

The Toy Industry . . .

is one of the last places where a man with a hot idea and a few dollars can make money quickly—or lose it. And according to the magazine "Engineer," a publication of the Engineers Joint Council, some 1200 toy manufacturers do almost $2-billion business each year. These companies employ a large number of engineers—some electronic, but mostly mechanical and industrial types—to do R&D and create new mechanisms and product designs.

Perhaps it's not strange that the toy industry is also one of the most cost conscious of all industries. It is constantly looking at new technologies in a way that benefits other industries as well as the toy business. And they investigate every conceivable material and device which in any way might bring costs down. Electronics, optics, audio techniques, and even fluidics (which has not even gained public acceptance) are all utilized Other advanced technologies still on the drawing boards of many companies—liquid crystals, for example—are being studied for playtime possibilities. Holography anyone?

Are Automated Highways . . .

around the corner? Some people at the *General Motors* Research Laboratories think they might be and have developed ERGS II (Experimental Route Guidance System) to provide drivers with automatic, high-quality routing instructions at certain decision points along highways or city streets. The work which is being done for the Federal Highway Administration, is aimed at determining whether route guidance can increase safety and reduce trip time, routing errors, and driver stress.

Essentially, ERGS II is a two-way communications and logic system where the car is a rolling transmitter that broadcasts its movements to a fixed station at certain intersections along the right-of-way. Here's what happens. When a driver leaves on a trip, he uses a five-letter code word to enter his destination on a console in the car. As the car approaches an instrumented intersection, the console automatically transmits the destination to roadside equipment where the code is processed and appropriate routing instructions are transmitted back to the car and displayed on a dashboard message panel. The entire transaction, which requires only a few milliseconds, is repeated at each instrumented intersection until the driver reaches his destination.

The important thing about this new development is its potential for improving highway safety. Often serious accidents are caused by drivers missing turns and backing against traffic, etc. Hopefully, the dashboard display with its large alphanumeric symbols will provide an easily interpreted method for presenting routing information to drivers.

Computers and Television . . .

team up in a new program by the University of California at Los Angeles and *General Electric Co.* which is designed to improve highway safety.

Working together, the University and company have developed a technique called Computed Perspective Image Generation. Computers are linked to the accelerator, brake pedal, steering wheel, and other instruments inside a mock-up car. These provide inputs for a master computer which, in turn, controls the projection of real life events on a gigantic television screen.

No cameras, films, or models are used. The entire highway environment, which includes moving cars and people, is computer-generated and displayed on a screen in front of the driver who sees the simulated roadway as though he were looking through his car's windshield.

Communications . . .

always an important, though vague, area of military operations will receive more emphasis in Army plans for the future. The removal of the distinction between strategic and tactical communications networks is being pushed and a master plan involving the Army Air Force in tactical field communications work is being pressed. The new role for communications was spotlighted at a recent classified briefing for industry held by the EIA and the Army Command. According to one manufacturer attending the conference, "The Army is the big customer for future communications equipment." This should make a lot of manufacturers happy, especially since Russell D. O'Neal, Assistant of the Army for R&D, estimates that total Army electronics procurement will reach $730-million in fiscal 1969.

Some Thoughts . . .

about things going on . . . Large-scale integration throws most of the old semiconductor reliability concepts out the window. Present testing techniques are inadequate because they do not include failure rate per failure mode as a function of time, and do not allow for variations in the manufacturer's line. . . . *Ampex* plunges into the data handling market with its Videofile system. The system with its six basic units—television camera, video tape recorder, buffer, remote display terminal, electrostatic printer, and control center—has applications in business and government for storage and retrieval of graphic material which cannot be digitized economically or microfilmed. . . . Looking ahead to the end of big military spending, *Bendix Corp.* is shifting emphasis to non-government markets, according to A. P. Fontaine, the company president. *Bendix* expects $2-billion in non-government sales by 1971. ▲

Break into the bu

A career in crime

What's a bigger business than banking? Robbing banks. And stores and factories, and warehouses, etc.

Are we suggesting you embark on a life of crime?Not exactly. What we have in mind is a career in crime prevention.

A burglary will take place approximately every 20 seconds in 1968. Not to mention vandalism, fire, malicious mischief, and other crimes against property. People want and need maximum protection.

And we've got just the product that provides it.

Radar Sentry Alarms. They work on foolproof microwaves, and they're selling at an unprecedented rate because businessmen are demanding defense against crime.

Two hundred million customers

With constant news stories about crime waves, national and state campaigns against violence, people are attuned to thinking about protection. Your prospects are every person who has been hit by a crime, and everyone else who's worried that the next burglary may be at his business. In a way, that's almost everyone in the country!

Or as one new Radar Sentry Alarm dealer puts it, *"...the market is like the boom days of early TV—only better. I never believed a product could sell itself like this one."*

"It's like getting in on the ground floor of IBM," writes another Radar Sentry Alarm dealer. *"When crime is on the mind of everyone in the country, and you're selling the best burglar trap in the business, you can't miss!"*

Because the crime rate is mounting so rapidly, you can get into the crime prevention business **now,** with no experience, and less than $500 of capital. You can even sell Radar Sentry Alarm in your spare time, out of your home. There's no franchising fee—no overhead!

Plus, your electronics background is a decided asset. Though you need no technical knowledge to install and maintain Radar Sentry Alarms, your electronics expertise is bound to instill the type of customer confidence that helps build sales and prestige.

Whether you're just out of school, or presently in another business—whatever your position—Radar Sentry Alarms will improve it. Selling Radar Sentry Alarms is the most profitable opportunity to come along in years. Read what other Radar Sentry Alarm dealers in your exact situation have said:

Part Time: *"I've earned more in three months part time as a Radar Sentry Alarm dealer, than my job paid all last year. Gave notice on my job today."* Sewarren, New Jersey.

TV Business: *"I've been trying to get out of the TV business for the last two years. Your product and program enabled me to do this and double my income at the same time."* Detroit, Michigan.

Full time from home: *"Working out of my home for the last year enabled me to pay cash for a new sales office. We now have four salesmen on the road..."* Winnetka, Illinois.

Thousands of Radar Sentry Alarms are already protecting offices, factories and homes across the country. Radar Devices has been in business long enough to establish a reputation for quality. But a short enough time to allow you to get in on the ground floor of a booming business! For instance, you can make as much as $1200 profit a month, by selling only **one** Radar Sentry Alarm a week!

The amazing facts and figures

IF YOU SELL	Gross Monthly Income from Sales Based on average selling price of $795 each	Typical Monthly Expense and Cost of Equipment	Your Net Profit per Month	Your Net Profit per Year approximate
1 per week	$3,180.00	$1860	$1,320.00	$16,000.00
2 per week	$6,260.00	$3920 (also includes Installation/ serviceman's salary)	$2,340.00	$28,000.00
5 per week	$15,900.00	$12,080 (also includes a Salesmen's Commissions, 3 Servicemen)	$3,820.00	$46,000.00

rglary business.

Radar Sentry Alarm solid state models

The new solid-state Radar Sentry Alarms feature the same design concept as our original tubed units, considered to be the best burglar traps in the world. These new models feature solid-state circuitry, for even more effective operation. Solid state means: less heat, no tubes to age and cause false alarms, reliable operation; less drain on batteries for long-term operation on battery standby. And the heart of the Radar Sentry Alarm's electronics is on a single printed circuit module. If there is ever a problem, the complete module is simply pulled out and a new one plugged in. Instant repair. No lapse in security.

Dialtronic automatic telephone dialer

Connects your Radar Sentry Alarm directly to the police station, the fire house, or your home. It automatically dials the phone and delivers any pre-recorded message for which it is programmed. Fires are reported to the fire department and burglaries to the police. The DT-1000 will not only notify the proper officials, but it will back up the first call by calling you or any other person designated. The Dialtronic can also be programmed to handle two different emergencies, automatically dialing the right people and delivering the correct message in each case. Retail price $599.50

Ride the crime wave today

Remember these 10 reasons for getting into the Radar Sentry Alarm business today:

- customers who need your product because burglary is the biggest crime category in the country.
- customers that never run out—because the crime rate is rising astronomically.
- a line of the best burglar alarm products available today
- competition that's still minimal.
- an immediate profit of 100 per cent with your first sale.
- no franchising fees.
- a full dealership program that supports you.
- minimal overhead.
- an initial investment of about $500.
- easy installation and maintenance.

But you must act fast. Radar Sentry territories are running out.

Send no money, just fill out this coupon NOW. YOU'LL BE BUILDING YOUR OWN FUTURE, WHILE PROTECTING EVERYONE ELSE'S.

Break Into
The Burglary Business Today

Act Now

RADAR DEVICES MFG. CORP. EW-2
22003 Harper Avenue
St. Clair Shores, Michigan 48080

Gentlemen:

Please rush me your dealer prospectus outlining the Radar Sentry program.

I want to launch my career in crime prevention now—while there are still choice territories available.

Name ____________________

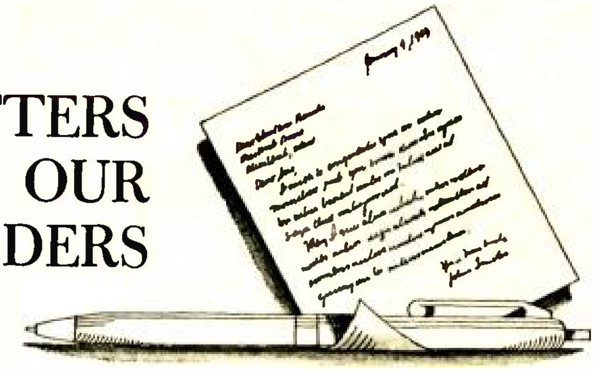
Street ____________________

City __________ State __________ Zip ______

Please state your current occupation: __________

CIRCLE NO. 83 ON READER SERVICE CARD

LETTERS FROM OUR READERS



ELECTRO-OPTICS TECHNICIANS

To the Editors:

The article "New World of Electro-Optics" (November issue) by Louis Arpino was recently brought to my attention. The article called attention to the fact that little or nothing was being done to train optics technicians for industry.

For your information, Triton College, which serves the area in which Mr. Arpino's firm is located, has recently instituted a two-year curriculum in optics technology. Completion of this curriculum leads to an associate degree in science. A well-equipped optics laboratory is currently being completed at our new campus in River Grove. A competent instructor, Mr. Raymond McNamee, has been employed to instruct the optics courses. An advisory committee, consisting of persons from the industry, served to guide us in curriculum development, facilities planning, and eventually student placement.

Gordon K. Simonsen
Dean of Technology
Triton College
1000 Wolf Rd.
Northlake, Ill. 60164

We certainly appreciate hearing from Dean Simonsen and passing along the information that was contained in his letter. We also thank him for sending along a catalogue of the courses of study that are available at Triton College. Incidentally, Triton is a public community college and a technical institute that was founded in 1964. For further details, readers may write directly to the address given above.—Editors

* * *

PHONO-CARTRIDGE BRUSH

To the Editors:

My *KLH* 20 stereo system uses a *Pickering* phono cartridge that has a small dust brush in front of the stylus. In setting the tracking force to the recommended 3-gram value, I find that I get a reading that is about ½-gram lower when the brush is resting on my stylus-pressure gauge than when the brush overhangs and does not rest on the gauge. How should the proper setting be made?

Richard Keen
Concord, Mass.

The tiny brush weighs just exactly 1 gram so that, with the brush overhanging your gauge, this much weight is added to the stylus pressure. Therefore, the tracking force should be set for 4 grams under these conditions. Then, when the stylus is playing a record and the brush is resting on the record surface, its weight is effectively removed and the stylus is actually tracking at the recommended 3-gram pressure.—Editors

* * *

TRANSISTOR BETA VARIATION

To the Editors:

I must take issue with the article "Transistor Beta *vs* Source Resistance" by Rufus P. Turner which appeared in the November issue of ELECTRONICS WORLD. It contains information which is incorrect and very misleading.

First of all, I assume that the parameter referred to as "*beta*" is that more properly symbolized as h_{FE}, the ratio of I_C to I_B. The very nature of the parameter indicates that it is a d.c. measurement and it is the ratio of two current levels. It is true that h_{FE} is indeed a function of collector-emitter voltage, collector current, and temperature. However, h_{FE} is *not* a function of source resistance.

Having read many of Mr. Turner's articles and books, I am surprised that he would make such a presentation as contained in the article. There are two possibilities as to an explanation for the observations which he made in this particular story.

First, it may be that he experienced some form of instrumentation error in which the measurements were not what they seemed. The entire and exact measurement circuit is not shown, so I can only conjecture. Assuming that d'Arsonval meter movements were used to measure the currents, it is possible that some hum or other extraneous signal might have been picked up by the base circuit. This could have induced some error, though I cannot see how it could go unobserved.

Another possibility might be that in some way the transistor was oscillating at some high frequency and here again produced a situation not valid for measurement of h_{FE}.

In an attempt to duplicate the phenomenon reported by Turner, I assembled the test configuration as shown. I used several different types of transistors, including the 2N2712, and varied R_B from 1 ohm to 999,999 ohms. Under no instance was I able to cause oscillation without intentionally inserting external inductances. By connecting a rather lengthy antenna to the base, I could get enough hum pickup to modify the readings, especially with high values of R_B. At low values of R_B, very little pickup sensitivity was noted.

The measured value of h_{FE} for all values of R_B remained constant within reading errors of the meters. Under no condition could I begin to reproduce the effects reported.

If the effect as reported were actually true, then it would be next to impossible to design circuits as *is* done every day. A 4.7 to 1 change in h_{FE} just due to a variation in source resistance would be murder.

CARL DAVID TODD, *P. E.*
Costa Mesa, Cal.

Quite a few of our readers have taken us to task for the conclusions stated in the article. Here are Author Turner's comments.—Editors

To the Editors:

I am indebted to Mr. Todd and others for pointing out the error in my article, and I am properly embarrassed. I read your comments first with a feeling of disbelief and then with a mounting sense of horror. Immediately, I assembled a test setup and discovered your correctness.

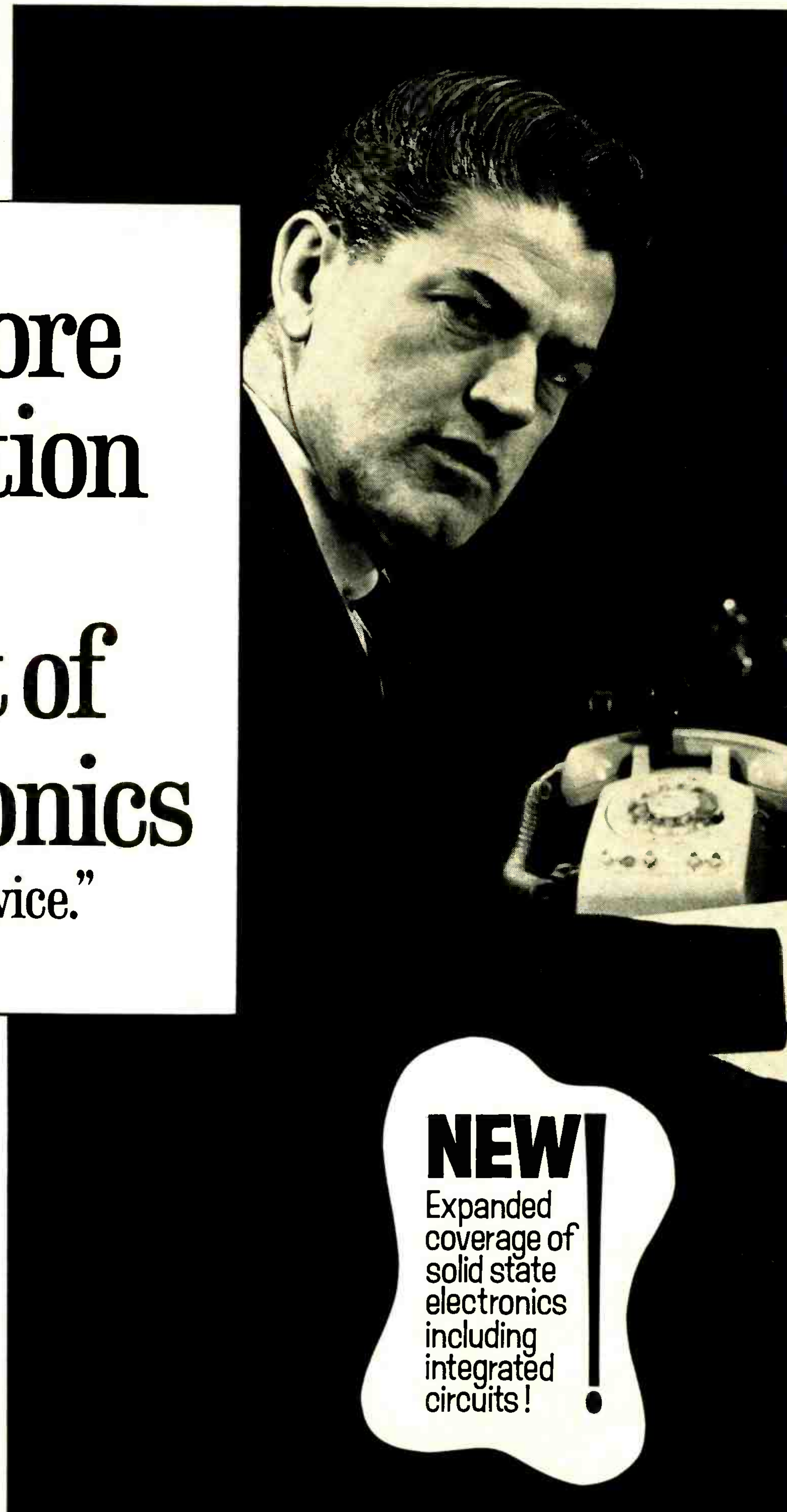
The original work was performed and the article written in good faith, and I don't know what went wrong. It has been some years since the original tests were made, but my recollection is quite clear that each transistor I tested at that time gave results which heeled close to the individual-transistor curve shown in Fig. 2 in the article. To be sure, I was surprised at what I observed, for I knew very well that the source-resistance term appeared in no *beta* formula I had seen. But each of the half-dozen or so transistors in my test sample showed this *beta* variation. And this behavior did indeed seem to explain why a number of my readers had consistently obtained such widely different results with identical-*beta* transistors in a simple d.c. amplifier circuit.

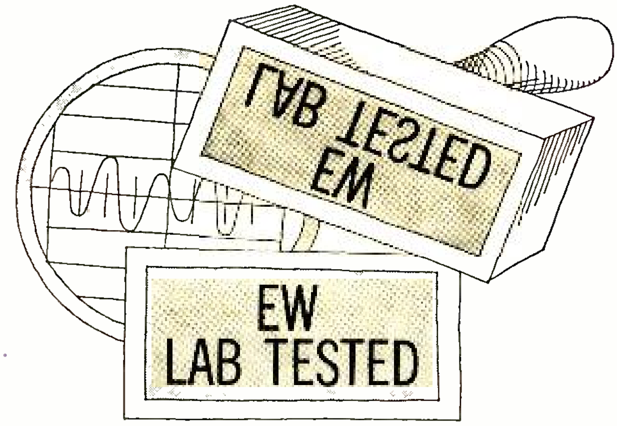
Since I no longer have the transistors, variable d.c. supply, and meters that were used, I regrettably am unable now to determine which is the blamable component. At this time, I can only apologize for any inconvenience or embarrassment the unintentional misinformation may have caused either to you or the magazine.

RUFUS P. TURNER
Altadena, Cal. ▲

"Get more education or get out of electronics

...that's my advice."





HI-FI PRODUCT REPORT

TESTED BY HIRSCH-HOUCK LABS

JBL SE400S Stereo Power Amplifier
Teac A-6010 Tape Deck

J. B. Lansing SE400S Stereo Power Amplifier

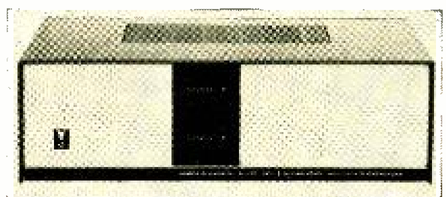
For a copy of manufacturer's brochure, circle No. 29 on Reader Service Card.

IN addition to a comprehensive line of high-quality speakers and speaker systems, *James B. Lansing Sound, Inc.* manufactures amplifiers with state-of-the-art performance. In our December 1966 issue, we reported on the SA600 integrated stereo amplifier, which is as near to perfection as any amplifier we have seen. The basic power-amplifier portion of the SA600, with some modifications, is also available as the SE400S, the subject of this report.

The salient characteristic of the Model SE400S is the use of a powerful direct-coupled differential-input operational-amplifier circuit (which the manufacturer refers to as the "T-Circuit"). Its gain is reduced to the desired level by over-all negative feedback, which not only stabilizes the gain against changes in component values or operating voltages, but reduces distortion to infinitesimal levels.

In common with some other fine power amplifiers, the SE400S appears to be deceptively simple. The only internal adjustments are the d.c. balancing controls, which are used to balance out the no-signal voltage across the speakers.

The amplifier is unusually compact and attractively styled. It measures about 15 inches wide by 8 inches deep by 5 inches high, and weighs a mere 17 pounds. It is installed in a textured olive-colored case with a brushed-gold



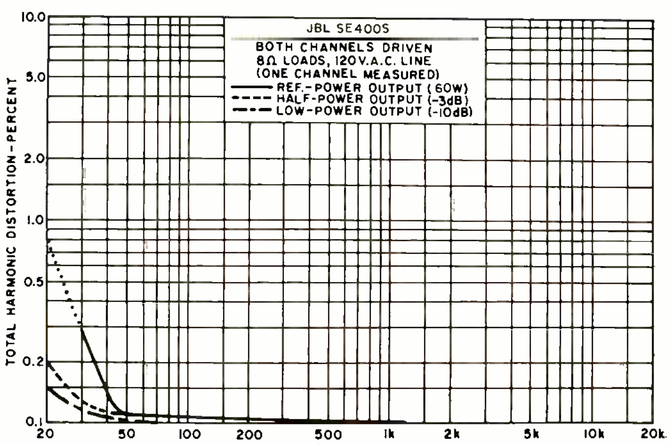
front panel. The inputs and outputs are in the rear. Spring-type binding posts simplify speaker-wire connections. Each channel has a level adjustment for balancing purposes, or to conform to the output capabilities of the associated preamplifier. Incidentally, any preamplifier used with the SE400S has to be able to work into its 35,000-ohm input impedance.

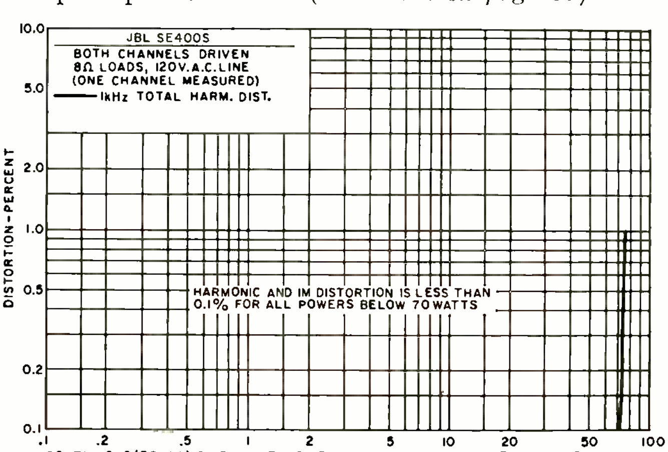
An unusual feature of the unit is its use of plug-in equalizer boards. These are available for any of the manufacturer's speaker systems, as well as for many other systems of different manufacture. When the equalizer boards are plugged in one way, they provide frequency equalization and damping-factor adjustment. If the opposite ends of the equalizer boards are plugged in, the normal high damping factor and flat frequency response are restored. A transparent window on the front of the amplifier permits identification of the installed equalizer without removing the cover. The amplifier has no power switch, but it can be switched on and off from the associated preamplifier. However, *JBL* states that it can be left on continuously, since it consumes very little power under no-signal conditions, and appears to be blow-out-proof under all conditions.

The amplifier is rated by *JBL* at 40 watts per channel output. However, there are no conditions attached to this rating, and the unit is guaranteed to have less than 0.15-percent distortion, either harmonic or IM, at any frequency or frequencies between 20 and 20,000 Hz when delivering a total power of 80 continuous watts into 8-ohm loads.

In the light of our tests, we must say that this is one of the most conservatively rated amplifiers we have ever seen. We could measure no distortion whatsoever at 40 watts or even at 50 watts per channel at frequencies above 30 or 40 Hz. All that our instruments indicated was their own residual distortion, which varies with frequency from 0.06 to 0.09 percent. By establishing 60 watts as the "full-power" reference level, we were able to measure 0.3-percent distortion at 30 Hz. Above 50 Hz it was again practically unmeasurable. At 30-watt (−3 dB) and 6-watt (−10 dB) outputs, the only measurable distortion was at 20 Hz, where it was 0.2 and 0.15 percent, respectively. The 1000-Hz harmonic distortion and the IM distortion were under 0.1 percent for any power output up to 70 watts per channel. The hum and noise were also virtually unmeasurable, at least 92 dB below 10 watts or

(*Continued on page* 60)





Should you be a nitpicker...

Should you be a nitpicker when it comes to selecting a stereo deck? Only if you want to get yourself a deck you'll be happy with for years to come.

Because every manufacturer *claims* to have the "guts" to make the best sound. But, if you had the opportunity to "tear apart" most of the tape recorders on the market, you'd find a lot of surprises inside.

Like flimsy looking little felt pressure pads to hold the tape against the heads which actually cause the heads to wear out six to eight times faster than Ampex heads.

Like stamped sheet metal and lots of other not-so-solid stuff that gets by but who knows how long? And all kinds of tiny springs and gadgets designed to do one thing or another. (If you didn't know better, you'd swear you were looking at the inside of a toy.)

Like heads that are only adequate. Heads that might work fine at first, but wear out sooner and diminish the quality of sound reproduction as they wear.

There are lots of other things, but that's basically what *not to get* in a deck.

Okay, now for a short course in what *to get.*

Exclusive Ampex dual capstan drive. No head-wearing pressure pads. Perfect tape tension control, recording or playing back.

Exclusive Ampex rigid block head suspension. Most accurate head and tape guidance system ever devised. Solid.

Exclusive Ampex deep gap heads. Far superior to any other heads on the market. Last as much as 10 times longer. There's simply no comparison.

So much for the "general" advantages of Ampex decks. Ready to nitpick about *specific* features on *specific* machines? Go ahead. Pick.

Pick the Ampex 755 for example. (This is the one for "professional" nitpickers.) Sound-on-sound, sound-with-sound, echo, pause control, tape monitor. Three separate Ampex deep gap heads.

Or, pick the 1455. For lazier nitpickers, because it has automatic two-second threading and automatic reverse. Plus sound-with-sound, pause control and tape monitor. Four separate deep gap heads.

One more thing you should get on your next deck, whichever one you choose: the exclusive Ampex nameplate on the unit. Just big enough to let everybody know you've got the best. (Who says a nitpicker can't be a name-dropper too?)

So, pick, pick, pick. And you'll pick Ampex. Most straight-thinking nitpickers do, you know.

AMPEX

AMPEX CORPORATION
CONSUMER EQUIPMENT DIVISION
2201 LUNT AVENUE
ELK GROVE, ILLINOIS 60077

Model 755

Model 1455

A deck for nitpickers. And a deck for lazy nitpickers.

CIRCLE NO. 124 ON READER SERVICE CARD

NEW FINCO®

COLOR SPECTRUM™ ANTENNAS

are "signal customized" for better color reception...

"the ANTENNA that captures the RAINBOW"

FINCO has developed the Color Spectrum Series of antennas — "Signal Customized" — to exactly fit the requirements of any given area.

There is a model scientfically designed and engineered for your area.

Check this chart for the FINCO "Signal Customized" Antenna best suited for your area.

STRENGTH OF UHF SIGNAL AT RECEIVING ANTENNA LOCATION	Strength of VHF Signal at Receiving Antenna Location: NO VHF	VHF SIGNAL STRONG	VHF SIGNAL MODERATE	VHF SIGNAL WEAK	VHF SIGNAL VERY WEAK
NO UHF		CS-V3 $11.50	CS-V5 $18.50 / CS-V7 $25.95	CS-V10 $37.95	CS-V15 $50.95 / CS-V18 $59.50
UHF SIGNAL STRONG	CS-U1 $10.50	CS-A1 $19.95	CS-B1 $31.50	CS-C1 $45.95	CS-C1 $45.95
UHF SIGNAL WEAK	CS-U2 $15.95	CS-A2 $23.95	CS-B2 $41.95	CS-C2 $54.50	CS-D3 $73.50
UHF SIGNAL VERY WEAK	CS-U3 $22.95	CS-A3 $32.50	CS-B3 $52.50	CS-C3 $62.95	CS-D3 $73.50

All Prices Subject to Change

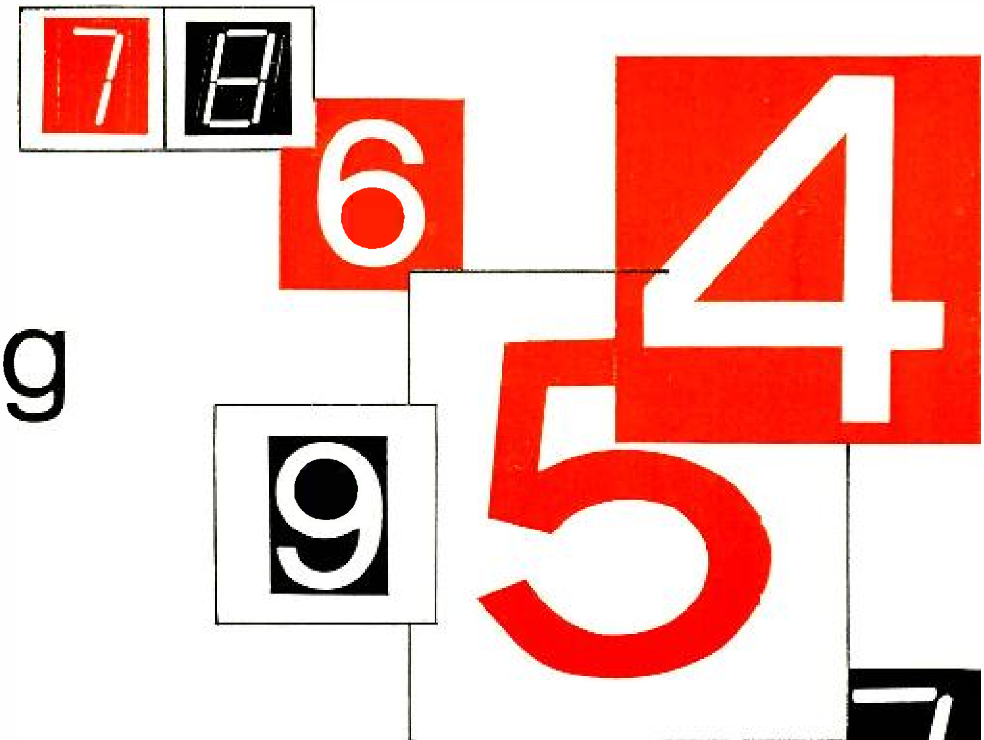
MAKER OF THE WORLD FAMOUS COLOR FINCO BLACK / WHITE ANTENNAS COMPONENTS AND ACCESSORIES

NOTE: In addition to the regular 300 ohm models (above), each model is available in a 75 ohm coaxial cable downlead where this type of installation is preferable. These models, designated "XCS", each come complete with a compact behind-the-set 75 ohm to 300 ohm balun-splitter to match the antenna system to the proper set terminals.

THE FINNEY COMPANY

34 West Interstate Street • Dept. 410 • Bedford, Ohio 44146

CIRCLE NO. 106 ON READER SERVICE CARD



Choosing a Digital Display

By ROD BELL
Director of Engineering
Tung-Sol Division/Wagner Electric Corp.

Almost all new automated equipment needs digital displays. The problem is to choose a display which presents required data effectively, and at low cost.

THE development of automation techniques has brought about important changes in the field of data presentation. A few years ago, it was usually cheaper and easier to obtain data from the deflection of a pointer along a calibrated scale, or by other analog methods, and then have an operator translate the data into digital notation for record and computation. But within the past few years, great masses of already processed information have been readily available in digital form, so the trend has been to digital readout and, recently, more and more to electronic types.

Digital readout, the direct display of characters or coded equivalents, offers the following advantages as compared to analog readout (where input is measured in terms of some parameter such as angular displacement, as in a meter), and digital printout (where input is converted to printed characters, as in a teletypewriter).

Immediate comprehensibility. An in-line digital display requires no translation. It presents information conventionally whereas meter readings frequently involve verniers, multiple scales, logarithmic calibration, and other complications.

Dependability. Digital displays reduce chances of mechanical and human error. Electromechanical readouts sometimes malfunction, but electronic digital displays, on the whole, are as accurate as the information fed to them. They require no instrument calibration.

Speed. Many digital readouts register data as fast as the human eye can follow (about two counts per second). Furthermore, the characters snap into position, to prevent blurring. This is an obvious advantage over a rapidly fluctuating meter, or a slow printout device. And if faster presentation rates are necessary, there are readouts available which operate in milliseconds and microseconds, although these must be "stopped" by photography or special timing pulses.

Flexibility. Many digital readouts can be used as either counters or indicators, depending upon external switching arrangements. In addition to digits (0 to 9), some readouts display letters of the alphabet, full messages, and special characters. Many incorporate dynamic alarms, and some accept, with slight modifications, a variety of inputs—pulses, parallel or serial binary codes, or straight "decimal" selection-switching.

Usually meters handle only one or two closely related units. But with proper switching, the same digital readouts can register widely differing units and symbols, for example, time, temperature, and baseball scores.

Appearance. Many of these devices are quite handsome,

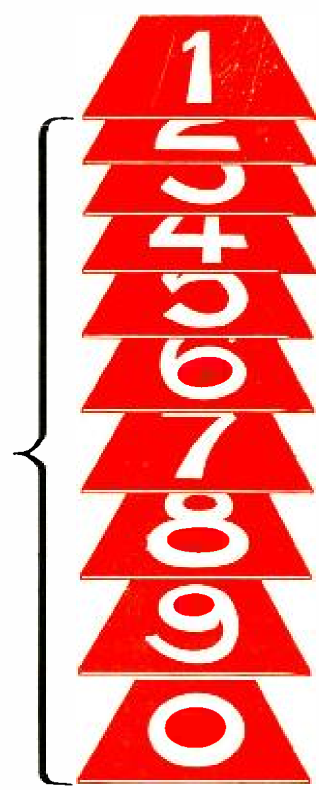


Fig. 1. Edge-lighted displays are used in cold cathode register tubes. Invisible characters become visible when energized. Characters are stacked in depth behind a readout window. Often lab instruments will use displays like these.

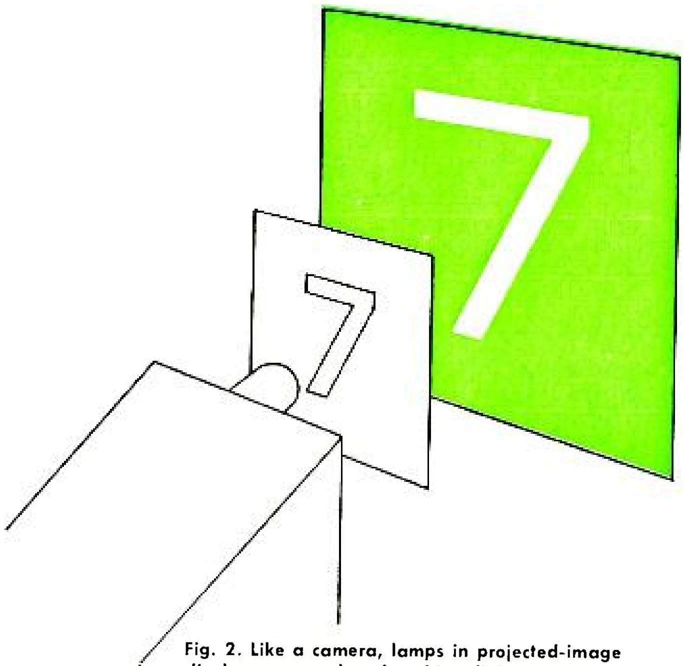


Fig. 2. Like a camera, lamps in projected-image displays are employed to shine digits on screens.

with the strong, clean lines of good modern architecture. They dress up a product—an important factor in today's competitive market.

Table 1 shows most of the basic types of digital displays now available. Of course, it cannot and does not include and compare every make and model but is a guide to help the user eliminate basic types which obviously don't apply to his particular application. It will help him choose those readouts which can display his message most efficiently. It also shows the chief techniques by which digital characters are formed.

Where to Start

When considering digital readouts first determine what must be read, where and in what form it is available, and who must read it.

If, for example, an engineer is working with binary-logic circuits in some form of digital computation, he needs a readout that accepts a binary input. Here, the problem is relatively easy because many readouts work well with binary inputs.

However, some otherwise suitable readouts may require signal amplification. Others are primarily numeric and some are fully alphanumeric. Some have memories of their own while others don't. Some handle straight 8-4-2-1 binary; while others will work with a variety of binary four-line and six-line codes. (The act of changing from one format to the other may involve nothing more than substituting one particular standard logic card for another in the system.)

The selection is large, but some types may be ruled out immediately. For example, if the output is a decimal stepping relay or other form of automatic selection switching, one does not have to consider binary translating devices; but, if a digital readout is required and an acceptable input is not available, the first concern must be the translation equipment. To read an analog error signal, an analog-to-digital (A-D) converter is necessary. A-D converters have digital readouts built in.

There are times when the cost of auxiliary equipment and its weight, bulk, and power requirements preclude the use of a digital display. In this case, a meter may have to do.

The next most important matter of concern is the audience. Will the information be read by one man within a foot or two of the display or by several people scattered at various distances and at various angles to the display face? Will it be read in a brightly lighted room or in semidarkness? By a programmer accustomed to binary notation? A machinist? A clerk? A crowd?

Of course the answer narrows the field of available displays.

The Final Choice

When the primary questions are answered, it is possible to make an intelligent evaluation of competing models that have not been eliminated in the preliminary screening.

A simple but effective method is to score the possible selections on a qualitative point scale—based on manufacturer's data and using the following criteria:

- Readability (consider the individual module and of a row of these modules racked together. Place special emphasis on the spacing between characters. See Fig. 3.)
- Life
- Reliability (When external conversion and switching are involved, reliability of the readout device alone means very little, unless of course, it is compared with a like unit in the same system. Do not rate the reliability of a device, such as a lamp, with that of an instrument which translates data from binary to decimal.)
- Size (unit volume *vs* character height)
- Power requirements
- Weight
- Cost

Score each readout type on these parameters, adding any special considerations of your own and tally the individual columns to make your choice.

So much for the precepts. We can now discuss the basic types of digital readout in fairly specific terms without making unfair comparisons.

The simplest digital display is a lamp array which is nothing more than an arrangement of lamps and sockets, either exposed or concealed by a screen of translucent numerals. But in a lamp array, the message is out of line and difficult to read, thus several means of compensation

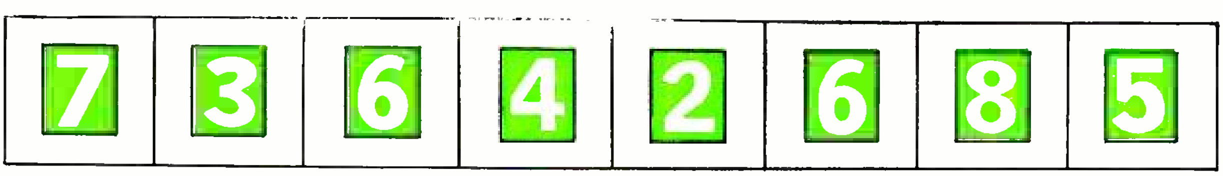
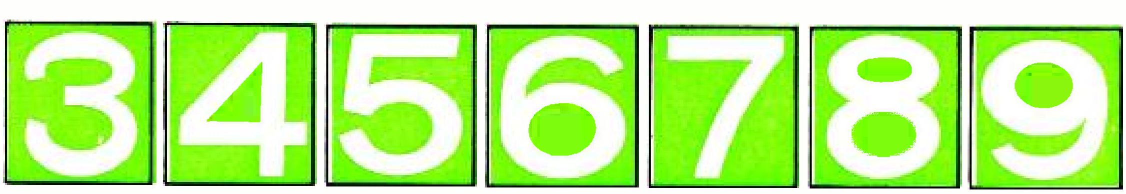
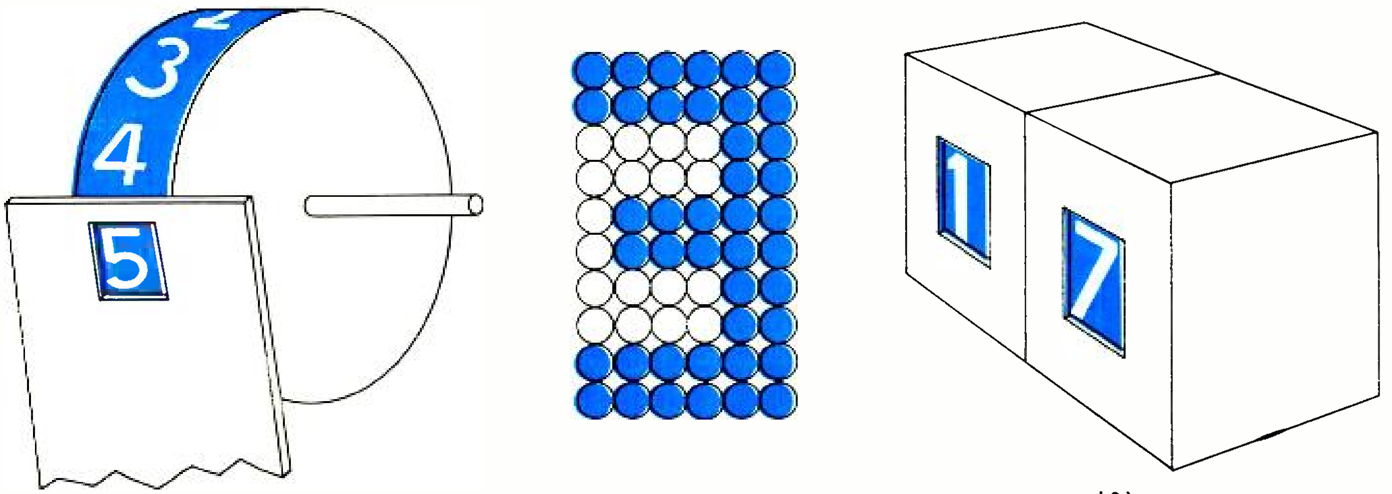


Fig. 3. When you have a choice, don't space characters too far apart . . . or crowd them too close together.





(A) (B) (C)

Fig. 4. (A) Some counters use numerals mounted on wheels or belts, but only one number can be seen at a time. (B) A matrix forms characters by lighting appropriate lamps. (C) Windows should be avoided because they increase spacing while limiting the viewing angle.

had to be devised to bring the indicators into line. The individual out-of-line lamps are no longer read directly. The array is concealed and the lamps are used to illuminate the characters of an in-line readout module. This improves readability without adding expensive circuitry.

Edge-lighted displays (Fig. 1) contain miniature lamps arrayed so that each one can edge-light one of a series of engraved, transparent acrylic plates arranged in depth behind the read-out window. When a lamp is switched on, the character or message engraved in its plate glows through the other plates, which remain unlighted.

These displays are most suitable for laboratory bench instruments, small one-man consoles, vending machines, and other applications where the display is viewed head-on and close up. The volumetric index (we'll elaborate on this term later in the article) improves with message capacity and character size. But there are disadvantages; interference and parallax reduces the viewing angle.

Projected-image displays (Fig. 2) are modules which have lamps arrayed at the rear of a light-tight housing behind a transparent integer outlined on an opaque condensing lens. When a lamp is lit, the character in front of it is projected onto a viewing screen. The major advantages of this display are its versatility and wide viewing angle (up to 150 degrees). The disadvantages include limited brightness, cost, and an increasing volumetric index (ratio of unit volume to character height—wasted space) with increasing character size. Brightness, a function of lamp wattage, is limited by the sensitivity of the module to heat. Character images can be distorted by a slight warping of the plastic lenses or by irregularities in the bulb filament.

Although the following readouts use different approaches and operate on different principles, they are all electronic and offer alternative solutions to the problems of converting electromechanical and electronic signals or pulses directly into readable characters.

Low-voltage vacuum-tube digital displays, a new development by *Tung-Sol*, are sold under the tradename of Digi-Vac S/G. The display is segmented, having seven bars of phosphorescent material. Each bar becomes an anode when supplied with signal voltage of 10 to 40 V d.c. The cathodes are two almost invisible wires strung between the segments and the viewer. Cathode temperature is extremely low because only 45 mA at 1.6 V a.c. or d.c. are needed to energize them. Its advantages are low cost, high intensity, long life, high speed, low power consumption, and a single-plane display which ensures a wide viewing angle and precludes the possibility of read-through or interference of the in-depth displays. An inexpensive metal-oxide field-effect transistor (MOSFET) integrated-circuit package is available to supply decoding, storage, and counting functions.

Register tubes, or Nixies, have stacked elements in the form of metallic numerals with a common anode. They can be adapted for binary coded decimal input by isolating the odd cathodes from the even ones and using two anodes. Plug-in binary translators are also available. The Nixie's major advantages are long life, high speed, low power consumption. However its principal disadvantage is electronic complexity. The cathode current must be kept within tight limits. There is an additional problem; if the ion current is excessive the "off" cathodes will glow and produce background haze, but if ion current is insufficient, there will be only partial presentation.

When negative voltage is applied to a selected character, it glows like the cathode of a simple gas-discharge tube. Usually only the selected numeral is visible in the viewing area because the visual glow discharge is larger than its metallic source.

Matrices (Fig. 4B) consist of neon lamps in optical reflectors banked on a solid mosaic pattern behind a viewing screen. The reflectors are for intensity and focus, not for compensation of an out-of-line array. A solid-state miniature integral counter and decoder network translates sequential pulses directly into digital presentations by turning on lamps to form images. Matrix indicators are capable of accepting binary or straight decimal inputs. They have no counter networks thus their major advantages are high speed and long life. Disadvantages are high cost (if used as indicator alone) and a coarse appearance. Matrices using solid-state light sources in place of lamps are also available.

Electroluminescent panels require extensive external translation circuitry, power packs, and other equipment. Activated by a.c., the lamps are flat-plate luminous capacitors built up on either glass-base sheets or on metal. One typical readout matrix has a glass-base sheet upon which a thin, transparent conductive film has been deposited in electrically isolated geometric segments. The segments form a pattern from which the numerals or letters of the alphabet are composed. Sandwiched between this base sheet and a metallic black electrode is a layer of an electroluminescent phosphor imbedded in a ceramic dielectric. Since light is emitted only when there is capacitive coupling, each segment can be lighted individually when excited by a high-frequency or high-voltage signal applied across its electrodes. The advantages of this display are generally cool operation with low current drawn and few sudden failures. The thin, solid-state lamps dim slowly with age because they contain

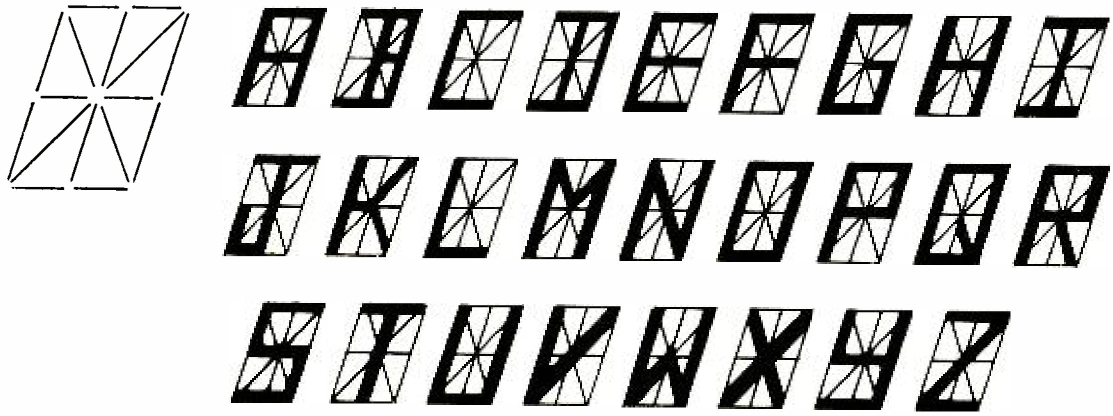


Fig. 5. Sixteen segments form letters and up to 65,000 symbols. Seven segments will form all numerals and 13 letters.

no vacuum, gas, or filaments. The disadvantages are low light level, the need for a high voltage, high-frequency input (240 to 460 V at 400 Hz), and sensitivity to heat, humidity, and surge voltages.

Incandescent bar segments (Fig. 5) are modular displays consisting of either seven or 16 segments on a viewing block, each lighted by a separate incandescent lamp. Various combinations of the seven display all numerals from 0 through 9 and part of the alphabet. The 16-segment type displays all numerals and the complete alphabet. In fact, up to 65,000 combinations are available. This is far beyond the usual demand for various symbols. Each segment, with its own lamp source, is a separate unit. The seven units (or 16) together with an extra one which provides a decimal point, are bonded to the molded viewing block to form a single display. Light is piped from each bulb to the surface of the viewing block through some sort of light pipe or chamber. Some advanced models provide for high contrast between lighted and unlighted segments by means of a 0.025-in thick filter molecularly bonded to the surface of the viewing block. The filter reduces surface glare, but more importantly, it virtually eliminates external lighting of the unlighted segments caused by light striking the surface, traveling down the light pipe, and reflecting back.

The incandescent bar-segment displays are extremely reliable because only the lamps are subject to wear and, in a properly designed unit, the lamps may last more than a 100,000 hours. Maintenance varies with the supplier: some provide for direct lamp replacement, some for lamp bank (sealed unit), and others recommend replacing the whole display. The advantages are light weight, maximum readability (because intensity can be varied as the environment requires), and long life. Disadvantage is high initial cost.

High-voltage vacuum tubes are a recent development that

Table 1. Characteristics of popular digital displays.

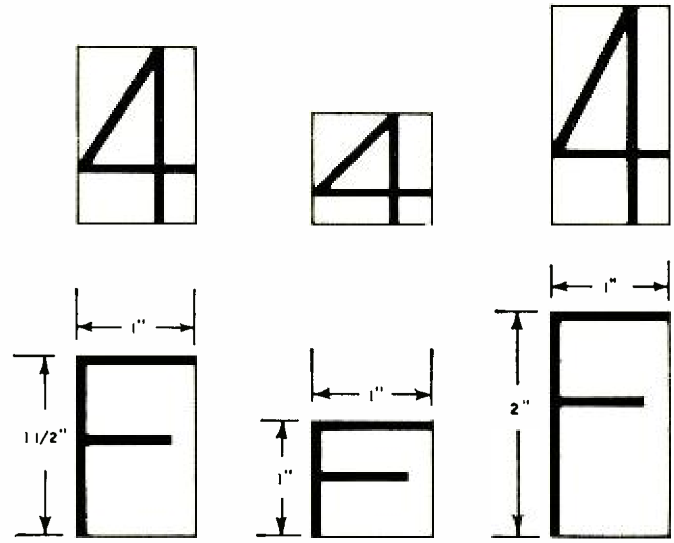
	Edge-Lighted	Projected Image	Low-Voltage Vacuum Tube	Register Tubes	Incandescent Bar Segments
Type of Information Displayed	Numeric or messages	Alphanumeric	Numeric and some alpha	Numeric	7 bar numeric and some alpha.; 16-bar complete alpha./numeric
Capacity per Unit	1-3 messages, numerals 0-9, and decimal	Up to 24 displays	23	10 characters	7 bar (23 characters) 16 bar (unlimited)
Character Formation	Solid, can be color lighted	Solid, usually luminous on dark or colored field	Segmented fluorescent glow	Solid neon glow	Back-lighted segment
Signal Input	6-28 V a.c./d.c. depending on bulb	6-28 V a.c./d.c. depending on bulb	10-40 V d.c.	170-300 V d.c.	4.0-5.0 V a.c./d.c.
Included Angle (°)	30-40	120-150	150	90-120	150
Additional Power Requirement	None	None	1.6 V a.c./d.c. at 45 mA	None	None
Symbol Height (in)	½-1	⅝-3¾	0.57	0.303-2.25	⅛-½
Volumetric Efficiency Index	3.3-9.6	11.7-5	2.0	1.1-2.0	1.5-2.0
Response or Count Rate	Depends on switching	Depends on switching	15-20 m-sec	As low as 10 μsec	15 msec max.
Maintenance	Lamp replacement	Lamp replacement	None	None	Lamp, lamp bank, or module replacement, depending on supplier
Life (hrs)	Lamp life 1000	Lamp life 500-3000	10,000 (est.)	To 100,000	40,000 (avg)
Cost Range ($)	11 (one message)-45	13-35	2 (approx.)	3.95	18 up

combine the rear-projection type display with a cathode-ray tube. A 10-gun CRT projects any one of the 10 numerals through a grid onto a fluorescent screen. Unlike a true CRT display, the gun doesn't scan; each gun is focused through a grid which forms a particular numeral. The advantages are relatively low cost, brightness, single-plane for good readability, and light weight. The major disadvantage is the need for a high-voltage (2.5 kV d.c.) power supply, although the over-all power consumption is low.

Solid-state bar segments are very similar to the incandescent bar segments except the light source is a gallium-arsenide phosphide instead of an incandescent lamp. This means that life is practically infinite (failures are indicated by a gradual dimming of the light source) but, in terms of today's development, price is high and brightness is limited compared to the incandescent type.

Cathode-ray tubes are usually custom-engineered for highly specialized applications. And most are military. Several products can be considered stock items, such as shaped-beam cathode-ray tubes, and character generators that can write decimal information on conventional tubes. Complete systems provide alphanumeric information positioned on detailed maps, catalogue formats and page prints.

Digital character formation on this level is generally accomplished either by extending an electron beam through individual "character cutters" pierced in a stencil-like mesh or by generating X and Y deflection voltages that cause the cathode-ray to trace out a fixed character matrix. On command, selected segments are intensified to produce the required character.



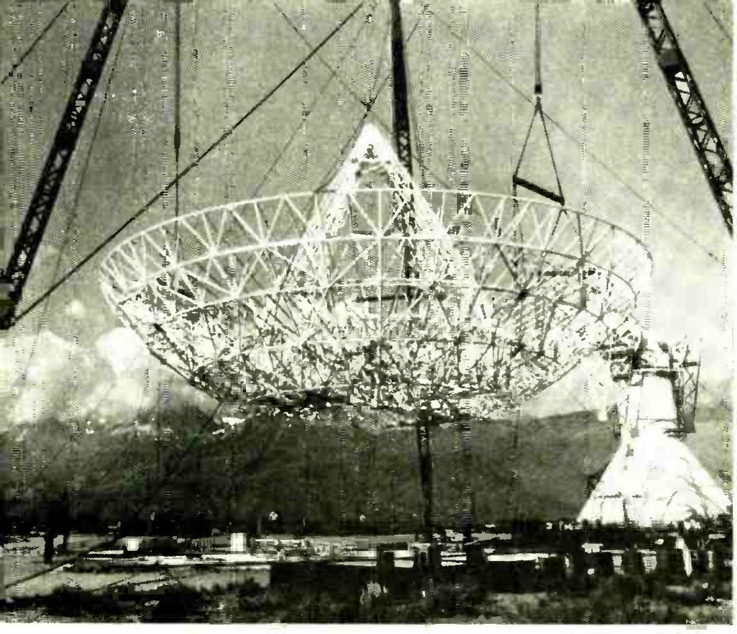
(A) (B) (C)

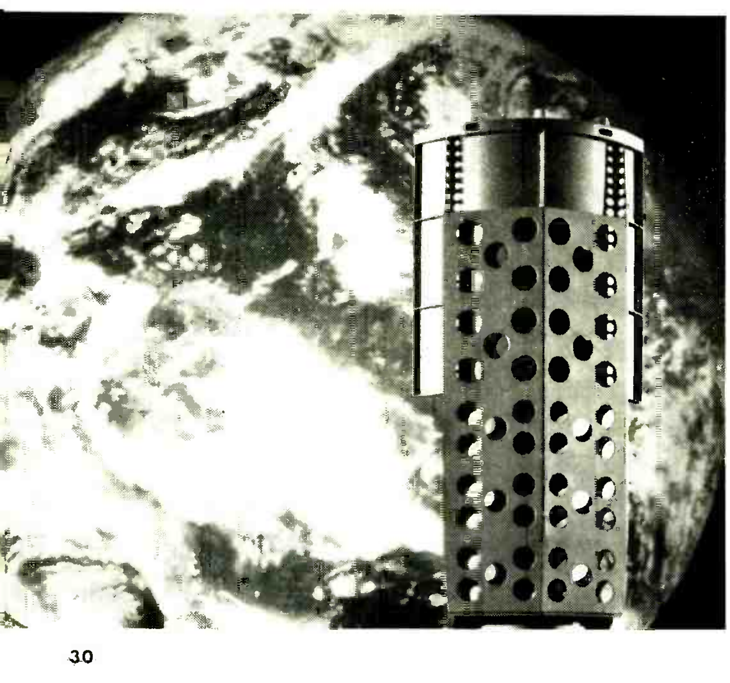
Fig. 6. Vary character size according to the spacing available. (A) is normal; (B) is for wide spacing; and (C) is for close spacing.

Volumetric Efficiency Index

The volumetric efficiency index is used in this article as a means of relating size efficiency. It is the ratio of unit volume to character height (Fig 6) and is applied only to modular units since it would be unfair (and unrealistic) to compare readouts of different types (particularly those that have decoding and memory capabilities with those that do not.). If a unit requires external equipment to provide equivalent performance, the gross volume of the external equipment should be included. The unit with the lower number is, of course, the more efficient. ▲

Matrices	Electroluminescent Panels	High-Voltage Vacuum Tube	Solid-State Bar Segments	Cathode-Ray Tubes
Alphanumeric & symbols	Numeric & some alpha.; alphanumeric	Numeric; symbols; messages	7-bar numeric & some alpha.; 16-bar complete alphanumeric	Alphanumeric, with special symbols, superimposed pictorial data, etc.
Unlimited	0-9, + —, 16 letters 0-9, + —, 26 letters	10	7 bar (21 characters) 16 bar (unlimited)	Full alphabet, all numerals, many special symbols
Dot formation	Segmented glow	Fluorescent glow	Back-lighted segment	Solid or imperceptibly segmented trace
Depends on light source	Complex selective switching	6.0 V d.c.	2-50 mA	Computer codes
To 90	Wide	90	150	Varies
Varies from 1 V d.c. for solid state to 110 V a.c. for lamps	240/460 V a.c. at 60-1000 Hz	2.5 kV d.c., 1.1 V at 0.2 A	None	Varies
Wide range	⅜-2¾	⅝	0.32	Variable at will
Wide range	2.3-4.8	3.5	0.5	Not applicable
Depends on switching & light source	msec	20 msec	1.0 μsec	μsec
Depends on light source	None	None	None	Periodic
Can be infinite, depending on light source	3000	10,000	Indefinite	Varies
25 up	15-50	14	50 up	1400-1500 for character generator; 5000-100,000 for display console





RECENT DEVELOPMENTS IN ELECTRONICS

130-Foot Radio Telescope Installed. (Top left) This huge antenna reflector being lifted to its pedestal at the right is the first of eight that will pick up radio signals from outer space. The reflector has since been completed and sheathed with 852 panels of aluminum surface. The installation is for California Institute of Technology's Radio Observatory in Owens Valley. The completed system will make this the world's most powerful and flexible observatory for studying radio sources in and beyond our galaxy. With the aid of smaller antennas at the Observatory, Caltech has already played a major role in the discovery of quasars, in locating and classifying radio objects, and in mapping exploding stars and other objects in our galaxy. The 120,000-lb dish was built by Westinghouse.

Laser Charts Nerve Routes. (Center) A laser and a marine snail have formed a partnership that may help man learn more about the body's nervous system and how it sends impulses to the brain. The snail was chosen for the experiments by Bell Labs scientists because its nerve cells are relatively large. By irradiating the snail's nerve fibers with a laser beam, it is possible to selectively stimulate nerve cells without damage and provide clues on how cells are connected. The laser beam affects the nerve cells in two ways: (1) it increases the conductance through the cell membrane of ions that travel in and out of the nerve cells, and (2) it increases the action of a pumping system that moves the ions against a concentration gradient. The pumping system maintains the balance of ion concentration necessary to the cell's functioning. It is important to study this phenomenon because human nerve cells are known to exhibit similar changes in generating nerve impulses. By learning more and more about nervous-system communications, scientists may be able to improve considerably on our cruder wired and wireless communications systems.

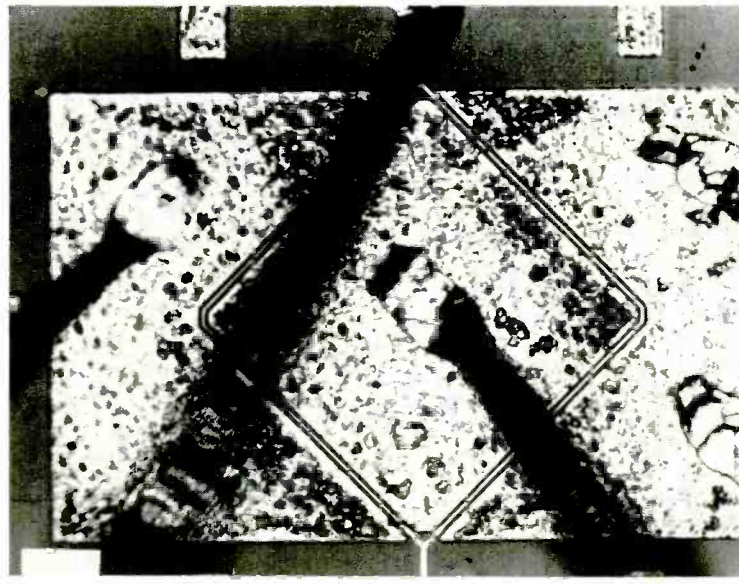
Advanced Antenna for TV Satellites. (Left) Color-television coverage of the recent Olympic Games in Mexico City was made possible in Europe by means of the advanced antenna shown in the photo. The 14-lb antenna is on the Applications Technology Satellite 3, which is in a synchronous orbit at an altitude of 22,300 miles above the Atlantic Ocean, east of Brazil. The experimental satellite beamed the video portion of the telecast to the Goonhilly Downs earth station in Cornwall, England, for relay to the continent. This satellite was pressed into service as a substitute for the first Intelsat III, the newest commercial communications spacecraft, which was destroyed Sept. 18 when its launch vehicle malfunctioned. The antenna system, made by Sylvania, also transmitted NASA's first color photograph of the earth from an unmanned satellite. This particular photograph, which is shown in black in white, is in the background.

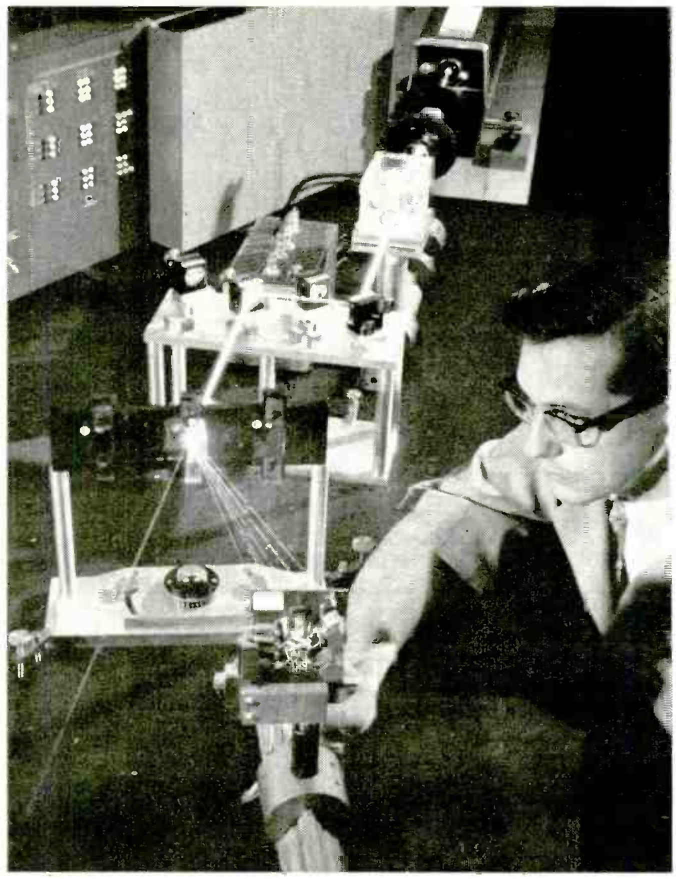
MESFET Oscillates at 12 GHz. (Top right) The photomicrograph shows an experimental MESFET (Metal Semiconductor Field Effect Transistor) which has oscillated as high as 12 GHz. Differing from a conventional IGFET, this device is a Schottky-gate transistor that does not have an insulating layer between the metal gate and semiconductor channel. Instead, rectifying contact is formed directly at the interface. In this experimental IBM device, the square central drain is completely enclosed by the gate, in the form of legs paralleling the sides of the square. The large notched areas at left and right form the source electrode of the experimental device. Gate width is only 1 micron.

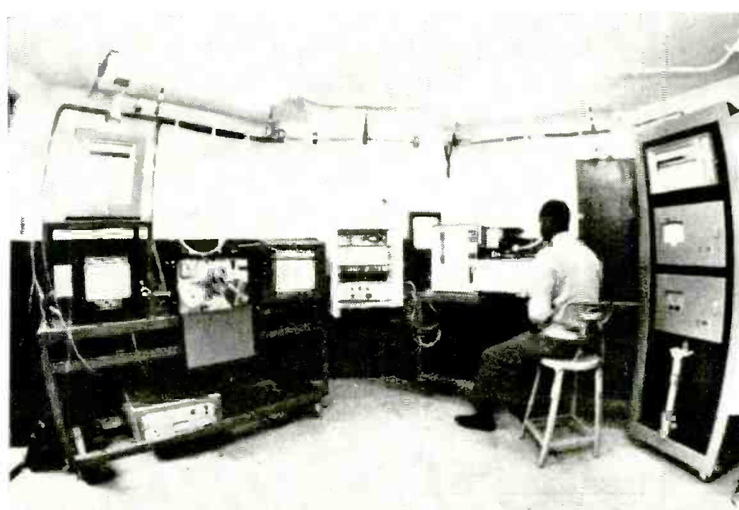
Experimental Laser Memory. (Center) This optical memory system transmits blocks of computer data recorded on a holographic plate a thousand times quicker than conventional storage devices. The intensive light of a laser is aimed at the plate at which the beam is split. The emerging light beams then go to a light-sensitive detector array. The optical information is converted to electronic signals and used by the computer. More than 100 million bits of information could be placed on a 9-in holographic plate in this experimental IBM system.

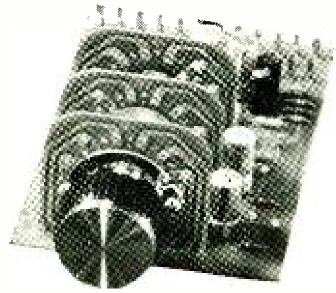
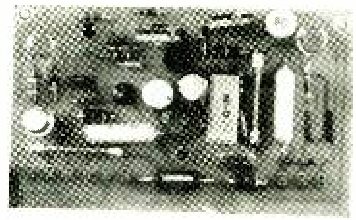
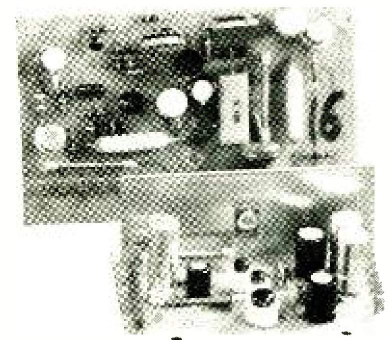
Gallium Phosphide Photomultiplier. (Below left) A radically improved photomultiplier tube with a first dynode stage that is ten times more efficient than those presently in use is shown here. By using a layer of gallium phosphide, the first dynode produces an average of 30 secondary electrons for every primary electron that strikes the surface. By contrast, the best conventional materials produce an average of only 5 secondary electrons. What is more, by raising the applied voltage, the ratio is still further increased with gallium phosphide. In fact, secondary emission gains greater than 100 have been measured. Conventional materials have intrinsic limits that are 10 times lower. Improved material is used in new RCA photomultiplier.

Air-Pollution Monitor. (Below right) New York City's Mayor Lindsay recently threw the switch on what is said to be the largest and most comprehensive air-monitoring system ever put together. Consisting of 38 monitoring stations, 10 of which are entirely automatic, the system provides real-time information on pollution concentrations and weather patterns throughout the city. The computer-controlled telemetry system, developed by Packard Bell, ties the monitoring stations together. All the information will provide a daily air pollution index for the public. The stations, like the one shown here, will check on dustfall, suspended particulates, sulfur dioxide, and carbon monoxide, as well as wind direction, wind speed, and air temperature.





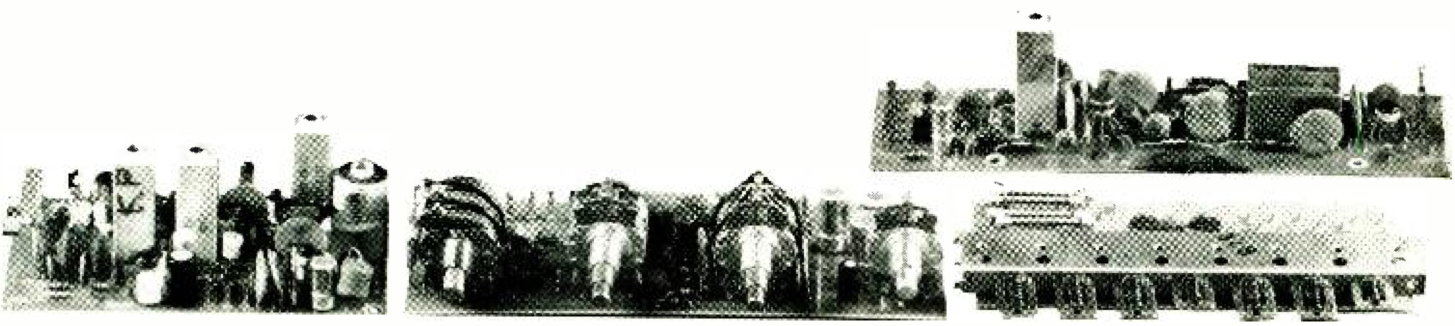


new concepts in
HI-FI RECEIVER DESIGN

By LAWRENCE W. FISH, Jr./Chief Development Engineer
and KLAUS J. PETER/Project Engineer
H. H. Scott, Inc.

Performance specs on the better receivers are close to their theoretical maximum values. Manufacturers are looking toward different approaches to improve their products. One company is going to the use of computer-like circuits, specially designed IC's, and a modular construction technique.



Prototype modules that will make up many of the new Scott Model 33 receiver designs are shown above.

DURING the past year, hi-fi receiver manufacturers have reached a stalemate on performance specifications for their stereo equipment. The striking progress made in the sophistication of semiconductors to a state of near perfection has made it possible for engineers to design units whose performance approaches the theoretical maximum. Consequently, specifications for competitively priced equipment reveal a remarkable similarity.

In a progressive and competitive field, such as the electronic home-entertainment industry, a stalemate of this kind can be broken only by radically new developments. Both manufacturers and engineers ask themselves, "What next?" Some may come up with changes in appearance, others may add new switches, dials, and meters. We believe that the answer lies in electronic innovation as well as in "human engineering."

Machines should be made simpler to operate as they become more complicated and sophisticated. More features are highly desirable—thus there is an increase in complexity; at the same time, it is essential that the equipment be simple to operate. No one wants to be faced with a confusing array of knobs and switches. One way that the design engineer can solve this dilemma is by employing computer techniques and designing a unit that can, to an extent, think for itself.

Comparator Tuning Indicator

Computer-like circuitry provides automatic operation, which means optimum performance with a minimum of time-consuming adjustments. The first example of this can be found in the tuner section of our new receiver. A signal-strength meter, which is normally used for tuning, may prove useless on very weak signals. Even on strong stations this method requires a certain amount of trial and error, due to the wide bandwidth of an FM receiver. To simplify and improve the accuracy, we have a sign which lights up and indicates "Perfect Tune" when the receiver is correctly tuned to the desired station. This is not a sales gimmick but an example of "human engineering."

This apparently simple feature is made possible by a computer circuit called a *comparator*. The output of a properly aligned FM detector is a voltage ramp as the user tunes past a station. As the exact center of the station is reached, the output voltage is zero. The "Perfect Tune" light circuit (Fig. 1) consists essentially of a differential amplifier whose inputs are connected across the detector output. Both outputs of the differential amplifier are fed through an "or" gate to an electronic switch which controls the light bulb. Since interstation noise also produces an average voltage output of zero, high-frequency noise is filtered, amplified, rectified, and used to extinguish the "Perfect Tune" light between stations. This circuit will respond equally well to weak or strong stations, and provides an easier-to-use indication than does a zero-center tuning meter. The signal-strength meter has been retained mainly for determining optimum antenna orientation.

The heart of the i.f. amplifier preceding the FM detector is a quartz crystal filter which never needs alignment, and has bandpass characteristics superior to an *LC* network (Fig. 2). In addition, improved phase linearity over the entire bandwidth reduces distortion and consequently im-

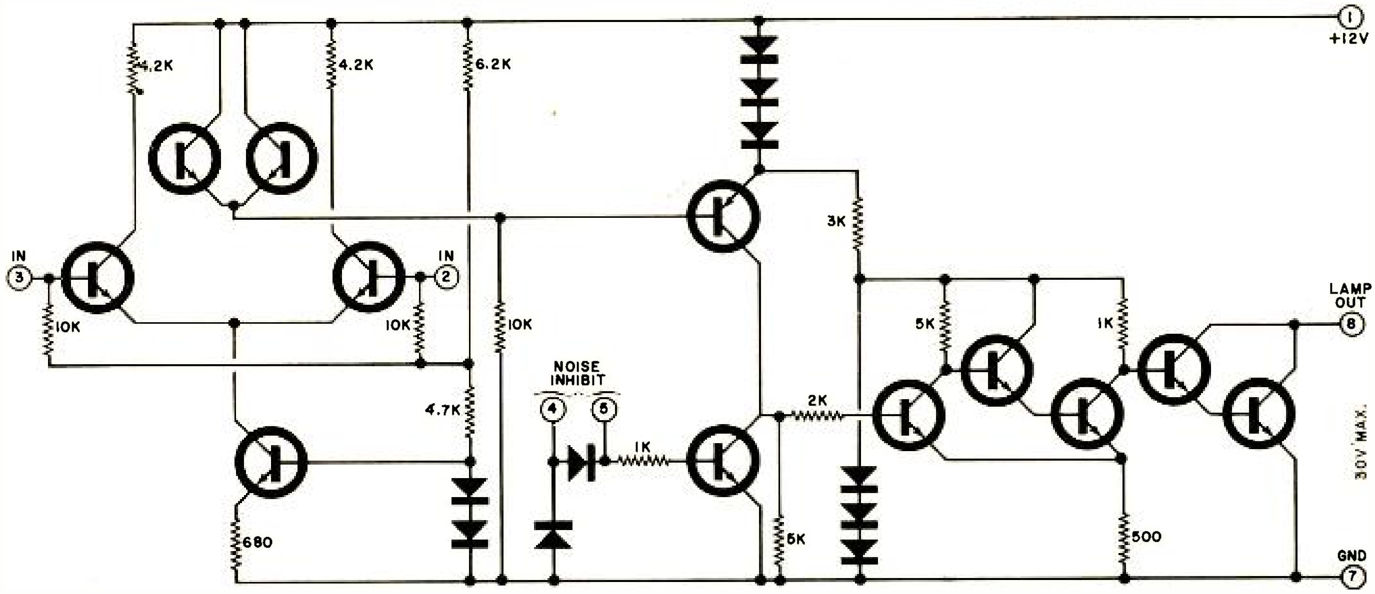


Fig. 1. Circuit arrangement used for the "Perfect Tune" light consists of a differential amplifier connected to the detector output. Outputs from the amplifier are fed through "or" gate to an electronic switch controlling a light bulb. Interstation noise is filtered, amplified, rectified, and used to turn off light between stations. Entire circuitry that is shown here is in a single IC chip.

proves stereo separation. High-frequency IC's provide 120-dB gain for limiting even at low signal levels, resulting in maximum AM suppression.

A number of semiconductor manufacturers are custom-designing IC's especially for the consumer market. The multiplex decoder as well as the tuning-indicator IC are such custom-made devices; they represent a combined effort by *Scott* and *Motorola*.

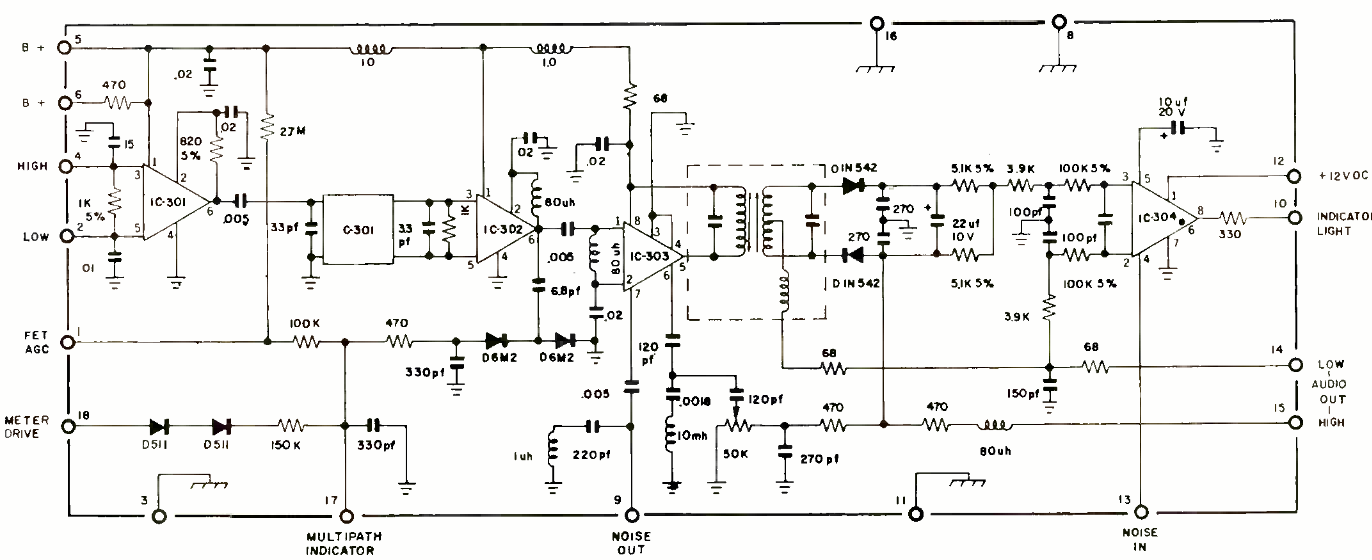
IC Multiplex Decoder

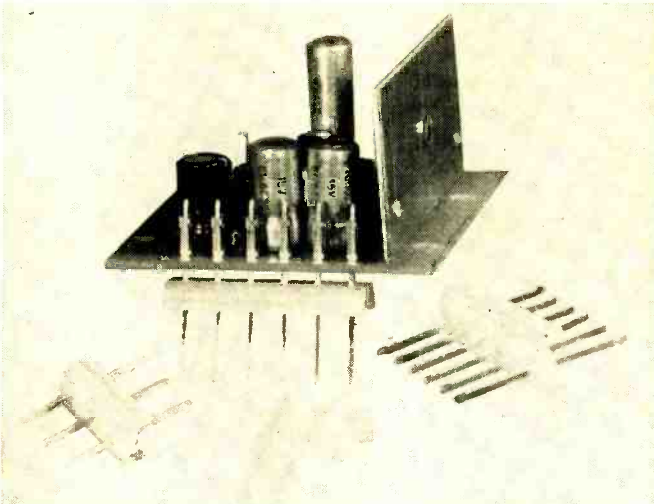
The IC multiplex circuit (shown in Fig. 3) features automatic stereo switching plus a noise-operated squelch. The minimum acceptable signal strength to provide good stereo is approximately 20-dB higher than that necessary for mono listening. The listener living in a fringe reception area is usually aware of this and couldn't care less about any sunspot solar activities that may make stereo reception impossible but allow adequate mono listening. Once again, computer circuits take over and make the decision for the listener—who never need miss a second of his favorite program.

The detected audio multiplex signal is fed to terminal 3 which is connected to the base of transistor Q3. The emitter of Q3 drives Q4 through a pair of resistors, and the emitter of Q4 in turn drives the base of Q9. Q8 and Q9 are connected in an emitter-coupled configuration with their collectors driving the pairs of switching transistors Q10, Q12 and Q11, Q13. Notice that the collectors of the switching transistor are cross-connected. This results in cancellation of the 38-kHz signal.

Going back to the emitter of Q3, we have a second pair of resistors that join to the base of Q5 and terminal 2. At terminal 2, a 19-kHz resonant circuit is connected to form a bandpass filter. Q5 also has another 19-kHz tuned circuit in its collector which feeds the base of Q29 and Q6, the second and third 19-kHz amplifiers. Q7 is the 19- to 38-kHz class-C doubler. The diode-connected transistors, *D*1, *D*2, *D*3, and *D*4 in the base circuit of Q7 act as limiters so that

Fig. 2. The i.f. strip of the receiver uses high-frequency integrated circuits along with a quartz crystal filter (shown between the first two IC's) which never needs alignment and has improved phase linearity over entire bandwidth. The meter-drive output (terminal 18) is for the signal-strength meter while multipath-indicator output (terminal 17) is also fed to the meter in some tuners in the company's product line. With no multipath distortion, the output across the receiver passband is flat so that the rectified output of this fast time-constant circuit is zero. If there is multipath, there will be some rectified output from this circuit and there will be a reading on the meter. The indicator-light output (terminal 10) illuminates the "Perfect Tune" lamp to show exact tuning of stereo signal.





Close-up of receptacles and plugs used to interconnect modules.

the phase and amplitude of the 38-kHz switching voltage remain constant. A 38-kHz tuned circuit is connected between terminals 10 and 13 to clean up the 38-kHz waveform before it is applied to the bases of the switching transistors. When the 19-kHz signal drives Q7 into class C, there is a voltage change on its emitter. This is fed to the bistable flip-flop, consisting of Q24, Q25, and Q26. It changes state and turns on the light drivers Q27 and Q28. The light, of course, indicates a stereo signal.

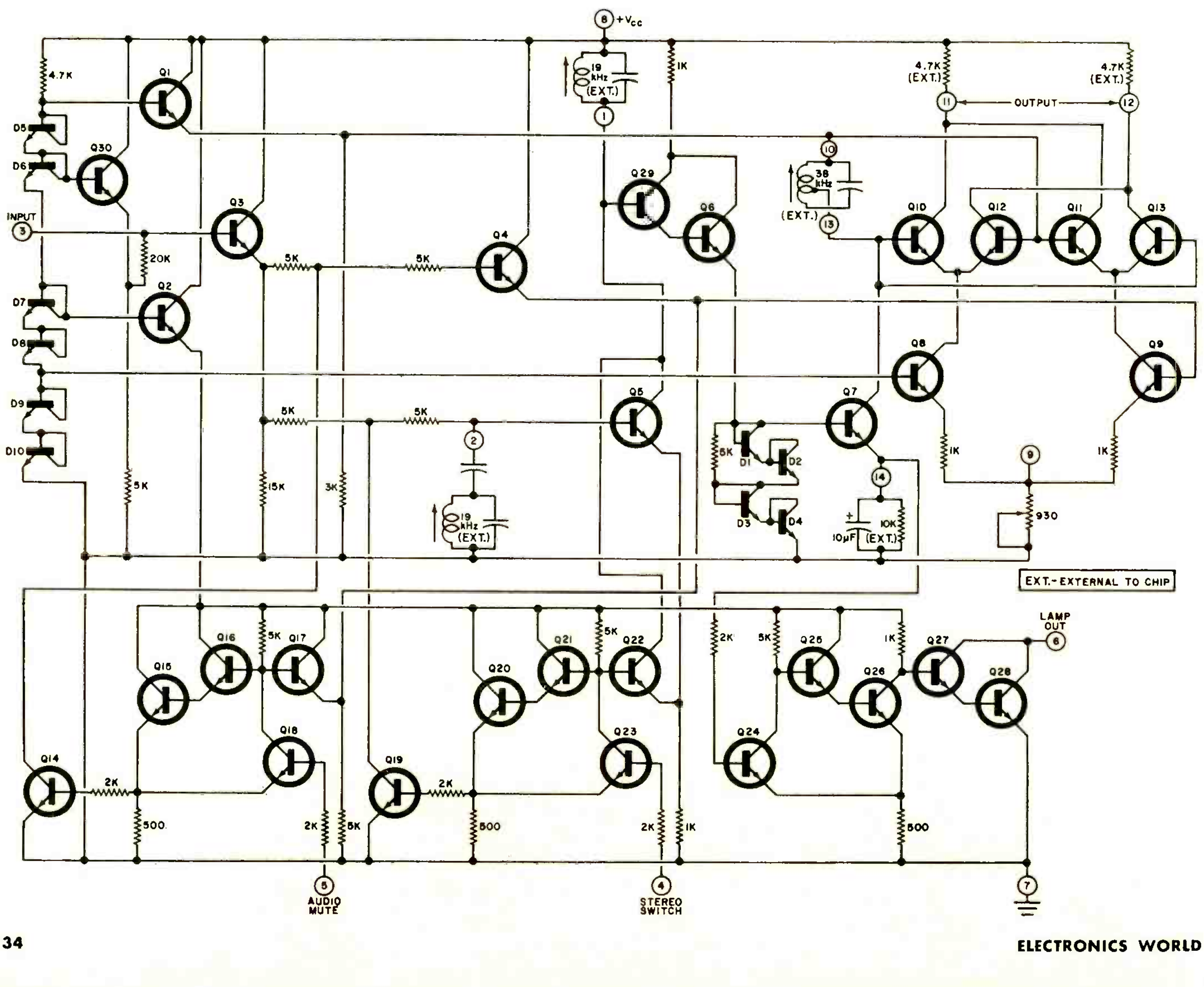
A separate circuit amplifies and rectifies random noise and the resulting d.c. is applied as a bias to terminal 5 of the IC. The bias keeps the bistable flip-flop Q15, Q16, and Q18 in a state which causes Q14 and Q17 to conduct. Q14 shunts the audio signal path to ground and cuts off transistor Q4. Q17 keeps the voltage at the base of Q9 constant. When a station is received and the noise drops to a predetermined level, the action is reversed and the signal is passed through the IC. The same noise-derived bias is also applied to terminal 4 but at a higher level so that the stereo switching function takes place after the muting gate is opened. This way, the greater signal-to-noise requirement of stereo reception is taken into account. Q19 is driven by the bistable flip-flop Q20, Q21, and Q23 and either shunts or passes the 19-kHz signal.

Amplifier Section

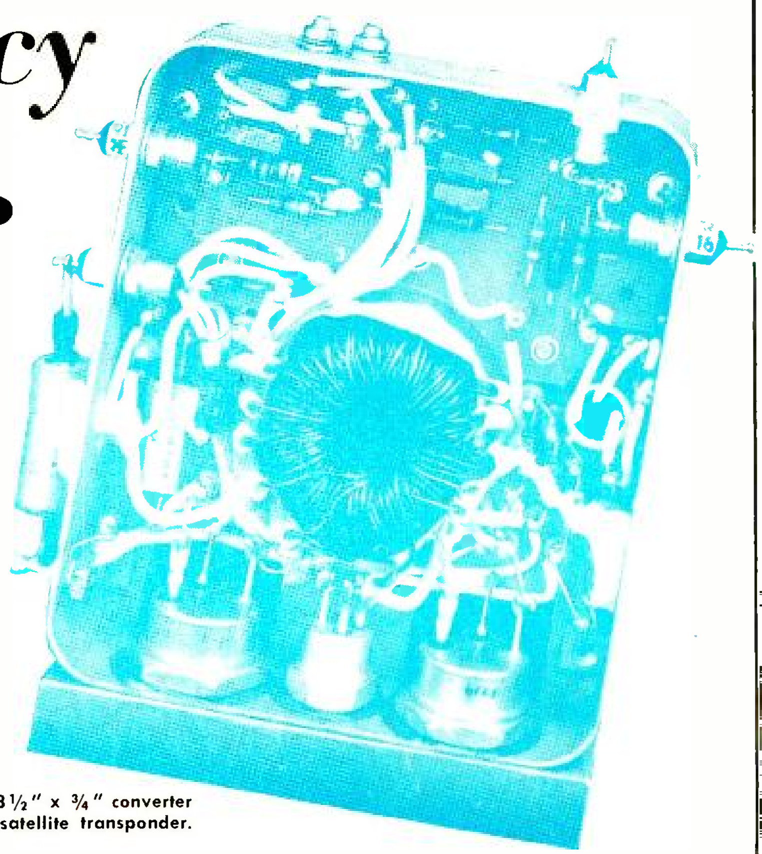
The preamplifier section contains the input selector switching facilities as well as the latest low-noise dual operational IC amplifier (see "IC Op-Amp Hi-Fi Preamplifier" by D. R. vonRecklinghausen in the June, 1968 issue). This state-of-the-art device was developed jointly by *Scott* and *Motorola* for hi-fi stereo applications. The tone control consists of an active filter circuit built around two FET's. With the tone controls in the flat position, the voltage gain of the circuit is unity. All low-level circuits receive power from an electronic regulator which derives its voltage from a zener diode reference. The regulator is short-circuit-proof for fail-safe operation.

The driver and output stages are (*Continued on page 69*)

Fig. 3. The multiplex decoder has automatic stereo switching and a noise-operated squelch. This entire decoder circuit, except for the components indicated as being external, was custom-designed into a single integrated-circuit chip.



High-efficiency D.C.-D.C. Converter



This 3″ x 3½″ x ¾″ converter powers a satellite transponder.

By SAMUEL LEVY, Design Specialist
and W. L. BLAIR, Project Manager
Cubic Corporation

The "Regverter" is a new kind of solid state power conversion device which uses a d.c. converter as a series regulator to obtain high efficiency.

MANY mobile electronic systems have operating voltages quite different from their source potentials and, quite naturally, they use some kind of voltage-conversion device. One of the newest of these, a "regverter" (contraction of the words *regulating* and *converter*), combines a series-type regulator and a d.c.-to-d.c. converter to achieve excellent performance characteristics while retaining simplicity and high reliability.

Actually, the regverter was designed for use with space electronics equipment and therefore had to be able to operate under the most severe environmental conditions. For example, one regverter was packaged into a 3″ x 3½″ x ¾″ module for use with satellite-transponder equipment. The power supply was turned on twice a day (for 10- to 20-minute intervals) to operate the transmitting equipment. An interesting point is that the satellite itself was designed to have a minimum life of one year continuous operation, but after more than three years in orbit, both the satellite and the regverter are still in good operating condition.

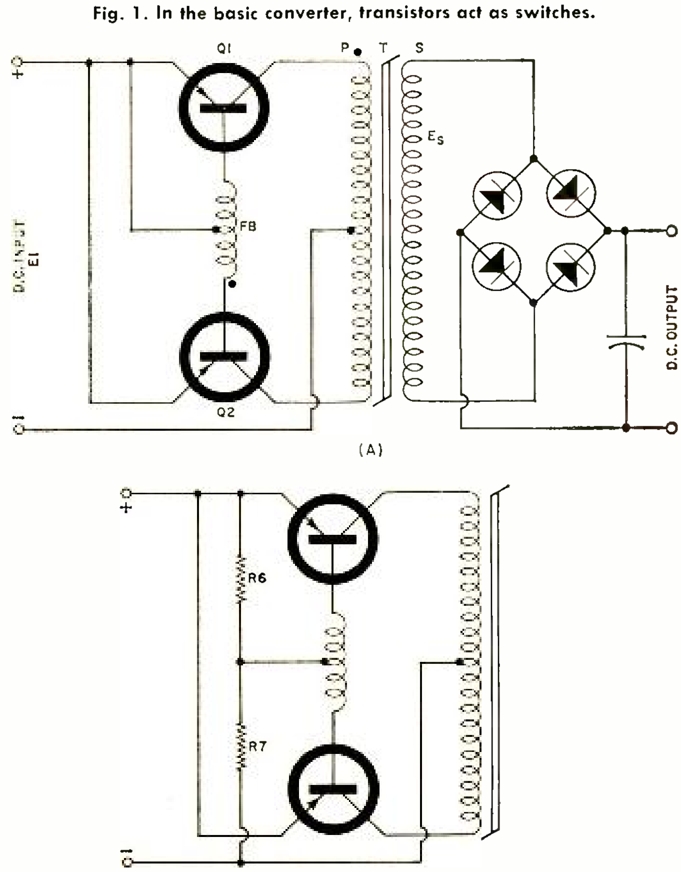
Here are some important performance advantages which the regverter offers the circuit designer: (1) simplicity and low cost; (2) high reliability; (3) good line and load regulation; (4) improved efficiency; (5) better heat dissipation; (6) minimal filter requirements; (7) overload protection; (8) reliable starting; (9) low radio-frequency interference; (10) constant current over the input voltage range; (11) constant switching frequency over the input voltage range. The last two characteristics result from the converter's d.c. input being held constant by pre-regulator action. This is especially valuable in situations where a stable a.c. supply is required for operation of 60- or 400-Hz equipment.

Circuit Theory

Fig. 1A shows a very basic converter circuit. Transistors Q1 and Q2 function as single-pole, single-throw switches and alternately connect the positive supply voltage to first one end and then the other of the transformer's primary, while the center tap remains connected to the negative return.

On-off switching of the transistors is controlled by the

Fig. 1. In the basic converter, transistors act as switches.



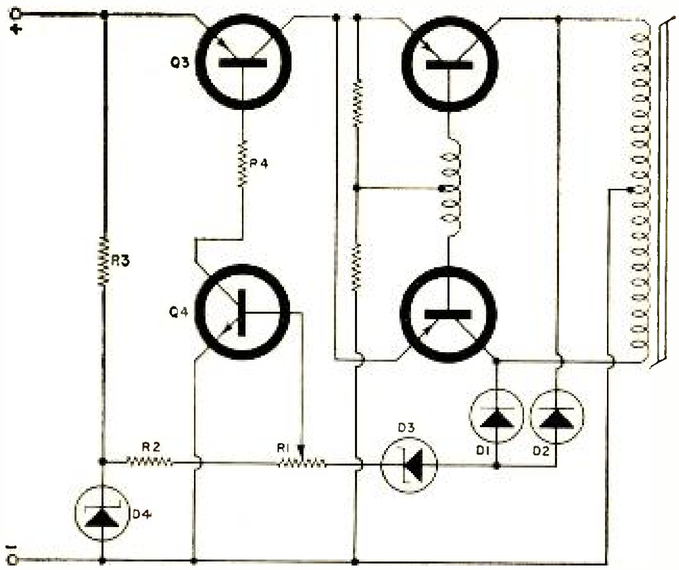


Fig. 2. Basic unit has series regulator as added attraction.

feedback winding (FB) on the transformer. If the windings are phased as shown by the dots on the schematic, feedback is positive and the circuit acts as a regenerative square-wave oscillator.

Remembering that transistors require forward bias for emitter-to-collector conduction, it is apparent that some uncertainty exists in getting the oscillator to start. In fact, this is the major difficulty with this simple circuit. At even moderately reduced temperatures, starting is inhibited completely. However, if the transistors were germanium, there would be sufficient leakage current (I_{co}) within the transistor to couple the turn-on voltage transient to the transformer and initiate the regenerative process.

Assume that Q1 has slightly higher current gain than Q2. The negative voltage from the feedback winding quickly drives Q1 into saturation, and the current increases linearly at a rate determined by the inductance in the primary winding. Current increase continues until the iron in the transformer core saturates. At this point, the magnetic lines of flux are no longer changing and consequently do not continue to induce voltage in the feedback winding. Without base drive, Q1 must shut off. This, of course, reverses the polarity of the feedback voltage and forces Q1 off and turns Q2 fully on. The bottom half of the primary winding then passes an increasing current until the transformer core saturates in the opposite direction. The subsequent lack of feedback voltage initiates the switch back to Q1 and the cycle is ready to start again. Neglecting saturation voltage across the transistors, IR losses in the windings, and hysteresis losses in the iron—the voltage appearing across the secondary is

$$E_s = E_1 \times \frac{N_s}{N_p/2} \qquad (1)$$

where N_p and N_s are the number of turns in the primary and secondary respectively.

Standard transformer iron may be used successfully in this type of converter, but hysteresis losses are extremely high and its relatively gradual approach to saturation slows down the switching action. This lowers efficiency and increases the peak currents drawn from the primary power supply. It is better to use one of the "square hysteresis loop" materials such as *Deltamax* or *Orthonol* tape-wound toroidal cores.

However, the poor starting characteristic of this simple circuit at low temperatures is readily overcome by the addition of two resistors (R6 and R7 in Fig. 1B). A few tenths of a volt across R6 serves to increase the static current flow through both Q1 and Q2 to a point where reliable starting is assured even at very low temperatures. Efficiency is still degraded due to the voltage divider current, but R6 does serve as a limit to base current for transistors having different current gains.

This simple converter has many applications where regulation is not required. However, it is totally inadequate when used to supply power to voltage-sensitive circuits because the output voltage is directly proportional to input voltage, and varying loads will produce output voltage variations due to voltage drops across various elements within the converter.

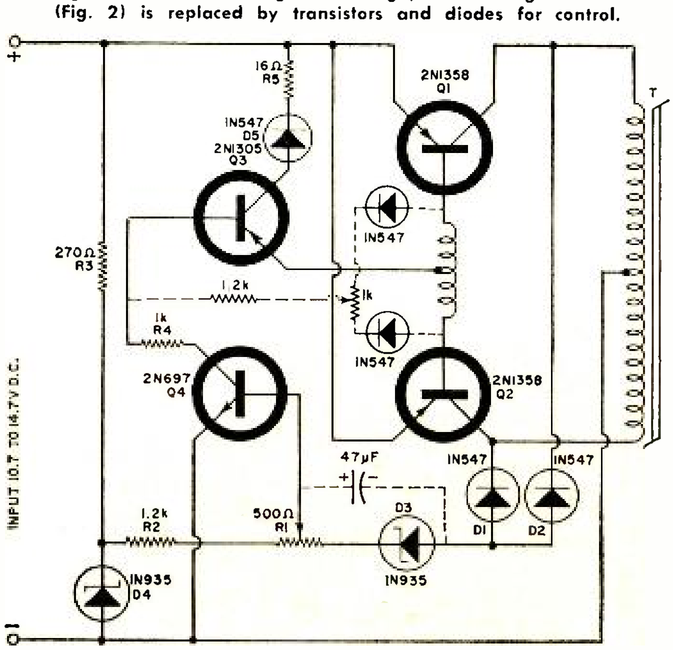
Adding Regulation

Regulation can be achieved by adding a series regulator in either the input or output circuit. Fig. 2 shows the inverter with a pre-regulator. The voltage across the transformer primary is sampled and rectified by D1 and D2. The sampled negative d.c. voltage is dropped to a few tenths of a volt negative by zener diode D3. The zener diode is used in place of a resistor so that changes in output voltage level are impressed across R1 on a one-to-one basis. If a resistor were used for D3, the voltage change would be "diluted" by the voltage-division ratio, and control would be reduced proportionately.

As with any system, the control is only as good as the reference to which the output is compared. In this example, the reference is the voltage appearing across zener diode D4. R3 sets the zener current at its rated value for best regulation. The wiper of the variable resistor, R1, can be set at any voltage from a few volts positive at one end to a few tenths of a volt negative at the other. R2 limits the maximum base current allowed into Q4 when the wiper is set for maximum voltage.

Assuming that output voltage regulation is desired over an input voltage range of E1 ± 4 volts, wiper R1 is set so the voltage drop across Q3 is about 4.5 volts as the input swings through the entire regulating range. When Q3 is fully on, there is a 0.5-volt collector-to-emitter saturation potential. When the input voltage is lowered, for example to E1 −1 volt, D1 and D2 deliver a less negative voltage to R1, and Q4 is biased for more collector current. Increasing the collector current in Q4 likewise increases the base current of Q3 and consequently reduces the collector-to-emitter voltage of Q3 by almost 1 volt. This results in holding the voltage input at the converter essentially constant as a function of input voltage. Regulation versus load variations

Fig. 3. In the final regverter design, the biasing network (Fig. 2) is replaced by transistors and diodes for control.



is also good since voltage changes resulting from varying currents through transistor Q3, and switching transistors Q1 and Q2, are sensed by D1 and D2 and corrected by the action of the feedback control loop. Taking the sample from the primary side of the transformer does not include compensation for the IR voltage drop in the windings, but it does permit a common regulator design to serve a wide variety of secondary voltage and rectifier configurations. Even more important, taking the sample from the primary affords complete isolation between input and output circuits. This feature is often a requirement in converter design.

The Final Design

At this point, nothing new has been added to standard regulator and converter design. However, it is now easy to show how the circuit of Fig. 2 can be modified to the regverter design and provide significantly improved performance characteristics.

One major difficulty with the circuit in Fig. 2 is its relatively poor efficiency, since there are always two transistors in series between the input and the transformer. This means that at the low end of the input voltage range, there is a voltage drop of 1.5 V or more across the two emitter-to-collector junctions. In a 12-volt system, this represents 12.5% loss in efficiency. In addition, at maximum input voltage the series regulator transistor must be capable of dissipating power equal to the operating current of the converter times the total regulating range in volts. Thus, in a 12 ± 4 volt regulator delivering 48 watts to a load, Q3 is required to dissipate 48 watts. At elevated temperatures, heat sinking could be a problem.

One change in the circuit will alleviate both problems. Instead of using Q3 as a series regulator in the emitter circuits of Q1 and Q2, use it to control the base drive to these switchers. In that position, the amount of controlled current is less (due to the current gain of Q1 and Q2) and consequently does not constitute a dissipation problem for Q3. Instead, power is dissipated in the switching transistors. However, since each of these devices conducts only half the time, the power loss is shared equally. And, since only one emitter-to-collector junction is between the supply line and the transformer, the loss at minimum input is cut in half.

Fig. 3 shows the final regverter circuit design. In the bias network shown in Fig. 1, R6 has been replaced by Q3, D5 and R5, while R7 has been replaced by Q4 and R4. D5 serves to block the flow of turn-on bias current through R5. This further reduces power loss. During operation, however, the diode conducts base drive current to Q1 and Q2, and R5 limits the maximum base current to a safe switching level.

When an input signal is applied to the regverter, a positive voltage across D4 and the lack of negative voltage from D1 and D2 turn Q4 fully on. Then starting bias current flows from emitter-to-base of both Q1 and Q2, and from emitter-to-base of Q3 (operating simply as a diode junction, since diode D5 opens the collector circuit) through R4 and finally to the negative line through Q4. As a.c. voltage appears across the primary of the transformer, D1 and D2 rectify and produce a d.c. voltage which quickly reduces the current through Q4, and subsequently Q3, sufficiently to limit the drive to the switchers and produce the desired output level. The setting of R1 adjusts the level of the regulated voltage, which appears across the transformer primary, and the minimum input voltage at which regulation holds. The latter is true since the voltage applied to the transformer obviously cannot be greater than the input voltage, less a few tenths of a volt drop across the switching transistors.

Fast Response

There is no capacitor in the regulation loop. This means that the circuit response to transients is extremely fast.

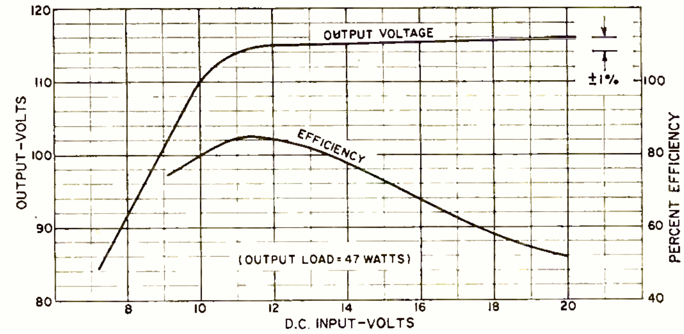


Fig. 4. Output is regulated to within ± 1%.

Therefore, Q1 and Q2 switch extremely rapidly and eliminate overshoot in the waveform. This has an additional benefit of greatly reducing ripple in the secondary rectified output. Output ripple can be reduced even further through the addition of a speed-up capacitor from the junction of D1 and D2 to the base of Q4. Much of the remaining output ripple is traceable to unbalance between the two switching transistors. This can be eliminated by the addition of two diodes, a variable resistor, and a current-limiting resistor, as shown in dashed lines on Fig. 3. The variable resistor is adjusted for minimum ripple in the filtered d.c. output.

Finally, the regverter has another very desirable feature. The output can be shorted continuously without damage to the components. R5 limits the maximum base current drive to Q1 and Q2, and thus the maximum power output which can be drawn from the converter. R4 is chosen to limit collector current when the output is shorted and switching action is stopped, thereby holding the dissipated power in Q1 and Q2 at a safe level.

Fig. 3 (including the components in the dashed lines) shows a mobile supply designed to operate from a 12-volt lead-acid battery. It serves to illustrate typical component values and performance characteristics.

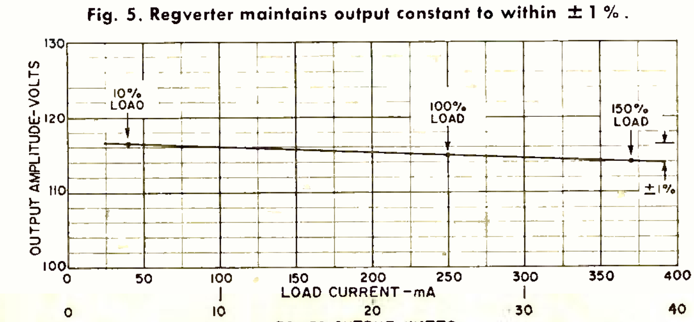
The design objectives were: input voltage 10.7 to 14.7 volts (typical range of vehicle batteries having charge regulators); power output 115 volts, 400 Hz, at 25 watts; and switching frequency 400 Hz. (Note that the output-voltage winding of the transformer is not shown in the schematic.) Germanium switching transistors were chosen for their lower V_{sat} characteristic, although silicon can be used equally well when appropriate attention is paid to voltage levels and polarity.

Allowing for a 0.7 volt drop across the switching transistors at minimum input voltage, the transformer is designed for a constant input of 10 volts. The number of turns required for one-half the primary is calculated from the equation:

$$\frac{N_p}{2} = \frac{E \times 10^8}{4B_m AF} \qquad (2)$$

where E=applied voltage; B_m=saturation flux density in gauss; A=core cross section area (*Continued on page 59*)

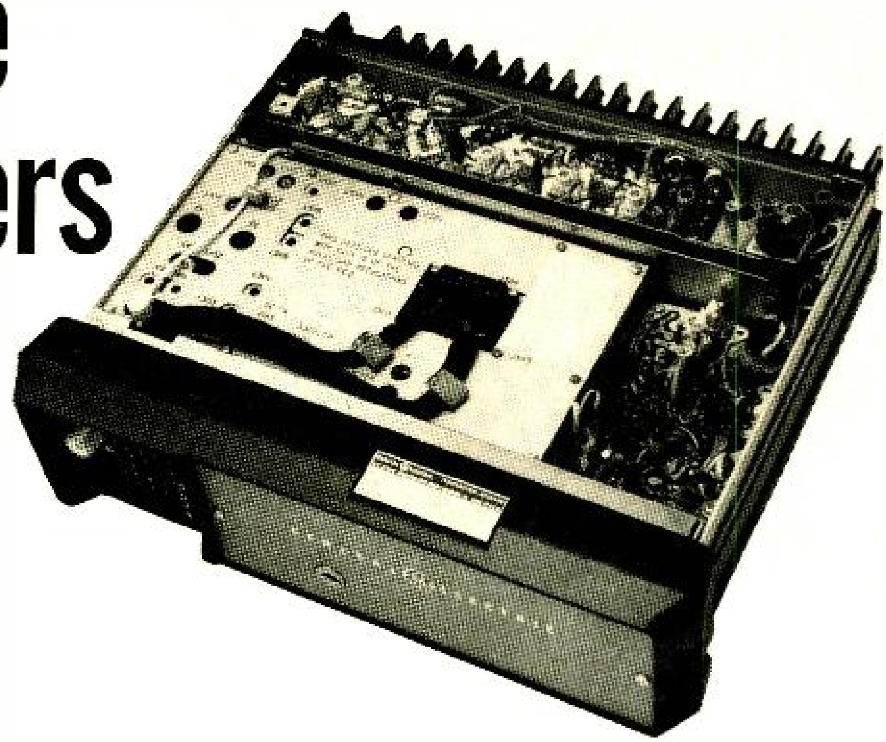
Fig. 5. Regverter maintains output constant to within ± 1%.



A Protection System For Solid-State Transmitters

By CANTRELL SMITH
Technical Specialist
General Electric Co.

The reliability of solid-state, 2-way radios is only as good as the circuits which protect them against abnormal operating conditions. Here is a system designed to guard such a radio against overvoltage, transients, excessive operating temperature, and itself against short circuits.



Top view of a 450-MHz, solid-state mobile radio. Transmitter portion is section of unit in which components are visible —multipliers, driver, and power transistors are at the top.

HIGH-power, solid-state communications systems offer greater efficiency and greater reliability than tube units. However, reliability is not realized simply by replacing tubes with transistors; the solid-state devices must be protected against inherent weakness. They are susceptible to overvoltage, current, and temperature and can be destroyed in a fraction of a second by either one or by a number of combinations of these things.

The circuit described here takes into consideration the limits of the r.f. power transistors for any combination of voltage, current, and temperature, and acts to protect them. Currently, this circuit is being used to control the power for *General Electric's* new solid-state MASTR Progress Line Royal Professional and Royal Executive series 2-way radios.

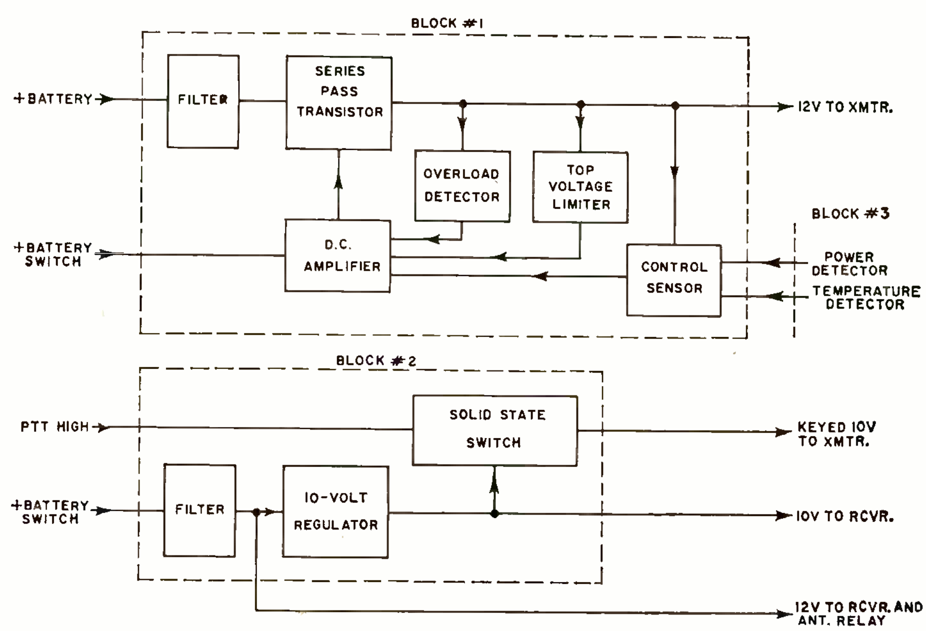
The function of any power control system is to allow maximum utilization of the capability of the r.f. power transistors, consistent with their safe operation. These devices must be protected over a wide range of possible stress and fault conditions. Thus, the power-control system must be capable of absorbing excess power when abnormal operating conditions exist; protecting the transmitter against excessive input voltage, excessive heat, and poorly matched antenna systems; and, in addition, protecting itself against short circuits at its output.

The block diagram (Fig. 1) shows the various control functions of this system. The dashed lines show the components contained in the various sections of the transceiver. Operation of the system will be explained by referring to the components and block numbers on the diagram.

In this circuit, the on-off switch carries only the low current for the receiver and control circuits. The high transmit current is carried and controlled by Q3 (Fig. 2). At all times, the emitter of Q3 is connected to the battery through L1.

When the on-off switch is closed, 12 V is applied to the 10-V regulator and to the receiver (Block #2). The filter,

Fig. 1. Block diagram shows functions of the control circuit.



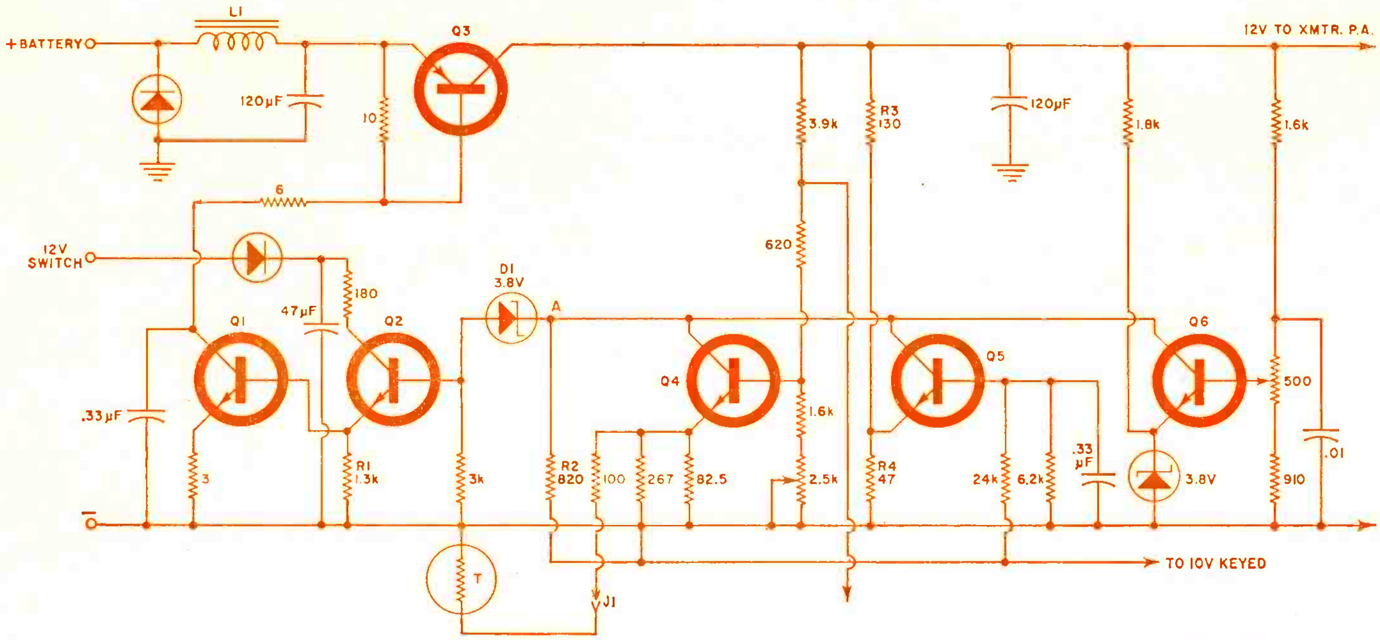


Fig. 2. Schematic shows operation and components of the main protection circuit (Block 1). Q3 is a series-pass transistor.

consisting of L2 and C1 (Fig. 3), prevents voltage spikes from the ignition system from damaging receiver and regulator components.

The 10-V regulator consists of Q7, Q8, Q9, and associated components. It supplies a continuous regulated voltage to the receiver, transmitter, and control circuits, and a switched voltage to the transmitter and control circuit.

In order to logically explain the operation of the protection and control circuits, it will be necessary to assume specific operating conditions, such as (a) all conditions normal; (b) loss of antenna or poor match to the antenna; (c) excessive transmitter temperature); (d) short on the transmitter 12-V supply; (e) excessive input voltage; (f) simultaneous faults involving (b) (c) and (e) above.

We will discuss the conditions in the above order and follow the action when the push-to-talk (PTT) button is pressed.

Normal Operation

Closing the PTT switch grounds the emitter of Q11 (Fig. 3). This transistor is biased on through D2 and R5 and it immediately saturates. This allows base current to flow in Q10, thereby driving it into saturation. When Q10 saturates, regulated voltage is applied to the various circuits in Block #1. With no fault conditions present, Q4, Q5 and Q6 (Fig. 2) are biased off. Base current through Q2 is drawn through D1 and R2. The resulting emitter-to-collector current through Q2 causes a voltage drop across R1, and therefore a positive voltage swing appears at the base of Q1. This action turns Q1 on and drives Q3 into saturation. Voltage for the transmitter is now available at the collector of Q3 and full r.f. power is delivered to the antenna.

Transmitter-to-Antenna Mismatch

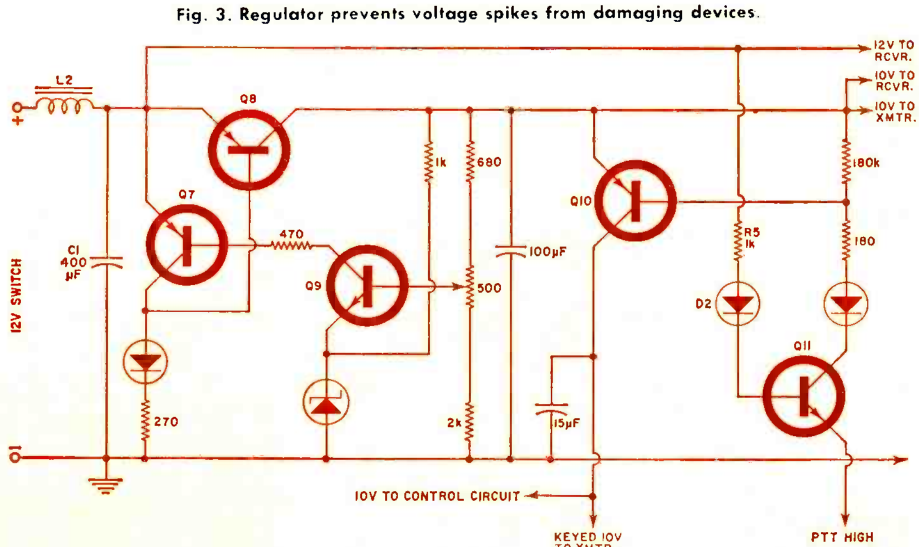
Essentially the same series of events occurs if there is a fault in the transmitter. However, the actions of Q1, Q2 and Q3 are modified by the protective circuit. Let us assume that the transmitter's antenna is disconnected or that there is a poor match between the transmitter and the antenna.

When the PTT switch is closed, Q1, Q2 and Q3 tend to turn on as before. This time, however, their action is limited by Q4. Under normal conditions, when the antenna is well matched to the r.f. output circuit, the output of the power detector (Q12 and Q13; Block #3; Fig. 4) is a control current. This control current keeps Q4 biased near cutoff. If for any reason r.f. power to the antenna decreases, the signal control current decreases, causing Q4 to conduct more. As Q4 conducts the voltage across R2 increases. The resulting decrease in voltage at point A tends to move Q2 toward cutoff thereby decreasing the drive to Q1 and Q3. The decreased drive to Q3 increases the voltage dropped across it, and decreases the voltage applied to the r.f. power amplifier. The circuits are designed to decrease the voltage at the collector of Q3 just enough to prevent over-dissipation in the r.f. power amplifier for any condition of antenna mismatch.

Excessive Transmitter Temperature

There may be times when all parts of the system are operating normally, but long transmit periods at high ambients cause an excessive temperature rise in the r.f. power amplifier. If this temperature rise becomes high enough to endanger the amplifier, Q4 acts to correct the condition. There is a thermistor (T) in the emitter circuit of Q4, connected between J1 and ground. (*Continued on page 77*)

Fig. 3. Regulator prevents voltage spikes from damaging devices.



Solid-State LSA MICROWAVE DIODES

By DAVID L. HEISERMAN

With a bulk semiconductor operating in the limited space-charge accumulation mode, it is possible to produce 20 mW output at 88 GHz.

Dr. John A. Copeland adjusts an experimental solid-state millimeter oscillator which replaces cumbersome klystron.

IT has taken nearly twenty years of reserach, but the communications engineer's dream of a practical solid-state microwave energy source is about to come true. Development in r.f. transistor and tunnel-diode circuitry were painfully slow and until 1963 when J. B. Gunn announced the discovery of his 1-GHz bulk semiconductor oscillator, a sweeping revolution in solid-state microwave electronics always seemed to lie somewhere just beyond reach.

Although Gunn's device stimulated a great deal of research activity with bulk semiconductors, it has not provided the final answer to the solid-state microwave problem. (See "Gunn Oscillators", ELECTRONICS WORLD, September, 1967.) One major difficulty with the Gunn device is that its operating frequency is determined primarily by the time it takes a space-charge to travel from the cathode to the anode. Unfortunately, shortening the active region in order to increase operating frequency also reduces the area available for dissipating heat generated by the moving space-charge.

Early in 1967, Dr. John A. Copeland of *Bell Telephone Labs* showed that it is possible to "quench" the Gunn space-charge and let an external *LC* circuit rather than the transit time of a space-charge determine the operating frequency. The implications were that the active region of the bulk semiconductor may be made much longer to facilitate heat dissipation without severely limiting the operating frequency.

This article outlines the theory of bulk oscillators in general, and points out the peculiarities of the LSA (limited space-charge accumulation) mode that makes it possible to obtain 20 milliwatts of power at 88 GHz.

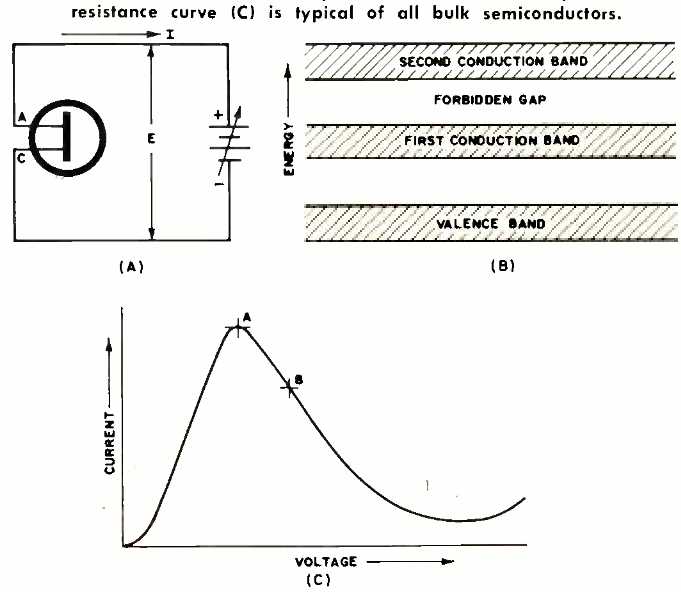
Negative Resistance

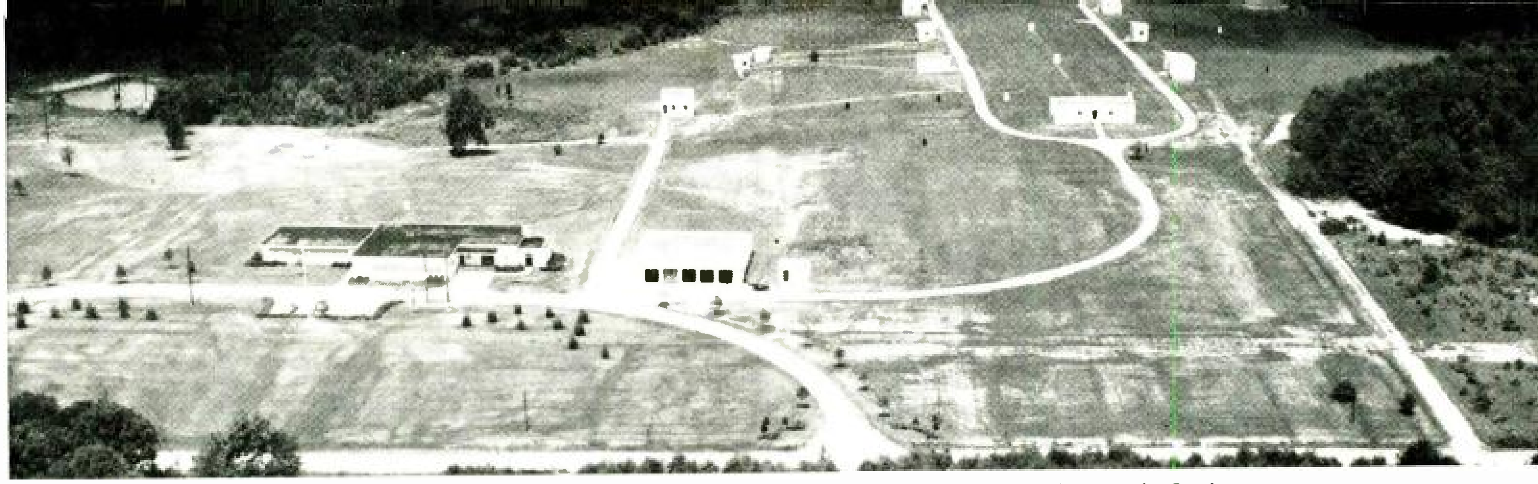
Both Gunn and LSA diodes operate on principles involving negative-resistance effects in bulk semiconductors. Unlike the conventional negative-resistance device, bulk semiconductors are simply pieces of highly purified *n*-type material—no *p-n* junctions enter into the structure at all. It is the quantum structure of bulk materials such as gallium arsenide that is responsible for junctionless negative-resistance effects.

Fig. 1B illustrates the electron structure of *n*-type *GaAs*. Note that there are two conduction bands separated by a forbidden gap. When an external d.c. source is below a certain threshold value, determined partly by the width of the forbidden gap, all electrons flow through the low-energy conduction band. Increasing the applied voltage slightly beyond the threshold potential gives a few electrons enough extra energy to jump the forbidden gap and flow through the high-energy conduction band. Any further increase in applied voltage simply increases the percentage of electrons using the high-energy band.

In semiconductors such as the *GaAs* diode, the electrons behave differently in the two conduction bands. The band that carries the most current tends (*Continued on page 76*)

Fig. 1. (A) A simple bulk diode circuit that may be used as a Gunn oscillator. (B) Energy diagram of "n"-type semiconductor is similar to that of gallium arsenide. The negative-resistance curve (C) is typical of all bulk semiconductors.





Fredericksburg Magnetic Observatory, Fredericksburg, Va., as seen from the air, looking north. Continuously recording magnetographs are located in the variation building, visible at the north end of the loop.

geomagnetic observatories

By L. GEORGE LAWRENCE

Observatories throughout the U.S. gather statistical data about earth's magnetic field. This information is important to scientists studying man's past and future, as well as to government and military agencies.

GEOMAGNETIC field fluctuations are caused by solar winds, auroral activity, ionospheric currents, seismic events, and nuclear explosions. Precise information concerning the earth's magnetic field changes is extremely important to certain scientific and military agencies; but the magnitude of the variations is so small that extreme care and precision must be exercised in gathering the data.

In this country, the U.S. Coast and Geodetic Survey has been conducting magnetic field measurements since 1882 and currently maintains 15 geomagnetic observatories in the Western Hemisphere.

During the International Geophysical Year, 1957-58, about 60 additional stations conducted temporary survey programs. Aside from furnishing detailed geomagnetic records, which are the basis for studies of transient magnetic variations, the permanent installations include facilities for calibrating electronic and mechanical survey magnetometers.

Geomagnetic Elements

The main geomagnetic field originates inside the earth and is often called the permanent field. At the surface of the earth, its strength varies from about 60,000 *gamma* (γ) or 0.6 gauss at the polar regions to approximately 30,000 γ in the equatorial zones. Defined more strictly, this is equivalent to the field of a centered dipole with a moment 8.05 $\pm .02 \times 10^{25}$ gauss cm^3, or $3.114 \times 10^{-5} T R_E{}^3$, where T is tesla and R_E the radius of the earth. The magnetic dipole is inclined at an angle of about 11° to the axis of the earth's rotation.

The main field has a slow secular change amounting to about 0.1% per year or less, but may be as much as 0.3% a year in some regions. Fields originating extra-terrestrially are much more variable and weaker. Electric-current systems in the lower ionosphere are major sources of the geomagnetic field's time-varying components. Typically, during large magnetic storms, field variations may be as high as 0.035 gauss in the auroral zones. This is more than 5% of the main field strength.

Electrical disturbances, notably magnetic storms, are associated with sunspots, and are characterized by auroral displays and severe radio transmission interference. A magnetogram of a typical magnetic storm is shown in Fig. 1. Storms like these may last a few hours, or as long as days.

At the present time, it's not possible to predict geomagnetic disturbances reliably. Observations are purely statistical, indicating the probability of disturbances as a function of latitude, altitude, amplitude, and time.

Observatory data is most frequently presented as hourly values of D,H, and Z (or X,Y, and Z). See Fig. 2. Hourly values for the five and ten most "quiet" days and the five most disturbed days, as well as reproductions of daily magnetograms are published annually. However, publication of this particular data may lag several years behind the observation period.

The magnetic induction at any point in space is the vector F (vector B of Maxwell's equations); the scalar F is called the intensity, or the total field. X,Y, and Z are the Cartesian components of the field. Thus, X and Y are positive in the North and East directions, Z is called the vertical intensity of the field and is positive in the downward direction, and H is the scalar intensity of the field's horizontal component. The declination, D, also called the *magnetic variation* and the *variation of the compass*, is the angle between X and H. D is positive when measured eastward (clockwise) from North. Therefore D is positive when Y is positive. I, the inclination or dip, is the angle between H and F and is positive in a downward direction from H to F. So I is positive when Z is positive.

F may be determined by any of several triads. The ones commonly used are: H,D,Z; H,I,D; F,I,D; and X,Y,Z.

At first glance, these relationships might appear complex—but they are easily confirmed by simple experiments. If, for example, a magnetized needle is supported at its center of gravity in such a way as to be free to assume any position, it would come to rest with its magnetic axis directed along the lines of force of the earth's magnetic field. The angle which this direction makes with the horizontal plane varies according to locality and may have any value from 0° to 90° (Fig. 3). At Washington, D.C. the dip of the magnetized needle is about 71°. This phenomenon enables the preparation of special charts which indicate the dip (or inclination) of the geomagnetic field at different times and different localities on earth. A typical chart is shown in Fig. 4. Other charts and maps, pertaining to other elements in the

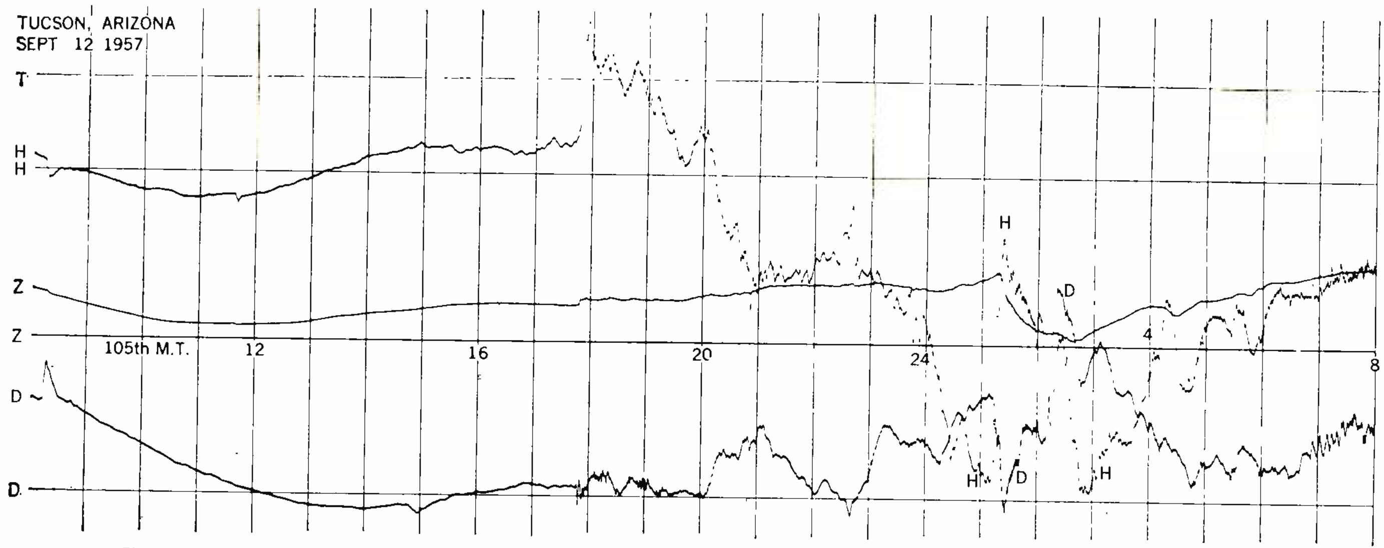


Fig. 1. Magnetogram recorded at Tucson observatory. Note heavy magnetic disturbances between 1800 and 0800 hours.

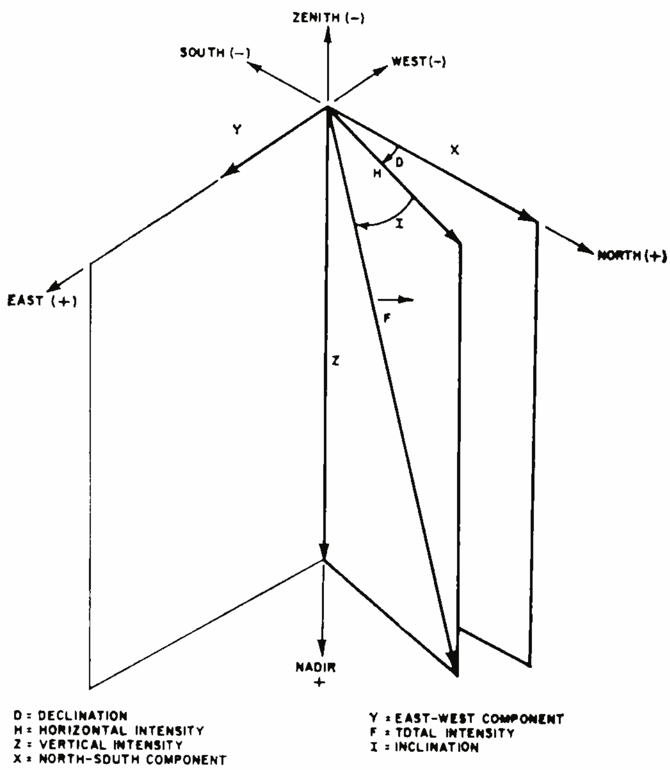


Fig. 2. Magnetic force F and other elements of earth's field.

field, are made available by the Navy Oceanographic Office.

Observatory Instrumentation

Observatory instruments are of two basic types: variometers which continuously record the time changes of three components of the geomagnetic field, usually D,H, and Z, with respect to fixed base lines; and absolute instruments which periodically measure three field quantities, usually D,H, and I, to establish the absolute values of the variometer base lines.

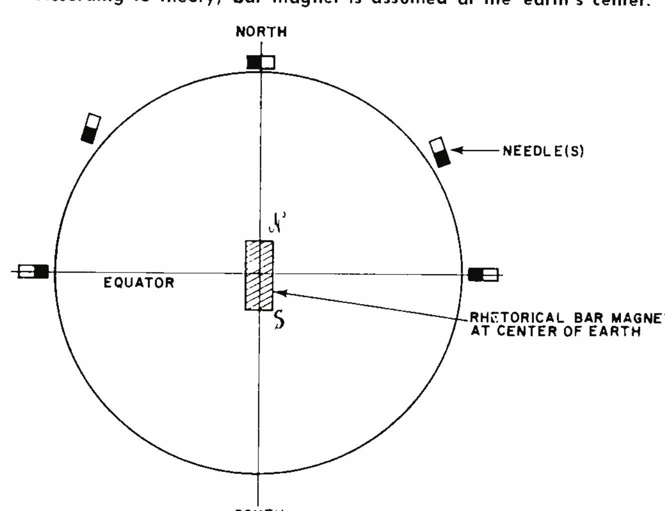
A standard magnetogram, as shown in Fig. 1, commonly includes traces from each of the D,H, and Z variometers, time marks, and a temperature trace. The effective sensitivity of this equipment varies from about $2\gamma\ mm^{-1}$ for lower-middle latitude stations to about $25\gamma\ mm^{-1}$ for auroral zone stations. Determination of D has a maximum accuracy of about 15 or 20 seconds of arc. H absolute may be measured with an accuracy of about 1γ by means of sine galvanometers, or about 5 to 20γ with a theodolite magnetometer, depending upon the observatory location. The accuracy of I is about 0.1 minute of arc. However, instruments for field use tend to be less accurate.

The proton free-precession magnetometer and the alkali-vapor magnetometer are the best instruments for rapid measurements of the absolute value of the total scalar intensity. Some other electronic measuring instruments are: second harmonic, heliflux, or saturable-core types such as those used in aerospace sounding systems, etc. (For a description of those and related magnetometers, see "Magnetic Measurements in Space", ELECTRONICS WORLD, January, 1966).

A large geomagnetic observatory is located near Fredericksburg, Virginia. In the construction of this and other facilities, great care was taken to exclude all material that might have a disturbing effect on instrument magnets. Wood is the principal construction material. Thermal insulation is provided by sawdust or glass wool enclosed in concrete blocks. Special provisions are made to keep out termites.

Some of the observatory's recording magnetometers (magnetographs) are shown in Fig. 5. Usually these devices consist of three variometers, one for each geomagnetic element, and a photographic recorder. These instruments are calibrated by measuring the magnetic declination D, inclination I, and one or more of the intensity components H,Z, and F. However, some stations located in or near the polar zones have oriented their apparatus so that measurements can be made of fluctuations in the North component X, East component Y, and vertical component Z.

Fig. 3. Dip of a magnetic needle at various points on the earth. According to theory, bar magnet is assumed at the earth's center.



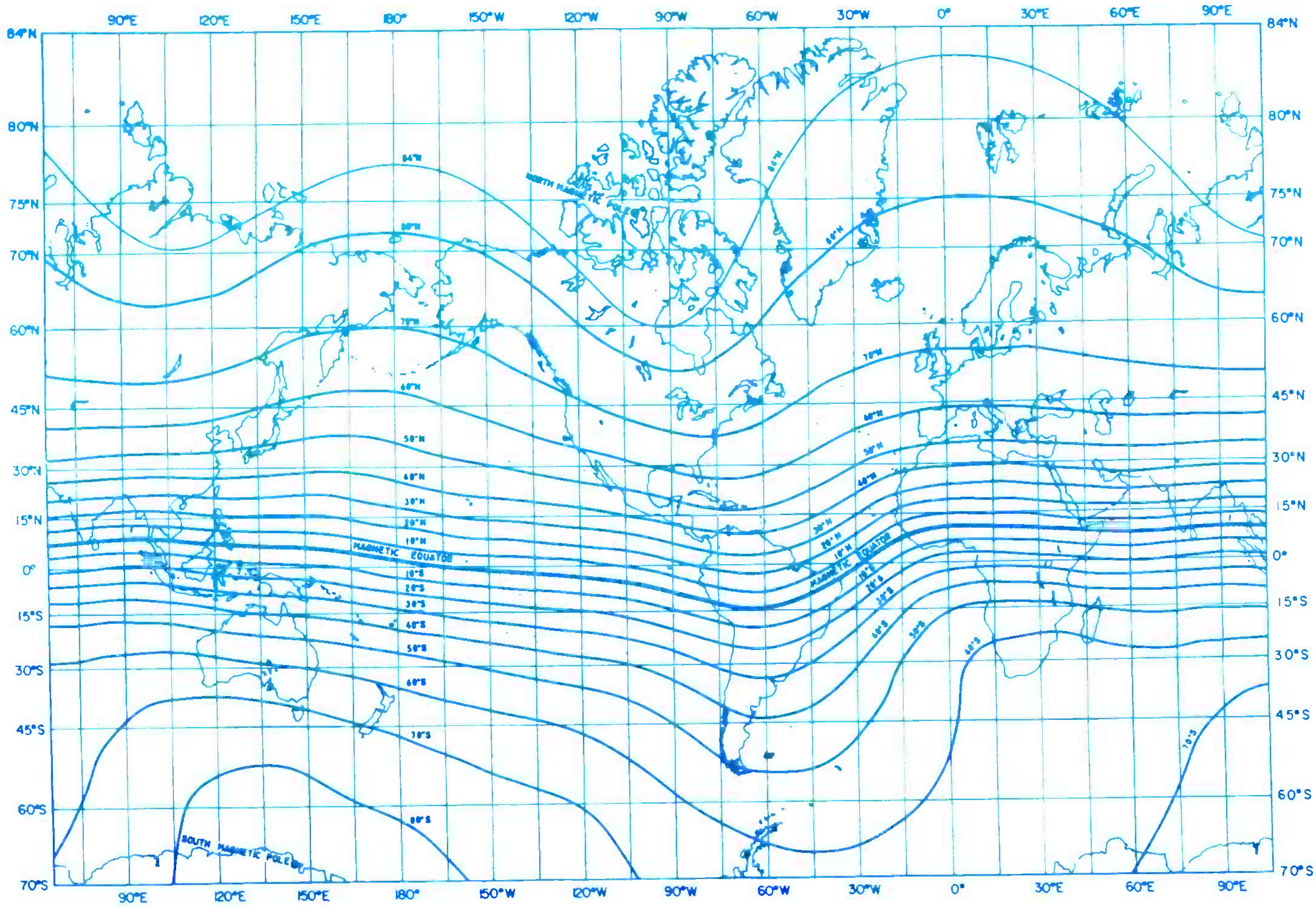


Fig. 4. Typical inclination (dip) of earth's magnetic field, giving magnetic dip poles, dip equator, and contours of constant I.

Typically, conventional variometers contain a recording magnet free to turn about a specific axis. Thus the magnet turns in response to changes in magnetic intensity normal to the axis of rotation and to the magnetic axis of the magnet.

In D and H variometers, recording magnets are suspended from quartz fibers (Fig. 6). The D variometer magnet is practically in the magnetic meridian and responds to changes in declination (changes of East intensity). The H instrument is equipped with a fiber of sufficient stiffness so that the suspended H magnet can be turned into a magnetic East-West position by introducing a twist in the fiber. Thus it will respond to changes in the North-South (horizontal) component of the field. The Z (or vertical component) variometer uses a magnet balanced horizontally on a knife-edged rod. This variometer will operate with the magnet in any azimuth, responding to changes of the geomagnetic element Z.

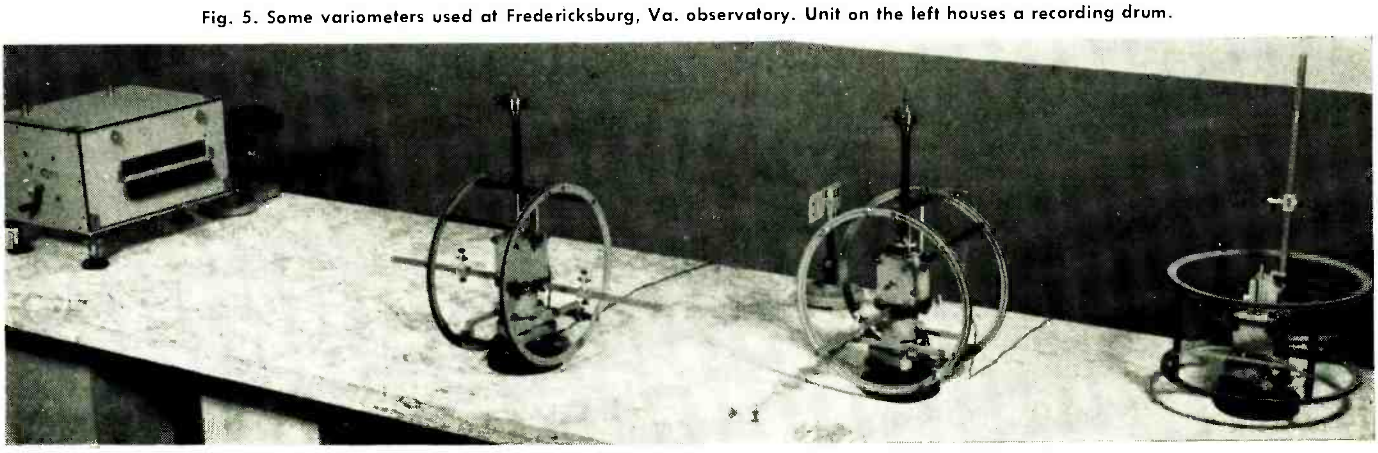
In these and similar applications, readout is accomplished by reflecting a beam of light from a mirror surface. A special optical system focuses the light to a point on the surface of a recording drum carrying photographic paper. The recorder's normal speed is 20 millimeters per hour, thus the drum turns once every 24 hours. Time markers are injected by flashing a fine line of light across the magnetogram once each hour.

Helmholtz coils envelope each variometer. The instrument's sensitivity can be checked by energizing the coils with a stable d.c. voltage. (The position of the coils around the variometer indicate which component of the geomagnetic field they are intended to measure.)

Nuclear Magnetometers

These rugged instruments are finding increasing acceptance and have been highly praised both here and abroad.

Fig. 5. Some variometers used at Fredericksburg, Va. observatory. Unit on the left houses a recording drum.



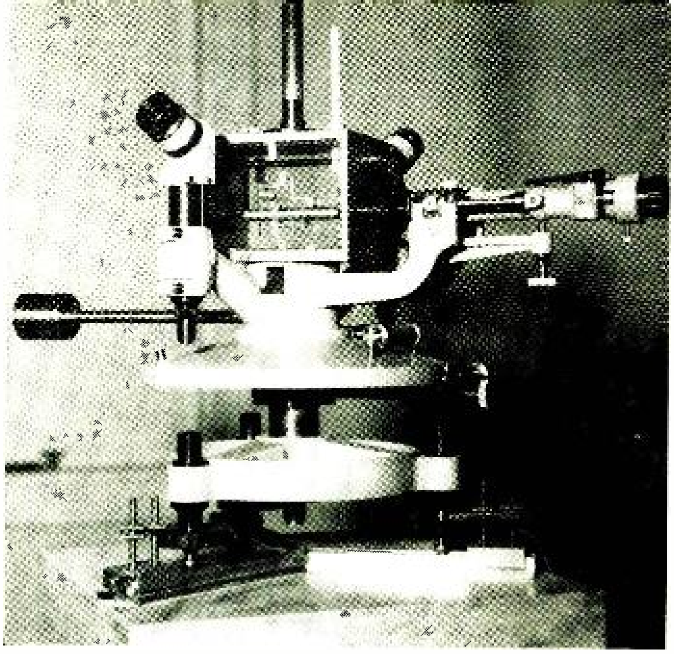


Fig. 6. Magnetometer measures declination, horizontal intensity.

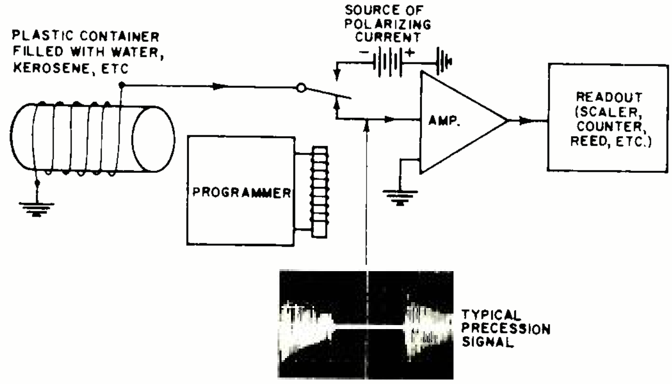


Fig. 7. Protons in distilled water or kerosene are subjected to a high d.c. field to cause realignment of their magnetic axes.

Nuclear magnetometers are especially valuable in areas of high volcanic or other earth activity since they are particularly immune to seismic vibrations.

The basic operation of nuclear magnetometers of the proton free-precision type is shown in Fig. 7. A few ounces of distilled water or kerosene furnishes a proton sample which can be magnetically polarized by subjecting it to a strong d.c. field (about 100 gauss) applied at right angles to the earth's field for a second or two. This process causes a large number of protons to align their magnetic axes parallel to the polarizing field. When the field is removed, the spinning protons precess, or wobble, about the direction of the remaining magnetic field—that of the earth. The protons always precess and the angular velocity of the precession is precisely proportional to the magnitude of the geomagnetic field. The precession signal has a frequency of 0.0426 Hz per *gamma*. Thus at a field intensity of 1000 *gamma*, a 42.6-Hz signal is available for processing. The result of the data processing is a geomagnetic field intensity level which is a function of frequency, not the amplitude of the proton's precession.

The proton magnetometer, Fig. 8 shows the coils and sensing head, is used to make vector measurements. This unit is able to measure the geomagnetic elements H and Z as well as F and enables scientists to compute dip. Declination is not obtained.

Special Applications of Observatory Data

The real value of continuous observatory records has been demonstrated in various ways, but it is only recently that these documents have helped shed light on an important contingency involving man's very existence on this planet. Of special interest to scientists are cosmic rays, geomagnetic field reversals, genetics, and subsequent mutation caused by these phenomena.

Records show that the earth's geomagnetic field is gradually declining; progressing toward a complete field reversal believed to occur every half-million years or so. At the midpoint of the reversal cycle, there will be no magnetic field at all and it follows that there will be no deflection of the high-energy cosmic-ray particles which move toward the earth from outer space. Since living organisms are extremely sensitive to radiation fields, cells will be altered and damaged and some species may be destroyed, others mutated, and new species may emerge.

Fossile remnants, contained in sedimentary cores taken from the bottom of the North Pacific region, indicate that the most recent reversal occurred about 700,000 years ago. New species of algae and protozoa appeared some 2.5 million years earlier and existed without significant change until the reversal began.

But specific data cannot be obtained with any great precision. Direct observations of the earth's geomagnetic field have been made only during the past 400 years. However, some reasonably valid data can be derived from palaeomagnetic and archeomagnetic studies dealing with measurements of the thermoremnant magnetism of clay samples. In early eras, notably in the Pleistocene, the amplitudes of the earth's magnetic field apparently varied from 0.3 to 1.5 times the present-day field intensity. The phenomenon is very interesting and might, in time, pending greater refinement of observatory instruments, provide a forecast of man's ultimate destiny. Electronics can help immeasurably to achieve this goal. ▲

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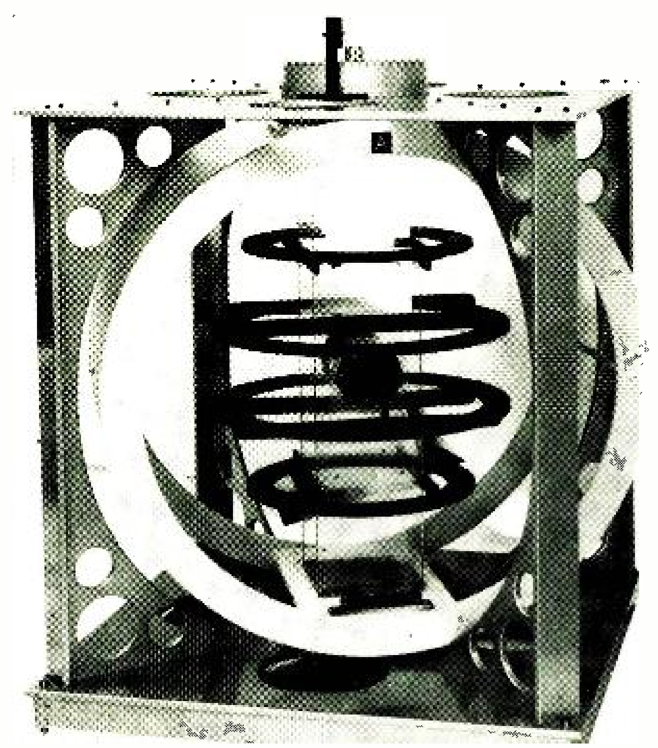
Fig 8. The proton sample and energizing pick-up coil are located in center of the vector magnetometer. The set of four inner coils is a Braunbeck nulling system; outer pair of coaxial coils is a Helmholtz system for nulling H during Z measurement.



DUAL UJT MULTIVIBRATOR

By FRANK H. TOOKER

Unijunction transistors in a multivibrator circuit can produce excellent square waves without the aid of other semiconductors.

UNIJUNCTION transistors have long been used in hybrid circuits—with another diode or bipolar transistor—to obtain multivibrator performance. But UJT's can produce excellent square waves without help from any other kind of semiconductor device.

In Fig. 1, the charging and discharging of a single timing capacitor, *C*1, fires the two UJT's, *Q*1 and *Q*2 alternately, and produces a rectangular wave at the base of each of the transistors.

It's easy to understand the operation of the dual-UJT multivibrator if we inspect the simultaneous waveforms shown in Fig. 2. Assume *Q*1 fires first, then at the instant of firing, the potential at the emitter of *Q*1 drops abruptly from point A in time to point B. (*Q*1 is held "on" until point C is reached.) During the interval between points B and C, capacitor *C*1 is charging in such a direction as to make the emitter of *Q*2 more positive. When this potential has increased sufficiently, *Q*2 fires. At this point, the potential at the emitter of *Q*1 drops abruptly below the hold-on level (from point C to point D) and *Q*1 turns "off."

The firing of *Q*2 initiates an identical sequence of events at the emitter of *Q*2. During the interval *Q*2 is "on" and *Q*1 is "off," capacitor *C*1 charges and makes the emitter of *Q*1 more positive (point D to point E in Fig. 2). When point E is reached, *Q*1 fires and turns "on." *Q*2 is turned "off" and the cycle repeats. The result is an output signal of rectangular waveform at the base-2 of each of the two UJT's and a triangular waveform across timing capacitor *C*1.

When the two unijunction transistors have identical characteristics, and the base-2 and emitter resistors in each side of the circuit have identical values, the output waveform is symmetrical, *i.e.*, mark and space ("on" and "off") times are equal. If the emitter resistors, *R*2 and *R*3, are made unequal in value, the mark-to-space ratio of the output signal will be changed accordingly.

In general, the repetition rate is determined by all the component values in the circuit, especially the UJT characteristics. For the component values given in Fig. 1, the repetition rate is about 180 Hz. The d.c. current drain with a 12-volt power supply is less than 2 mA.

In certain experimental circuits, dual-UJT multivibrators have been operated at a switching rate as low as one cycle every 30 seconds. In this case, emitter resistors *R*2 and *R*3 each have a value of 20 megohms, and capacitor *C*1 is 10 μF. But, because *C*1 reverses polarity, electrolytic capacitors are not recommended for this application.

The single-transistor circuit of Fig. 3 is unique in that it combines the function of two UJT's in one. Furthermore, it produces a triangular waveform at E while providing a rectangular signal at B2. Although triangular waves are customarily obtained as an integration of a square wave, the circuit of Fig. 3 accomplishes this automatically by the action of resistor *R*2 and capacitor *C*2.

Pulse repetition rate is determined largely by *R*1 and *C*2, while waveform symmetry is determined by *R*1 and *R*2. The value of feedback capacitor *C*1 is not critical. For the component values given in Fig. 3, the repetition rate is about 60 Hz. ▲

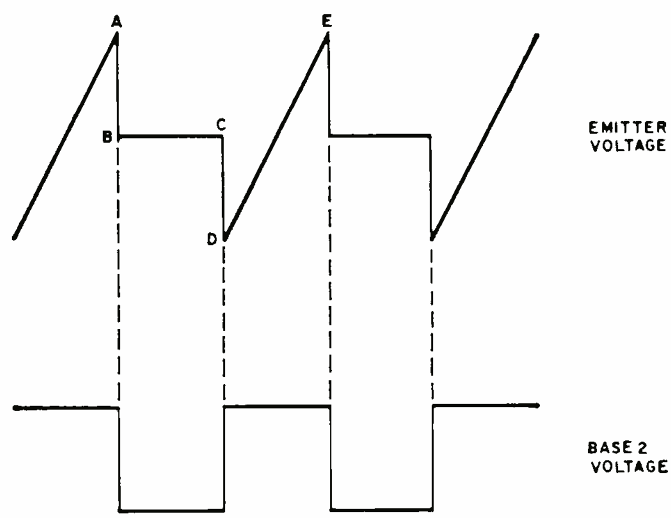


Fig. 2. Timing diagram of UJT multivibrator.

Fig. 1. Dual UJT multivibrator has square-wave output.

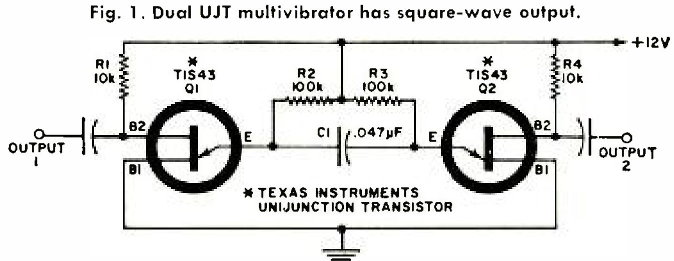
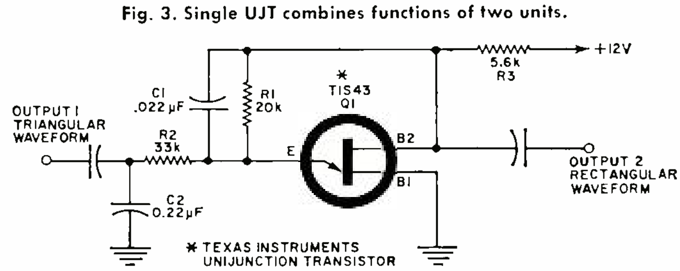
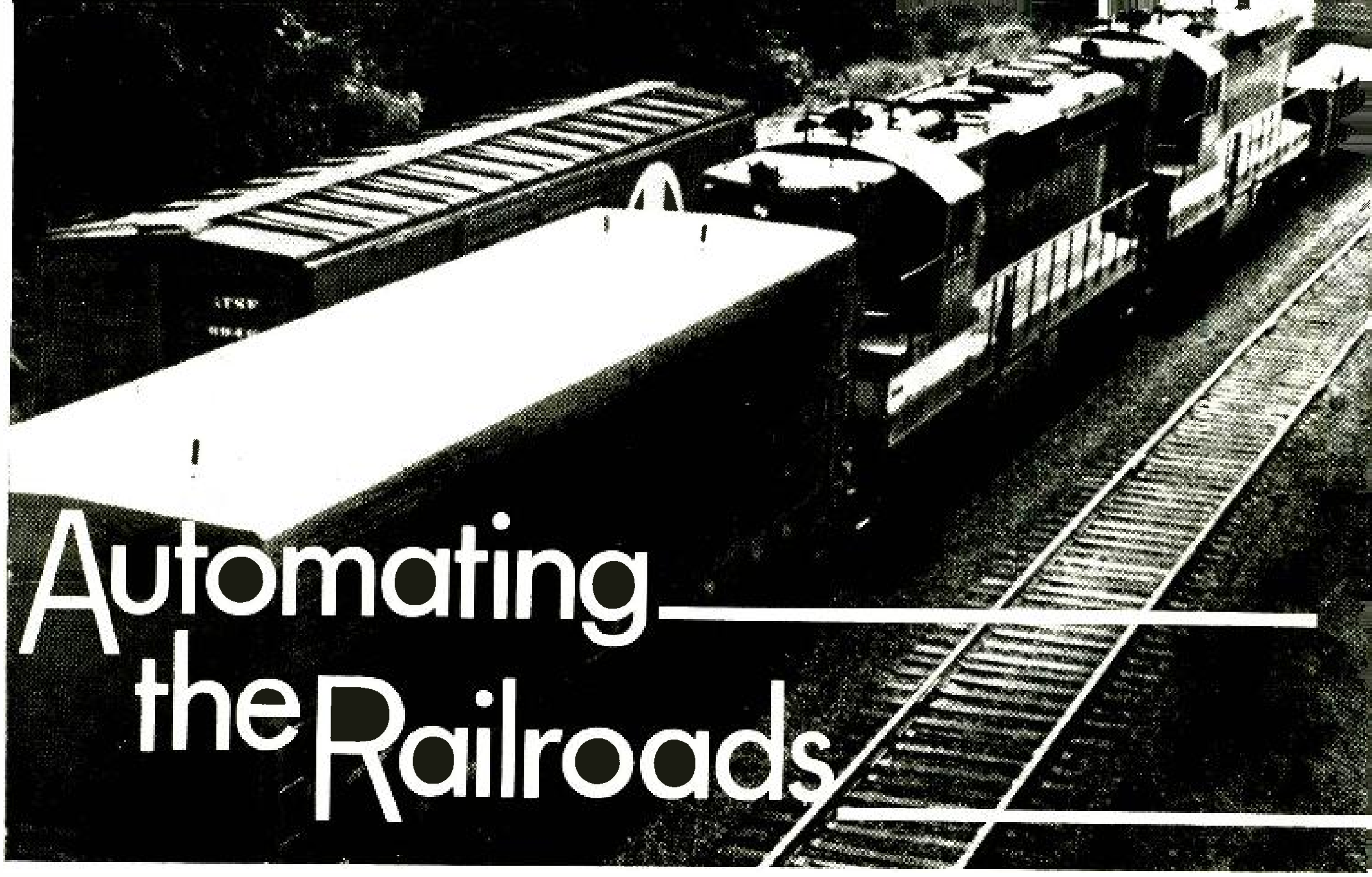


Fig. 3. Single UJT combines functions of two units.



Automating the Railroads



Radio-controlled slave engines like these push and pull huge freight trains. Unit trains 500 cars long are possible.

By DON SELBY/ Radiation Incorporated

Radio-controlled slave locomotives help railroads become more competitive by raising their efficiency levels and by cutting costs.

AIRPLANES, buses, and trucks have spirited away much of the business (and profits) which railroads once enjoyed. Thus, a number of railroad lines have reduced their passenger and freight services, and several have eliminated commuter services almost entirely. However, the ability to move the equivalent of several warehouses of goods from one coast to the other in one fell swoop, is still one of the railroad's most important assets.

Granted railroads have the ability to move tons of commodities, the problem is to be able to do it quickly and efficiently, and above all, competitively.

To help railroads improve their competitive positions, *Radiation Inc.*, a subsidiary of *Harris-Intertype Corp.*, has developed a supervisory system designed to coordinate the throttle and braking actions of two or more locomotives within a single freight train. This system is called "Locotrol" —a two-way radio system which permits the positioning of a slave locomotive in the middle or elsewhere within the lineup of cars in a long freight train. Tests by major U.S. and Canadian railroads have shown that radio-controlled systems such as Locotrol can reduce delivery times and operating and maintenance costs while increasing over-all operating efficiency, thus bolstering railroad profits.

In a Locotrol-equipped train, a master station is located in the lead locomotive. Here, in addition to the console on which is displayed the status and the operating conditions of both the lead and slave engines, are placed two logic cabinets (all solid-state), a power supply, a brake manifold, and relay interface cabinet. Each slave unit contains two similar logic cabinets, a power supply, an air brake manifold, and a relay interface cabinet.

Since the Locotrol system permits spacing engines throughout the train to take advantage of the full potential of locomotive power, direct control lines are not used. It is here that the principles of digital control, utilizing radio equipment as a telemetry link, provide the precise timing necessary for coordinated operation of the lead and slave units, which results in increased power efficiency and faster, smoother, safer stops and starts.

Digital control also increases the efficiency of initial air-brake line charging and consequent air-brake reductions and release.

In conventional trains, the locomotive is controlled from the engineer's position in the cab by the manipulation of levers and other types of controls. These devices supervise the application of certain voltages to their respective locomotive command functions. When two or more locomotives are coupled together for multiple-unit operation, all can be simultaneously controlled from a single set of controls located in the cab of the lead unit. This is possible because jumper cables electrically couple the engines together.

Digital Commands

The digital logic used in the Locotrol system provides all the capabilities for remote control.

Those familiar with train operations know each function of the locomotive is controlled by the presence or absence of a train voltage—72 volts. A diesel locomotive has eight throttle positions (also forward and reverse in each position and many others) which control power by means of five train line wires. These wires, in turn, are activated by relays energized in various combinations by the "Q" output of the Locotrol logic system. In the binary operation of the digital logic only two states are recognized, true or not true—also defined as "Q" and "$\overline{Q}$".

Braking, on the other hand, is controlled by a 0 to 72-volt d.c. analog signal on the lead locomotive's DBC (dynamic braking control) #24 train line wire. This analog control is broken down into eight discrete steps of dynamic braking for transmittal to the slave engine. For example, 0, 5, 15, 30, 45, 60, 85, and 100 percent dynamic braking steps may be used. These steps are decoded to an analog signal for control of the slave locomotive and encoded to decimals for display in the lead engine.

Both the throttle and dynamic braking positions are sensed and encoded to binary digits in the logic system of the lead unit, decoded in the slave unit's logic, and displayed on the control console's panel in the lead engine's cabin.

Every time the engineer in the lead locomotive changes the throttle's position, a 50-bit digital message is radioed to the slave. Of the 50 bits, eleven make up the address code which identifies the originating point and prevents conflicts with similarly equipped train systems, and 32 bits correspond to the sensed function in the control locomotive. In addition, each message contains a 6-bit error check code which detects errors in the operating signals. The message's total transmission time is less than 200 ms.

All in all, the Locotrol message format contains a total of 33 different control and alarm functions, plus three spare functions which permit custom engineering to meet specific railroad requirements.

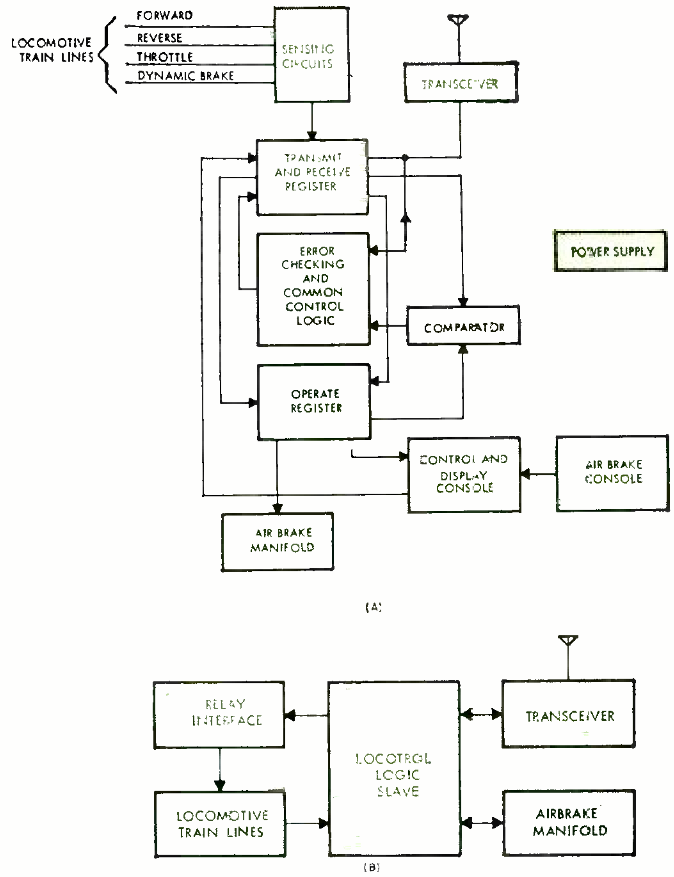
As was previously indicated, the throttle or brake action taken by the engine man in the lead locomotive is converted automatically to a digital code and transmitted instantly to the slave unit. A receiver in the slave locomotive picks up the signal and passes it to the logic circuits where it is decoded and the result used to drive the relays and servos that position the slave locomotive throttle and brake controls.

While the control locomotive is transmitting an action signal to the slave engine, the slave is also transmitting a signal. Furthermore, this signal is displayed on the control panel in the lead locomotive's cabin and provides the engineer with a continual position check of the slave engine's control lines.

Uses Available Transceivers

In a typical Locotrol-equipped train, digital commands are transmitted by v.h.f. or u.h.f. radio to the slave units. (For reliability, two radios are used in each control and slave engine.)

The transceivers themselves are relatively unsophisticated. Usually they are *Motorola* Type AAR "Motran" sets which are commonly used by the railroads for communications. Special radio sets are not required since the system is designed to operate on the noisiest of communications channels. Information is transmitted between control and slave units as frequency-shift-keyed (FSK) messages. Normal frequencies used in the Locotrol system are 1500 Hz (space) and 2500 Hz (mark).



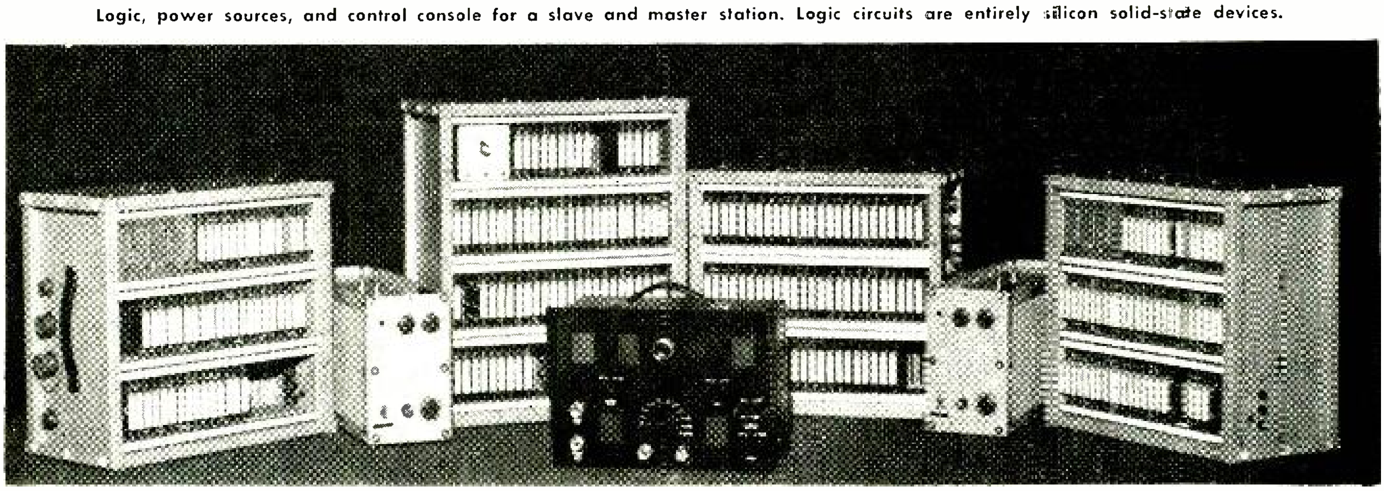
Block diagrams of master (A) and slave (B) station. Position of the lead engine's controls is automatically relayed to slave.

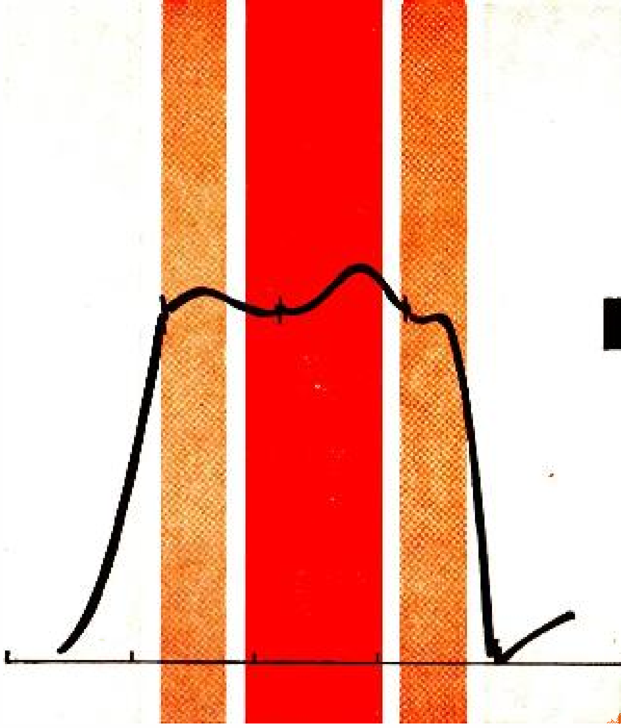
Three Operating Modes

An engineer using a Locotrol system has a choice of three modes of operation: synchronous, individual control, or isolation.

When synchronous control of master and slave engines is required, the slave engine is operated automatically. Any change in the leading locomotive's controls is transmitted automatically to the slave where it is verified and then applied to the slave controls. As stated previously, the slave unit automatically transmit a status signal to the lead unit. However, should the status signal, as received by the lead unit, fail to match the command signals originally transmitted by the control locomotive to the slave, the lead engine continuously transmits (*Continued on page* 81)

Logic, power sources, and control console for a slave and master station. Logic circuits are entirely silicon solid-state devices.





TV Chroma Circuit Alignment

By FOREST H. BELT/Contributing Editor

A logical approach to the chroma section and use of the proper techniques will solve those alignment problems quickly and easily.

TELEVISION troubleshooting is never an exact craft. Not even the country's top experts always agree on the best way to go at each job. Color-TV has produced an even wider diversity of techniques among servicers.

There is one criterion that can be applied to any troubleshooting method: *Does it fix the set, and properly?* If the answer is *yes*, the method is acceptable. If, in addition, it fixes the set quickly, then it is more than just acceptable—it's good.

Alignment of the chroma section in a color receiver is one facet of color-TV servicing that has been considered reserved for the expert. Many otherwise capable technicians hesitate to try it, simply because they are not sure what to expect. So many ways are outlined in books, articles, and service manuals, and by technicians who "know," it's easy to become confused. Circuits differ too; that stimulates more doubt. If you're one of those who avoids chroma alignment, what you need is a logical way to look at the chroma section—a means of sorting out an alignment method that suits you. To work successfully, your method must meet the criteria already spelled out: It must align *properly* and *quickly*.

Chroma Section

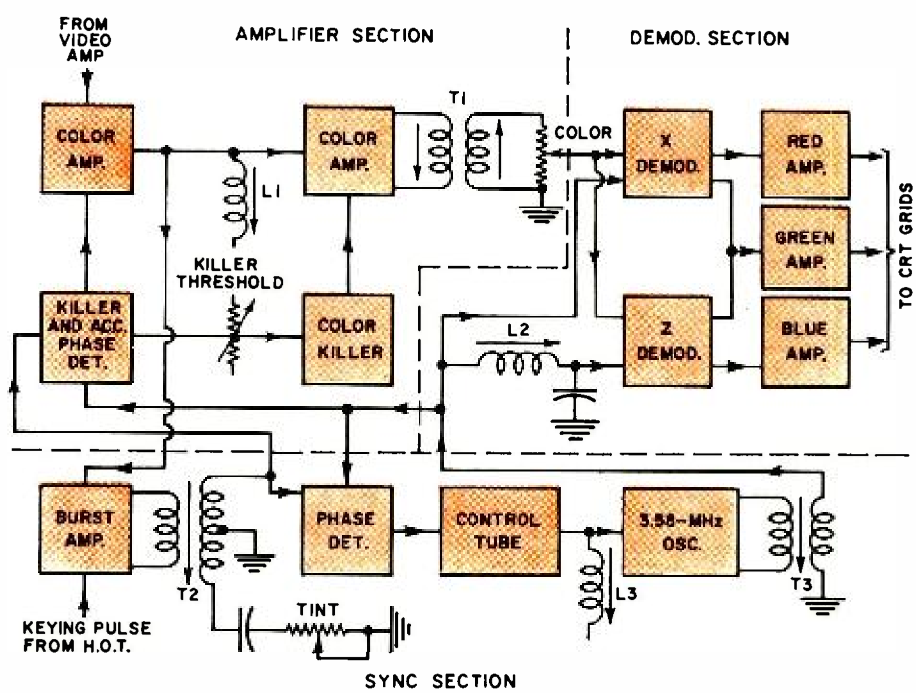
For alignment and troubleshooting, it is convenient to think of the chroma section divided according to its three functions: amplifying chroma signals, demodulating them, and synchronizing all color-handling functions. The function diagram in Fig. 1 shows the divisions.

Amplifying is handled by the two *color amplifiers*. They may be called *band-pass amplifiers* or *color i.f.* amps. Also grouped in the amplifying division are stages that affect the amplifiers directly—the color killer with its phase detector, and the automatic color control (a.c.c.) phase detector. The a.c.c. and killer phase detectors are usually combined.

The demodulator division includes the demodulator stages themselves and the color-difference amplifiers (also called *R-Y*, *G-Y*, and *B-Y amplifiers*). In some color receivers, a separate demodulator is used for each color.

Synchronization is handled by a group of stages. They are: burst amplifier, burst phase detector, control tube, and

Fig. 1. Three major divisions of a typical chroma section. There are seldom more adjustments than are shown here.



3.58-MHz oscillator. The *burst amplifier* is also named *color-sync amp.* Because it is activated by a pulse from the horizontal-output transformer, it is sometimes called *keyed* or *gated.* The oscillator has various labels: *reference oscillator, chroma* or *color oscillator*, or *c.w. oscillator.* In some color chassis, the control tube is not used.

The diagram also shows the adjustments in this particular chroma section. As you can see, they are few, so an alignment job shouldn't require much fuss. Seldom do you encounter a chroma section with any more adjustments than shown in Fig. 1. Understanding chroma alignment is easier if you know what is accomplished by each adjustment. Therefore, let's examine them.

The first is *L1*, a coil in the output circuit of the first color amplifier. It is broadly resonant, and its main purpose is to center the response of that amplifier near 3.58 MHz—the chroma subcarrier frequency. The second, *T1*, is a double-tuned transformer in the output of the color amplifier. Its two adjustable slugs are set for a specific broad-band response curve (shown later), centered around the 3.58-MHz subcarrier. *L1* and *T1*, working together, create an over-all band-pass response that extends from just above 3 MHz to just under 4.5 MHz. They also form a very steep skirt on the side of the curve near 4.5 MHz, so that unwanted sound-i.f. energy is knocked out completely. When you make the adjustments, you'll find that *L1* plays an important part in shaping this upper-frequency skirt of the band-pass curve.

Three adjustments are necessary in the sync section. To align them, you usually start with *T3* and work your way back. Transformer *T3* couples the 3.58-MHz signal from the reference oscillator to the demodulator section. Initially, it is peaked for maximum output from the oscillator at 3.58 MHz. In some receivers, it is touched up later to make demodulator phasing "track."

Coil *L3* adjusts the frequency of the oscillator to bring it near to 3.58 MHz; the d.c. voltage from the phase detector—acting through the control tube—brings it precisely on-frequency. Procedure is usually to adjust *L3* with the phase-detector voltage disabled; that puts the frequency as near correct as possible, leaving only a small difference for the phase detector to overcome.

The third color-sync adjustment is *T2*, the burst-amplifier transformer. Mainly, its job is to couple the burst signal (the few cycles of 3.58-MHz signal that come regularly from the color-TV transmitter to synchronize the receiver color circuits) to the phase detectors. However, because of its effect on the phase of the color-sync signal fed to the detector, the burst transformer controls the reference phase of the c.w. signal fed to the demodulators. On the screen, this transformer has control over the hue of colors—most noticeably the skin tones. A capacitor and a potentiometer across one half of its output winding provide a way for the viewer to control hue (tint) from the front panel. It follows that the adjustment of the slug in the coil also affects hue, so its final touchup adjustment is to center the action of the front-panel Hue or Tint control.

Only one demodulator adjustment is shown for this particular color receiver. Most modern receivers have none; in them, proper alignment of the color-sync section suffices to keep demodulator action true. In sets that have it, *L2* is a phase-shift coil that controls the phase separation between signals fed to the X and Z demodulators. Receivers that use different demodulators may have two or even three adjustments. A color-bar generator is generally used to assure that the adjustments in this portion of the color-TV receiver are correct.

Of course, Fig. 1 is not the only chroma-section design. Other receivers have fewer or more stages. The adjustments shown, however, are the most common. Additional ones are usually mere refinements on these. A study of the schematic diagram and the chroma alignment instructions for the set

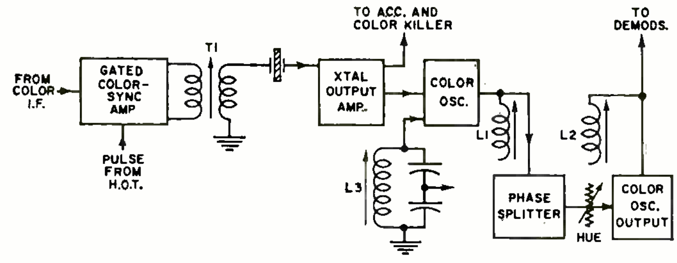


Fig. 2. Color-sync section of Motorola transistor color set.

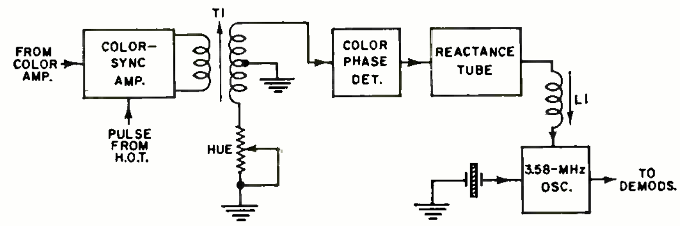


Fig. 3. Color-sync section in a typical tube-type color set.

you have on the bench will acquaint you with the small differences.

Color-Sync Alignment

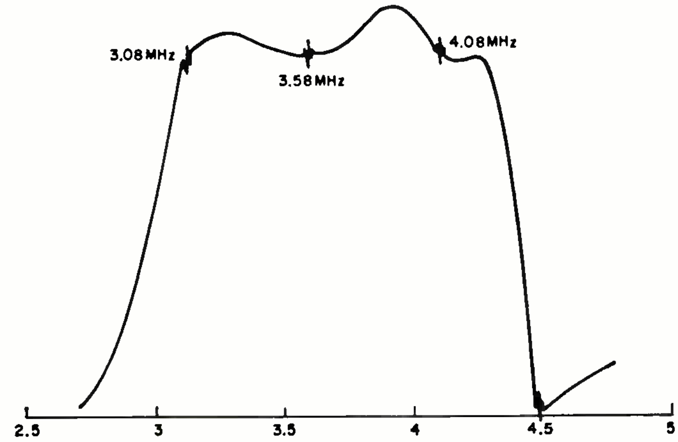
Not much equipment is needed to align the color-sync adjustments. It isn't unusual for a technician to make the necessary adjustments in the home. Instructions in service data may be labeled *automatic phase control (a.p.c.)* or *automatic frequency and phase control (a.f.p.c.)* alignment. By whatever name the various manufacturers use, the adjustments are simple.

For a specific example, take a look at the schematic of Fig. 2. It is a simplified diagram of the color-sync section of *Motorola's* transistor color-TV. It differs very little from color-sync stages in a tube set. The oscillator and control arrangement is the chief difference, but adjustment varies hardly at all.

The first step is to bring the color oscillator as near to its proper frequency as possible without sync. So, disable the incoming sync. In this chassis, you can jumper the secondary of *T1*. With color bars or a color program on the TV screen, adjust *L3* to make the color stand still or drift very slowly. If you can't, the oscillator has a defect.

Remove the jumper from *T1*, allowing sync through the crystal and its amplifier. Adjust *T1* until the color bars or the colors are locked solidly into position. At this point, ignore whether the positions are correct or not; you'll adjust for proper hues next. For now, make the bars stand solidly still. Turn the slug of *L1* in one direction until the colors or color bars drop out of sync. Then reverse and turn it

Fig. 4. Proper sweep-response curve of band-pass amps in one set.



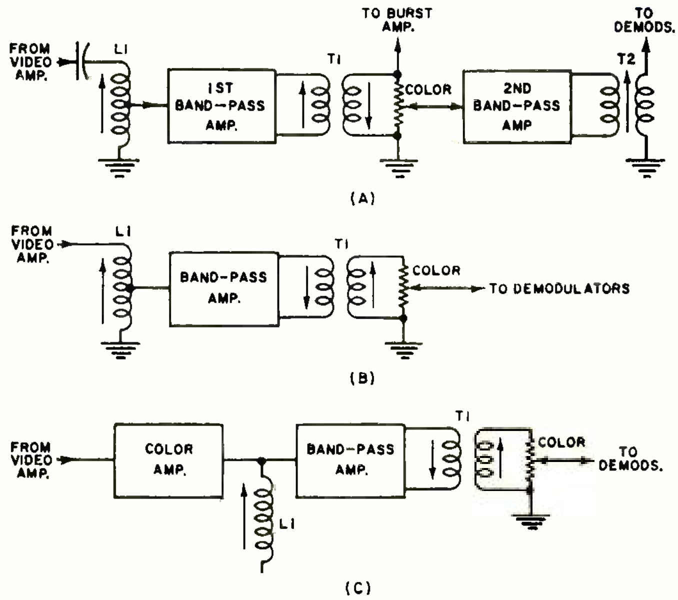


Fig. 5. Color-amp arrangements and adjustments in typical sets.

the other direction until the same thing happens, counting turns as you go. Now set *L*1 halfway between the two points of poor color sync.

Finally, set the Hue control at midrange. With a color program, adjust *L*2 for true flesh-colored skin tones. If you are using a color-bar generator, adjust *L*2 for proper positioning of the bars: first bar at left, yellowish-orange; last bar at right, green.

That's all there is to adjusting the color-sync section in a transistor color receiver. Compare that, now, with the procedure common to a large number of tube models. Fig. 3 is the diagram. Only two adjustments are shown in this *Zenith* configuration, although some sets have another coil, following the oscillator. (The coils following the oscillator in *Zenith* chassis are in the demodulator stages, which will be discussed later.) To adjust *L*1, jumper the phase detector output voltage to ground. Make the colors on the screen stand still or drift only very slowly. Remove the jumper and adjust *T*1 for proper skin tones, with the Hue (Tint) control centered. You can use a color-bar generator, as described already. There are just two quick adjustments in this tube-type color-sync section. Others are seldom any more complicated.

Direct Band-Pass Alignment

Band-pass adjustments are not a field job. You need a sweep generator, marker generator, and scope. For most chassis, you also need a bias supply to clamp the a.c.c. Otherwise, you can't be sure of color-amplifier gain.

The response-curve of Fig. 4 shows what you are trying to accomplish with band-pass alignment (often called just "chroma alignment"). The amplifiers must pass freely all frequencies between 3.08 and 4.08 MHz—which are 0.5 MHz to each side of the color subcarrier. At the same time, the 4.5-MHz sound intercarrier must be blocked completely. Hence, a very steep skirt is necessary from just above 4.08 MHz to the near-zero dip at 4.5 MHz.

There are two easy methods of viewing the response curve of the chroma bandpass stages. The simpler of the two is the one to be described first. Some typical chroma amplifiers are shown in Fig. 5. All have the same purpose and similar adjustment procedures.

The sweep generator must be capable of sweeping at least 1 MHz up and 1 MHz down (2 MHz wide) from a center frequency of 3.58 MHz. Some generators with saturable-inductor systems of sweeping can't be used because their sweep widths are too narrow at the bottom end of their frequency ranges. Electromechanical sweep generators can sweep well above and below even their bottommost dial frequency.

Start by making sure the video i.f. section of the color receiver is properly aligned. By all means, make sure the 4.5-MHz trap in the video amplifier is adjusted for minimum; it won't do to have any 4.5-MHz signal coming through. If you're already sure the i.f. response of the receiver is accurate, prepare the receiver as for i.f. sweep alignment. Disable the horizontal output stage. Pull the tube from its socket. You'll have to load down the "B+": one manufacturer recommends a 2500-ohm, 100-watt resistor—four paralleled 10k, 25-watt resistors will do. Also disable the last i.f. stage by pulling the i.f. tube from its socket.

Connect the sweep generator to the output side of the video detector, which is about the same as connecting to the grid of the first video amplifier. Use a demodulator probe with the scope, and connect it to the output of the last band-pass amplifier transformer. If the Color control is a potentiometer between the last band-pass amplifier and the demodulators, connect the scope probe to the output side of the control. The marker signal can be fed in at the same point as the sweep signal, but use a 1500-ohm resistor to isolate its hot lead.

Set up the response curve and notice there is already a marker at 3.58 MHz (caused by the receiver's own 3.58-MHz oscillator). Does it fall in the center of the curve you see? If not, correcting that is the first thing to do. Adjust the tuned circuits in the chroma amplifiers until the curve is about evenly distributed on each side of the 3.58-MHz marker. Ignore the shape of the curve during this preliminary step.

In most chassis, you can shape the symmetry of the curve best with the double-tuned transformer. That's *T*1, in Figs. 5A, 5B, and 5C. The upper skirt, the one that must be so steep between 4.08 and 4.5 MHz, can usually be shaped nicely by the single-tuned coil—represented by *L*1 in the three-part figure. The final transformer, *T*2 in Fig. 5A, keeps the center of the curve filled in; if the curve shape recommended by a manufacturer includes a hump on the up-frequency side of center, this transformer can be swung over to boost response there. The shape in Fig. 4 is representative, but isn't the last word. Follow the manufacturer's recommendation for his particular receiver.

Indirect Band-Pass Alignment

The other "easy" way to view the response curve is for use when you have a generator that doesn't sweep the needed 2-MHz width at 3.58 MHz. You feed the i.f. sweep generator signal through the video i.f., beating it against an accurate 45.75-MHz signal from an r.f. generator. Demodulated at the video detector, a beat sweep signal goes through the chroma amplifiers. With the scope connected at the output of the band-pass amps, through its own demodulator probe, a response curve of the chroma stages is produced. Here, in brief, is how to set this up.

Make sure the video i.f. section is in perfect alignment. Leave the sweep and marker generators connected to the mixer test point, and the scope to the video detector output. (*Editor's Note: If you don't understand i.f. alignment, see "TV Alignment Techniques" in the August and September 1968 issues.*) Add d.c. bias to the a.c.c. as recommended by the manufacturer; about 1.5 volts is usually enough. Adjust the sweep width until the response curve just fills the base line on the scope. Set the height to a convenient level for viewing—1½ inches is fine.

Set up a *very accurate* 45.75-MHz marker signal. One way to get accuracy is to tune in a station temporarily; the curve will be messed up, but you'll be able to see a strong marker at the picture i.f.—45.75 MHz. Superimpose the marker from your r.f. generator on the one from the station, then tune away from the active channel; the accurate generator marker will remain. Do not touch the dial of the r.f. generator again.

Remove the scope from the video detector. Connect it through a demodulator probe to the output of the band-pass amplifiers. Set the Color control at about three-quarters of maximum. You should be able to see a response curve of the band-pass amplifier on the scope. Readjust the scope vertical gain controls to make the curve easy to view, but do not change any generator controls.

At this point you need another r.f. generator (or use the sweep generator if it has additional marker facilities) to mark the response curve of the band-pass amplifiers. There is already one marker visible—from the receiver's 3.58-MHz oscillator. Tune this third generator to 42.17 MHz. Feed its signal into the color set along with the other two, at the mixer test point; use a 1500-ohm isolating resistor. The 42.17-MHz signal will mark the curve near the one already there. Zero it in exactly. Then you can kill the receiver 3.58-MHz oscillator so it doesn't swamp the curve.

Note the exact dial setting of the third generator. At 0.5 MHz above that point, the generator will produce a 4.08-MHz marker on the band-pass response curve; at 0.5 MHz below, it will produce a 3.08-MHz marker on the curve.

The adjustments themselves are the same as for the simpler method already described. The double-tuned transformer is for the width and symmetry of the curve, and the single-tuned coil or transformer determines the centering and steepens the upper-side skirt.

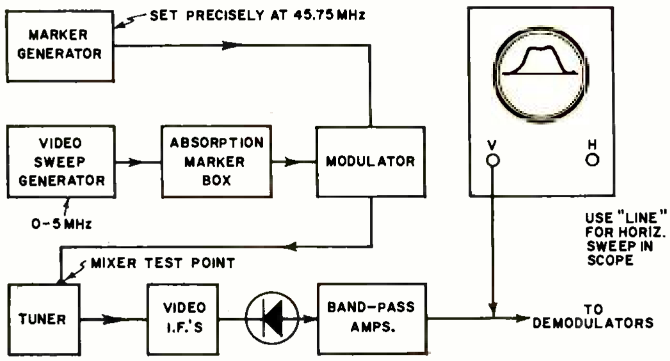
Video-Sweep-Modulator (V.S.M.) Method

A variation on the indirect method is recommended by *RCA*. It requires some special equipment, in the hookup shown in Fig. 6. The signal from a video sweep generator, already marked at 3.08, 3.58, 4.08, and 4.5 MHz by an absorption marker box, is mixed with a highly accurate 45.75-MHz signal. Fed through the i.f. stages, video detector, and band-pass amplifiers, the signals make a sweep signal that displays the band-pass response on the scope.

One advantage of this method of generating the sweep curve is that markers can't swamp the tuned circuits and distort the true response. They are absorption markers that merely cause tiny notches in the response curve at their designated frequency points. Because there is no distortion problem with absorption markers, all the significant points on the curve can be marked at the same time. *(Multiple marking of curves is also possible with a marker generator that has a number of separate marker oscillators, provided the marker-adder approach is used, as described in "TV Alignment Techniques," August and September 1968 issues.—Editor)*

Another advantage is the same as derived from the other indirect method: the response curve of the band-pass section also takes into consideration the video i.f. response, which can have a decided effect on color reception. If the i.f. strip is out of alignment, sweep and marker frequencies won't show up correctly at the output of the video detector, and will therefore be wrong at the band-pass output, too. It would be impossible to get a correct band-pass curve. So, if you have that trouble, when using either the beat-signal method or the v.s.m. method, recheck video i.f. alignment.

Fig. 6. Equipment setup for v.s.m. method of chroma alignment.



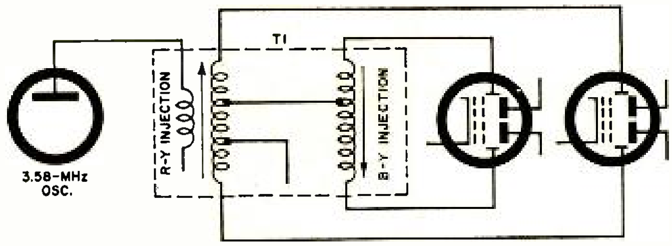


Fig. 7. Demodulator adjustments found mainly in Zenith sets.

The Demodulators

Only a few brands and models of color sets have adjustments in the demodulator sections. In those that do, the adjustments are important to fidelity of color. Fig. 7 shows the one that is common—a *Zenith* circuit. Once adjusted, it seldom needs touchup, but it might. You need a scope, a color-bar generator, and a v.t.v.m.

Connect the color-bar generator to the antenna input and the v.t.v.m. to the positive voltage output of the chroma phase detector (use the 50-volt d.c. range). Adjust the R-Y injection slug in *T1* for maximum reading, and the B-Y injection slug for minimum. You might have to repeat each adjustment a few times. Be sure the other chroma band-pass and color-sync adjustments were made *before* these coils are adjusted.

Set the Hue (Tint) control to midrange, and the Color control to about three-quarters of maximum. Connect the scope to the red CRT grid. Adjust the burst transformer (not shown) until the second and fourth bars on the scope display are equal in amplitude.

Move the scope to the blue CRT grid. The sixth and seventh bars should be equal in amplitude. If not, touch up the B-Y injection coil ever so slightly.

Move the scope back to the red CRT grid and turn the Hue fully counterclockwise. Touch up the burst transformer, if necessary, until the first and second bars are of equal height. Turn Hue maximum clockwise. The fourth and fifth bars should be equal in height. If not, go through the adjustments with the color-bar generator and scope again. You may find it necessary to compromise the final adjustment of the burst transformer to "center" the range of the Hue control.

The final adjustment in any color-TV chroma alignment is of the 3.58-MHz traps. If the set has them, they are between the demodulators and the color-difference amplifiers. Connect the scope at the output side of the traps and adjust them for minimum 3.58-MHz response. Most receivers have this refinement, but the traps may not be adjustable. ▲

EDITOR'S NOTE: *As mentioned previously, readers of this article on chroma alignment should also be interested in two other related articles by the same author on the important topic of sweep alignment. These articles are entitled "TV Alignment Techniques," Parts 1 and 2. The first article, which appeared in our August, 1968 issue, goes into the various pieces of test equipment that are required to do the alignment job. The second article, which appeared in our September, 1968 issue, then tells how to interconnect these instruments and gives the proper alignment procedure to use for the r.f. and i.f. sections of the TV receiver.*

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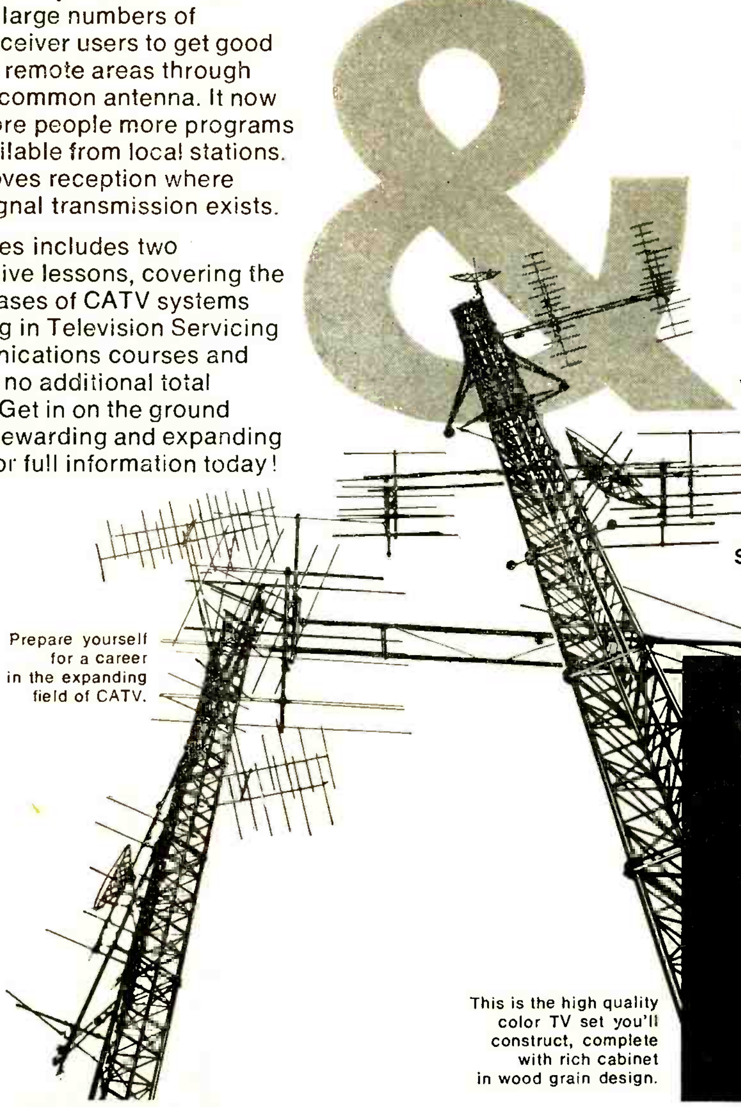

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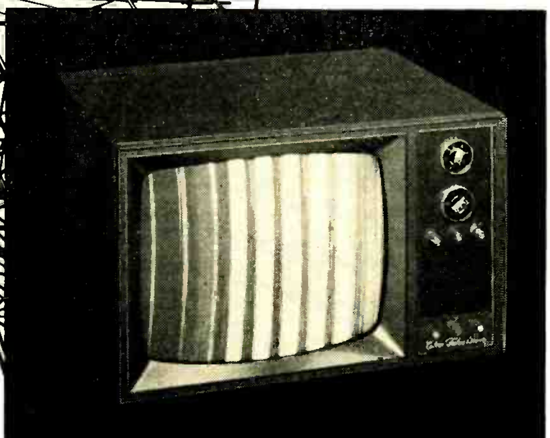

This is the high quality color TV set you'll construct, complete with rich cabinet in wood grain design.

JOHN FRYE

By providing built-in serviceability, set makers can reduce the soaring cost of color-TV repairs.

COST OF COLOR-TV SERVICE

IT WAS a pleasant February day, both inside and outside Mac's Service Shop. Outside the brilliant sun had nudged the mercury up to nearly 50 degrees—the warmest it had been since last November. Inside Mac and his assistant, Barney, were enjoying the rare experience of having every single set in the shop repaired, ticketed, and ready to go. They chatted back and forth contentedly as they cleaned up the bench, wiped off the instruments, and racked up the tools.

"Mac," Barney said, "a little while back I read an interview with Joseph C. Duncan, national customer service manager for the *J. C. Penney Co.*, in which he said that according to an industry estimate the owners of color-TV sets spent some $400 million on repairs in 1968 and that this annual color-TV service bill would zoom to $4 billion within the next ten years."

"Sounds good for the color-TV service business."

"That is not exactly what he had in mind. He feels that within five years these skyrocketing repair bills will begin to clog sales, and if that is allowed to happen, everyone in the color-TV business will be adversely affected."

"Does he consider color-TV service charges excessive?"

"He didn't seem to be criticizing the service technician as much as he did the color-TV manufacturer. He said poor chassis layout and allowing manufacturing cost considerations to arbitrarily dictate component location and fabrication techniques were major factors in the high cost of color-TV service. Test points are often buried so deep inside the chassis that they require considerable labor to reach. Other components, such as transistors, are soldered into the circuit so they are difficult to remove for testing or replacement without damage; and when a new unit is called for, it is likely to be damaged in soldering it to the circuit board."

"He'll not get an argument out of me that way," Mac stated. "You know what a rare and pleasant surprise it is for us to find transistor sockets in any present-day electronic equipment. When this does happen, we feel a warm wave of gratitude to the engineer who designed the equipment. He obviously expected his brain-child to last long enough to need service eventually and to be worth repairing—two considerations that obviously played no part in the design of much of the stuff that crosses our bench today. Does Mr. Duncan have any suggestions as to how color-TV repair costs can be lowered?"

"Quite a few. He wants all TV sets designed so test points are clearly called out and easily accessible. He estimates this would add only about 50¢ to the cost of manufacturing a set. He also thinks transistor sockets should be used. This, he admits, would add a few more dollars to the cost of the set.

"But he doesn't stop there. He believes a special, easily accessible panel should be developed that would connect to all important test points and permit a malfunctioning circuit to be quickly located by current and voltage measurements or waveform analysis made right at this test panel."

"I should imagine he would react favorably to *Motorola's* new Quasar chassis. You know that's the one using only one vacuum tube (the picture tube) along with 68 transistors and other solid-state components. It employs ten plug-in component boards, each of which is removable and can be replaced as a whole by the service technician."

"You're right; but he thinks this module concept should be carried still further to include an indicator for each module to show if it is functioning properly. How does that strike you?"

"Not quite so favorably. Making color-TV sets easier, quicker, and less costly to service is one thing; trying to build them so the customer can do his own servicing is something else. Encouraging the customer to believe he can successfully and safely service something as complicated as a color-TV receiver is about as practical as publishing a book on 'Brain Surgery Self-Taught.' You and I both know that designing an indicator to signal a significant deviation from a normal waveform would be both complicated and costly. Equipping each module with a reliable trouble indicator—and a trouble indicator is worse than useless if it's not reliable—would add a prohibitive amount to the cost of the receiver."

"I agree. You can justify just so much extra cost to make a receiver easier to service; from there on you're defeating your purpose. Mr. Duncan apparently knows that, but he argues that not all the increased set cost would have to be passed on to the consumer because warranty service costs to the dealer would be less expensive."

"That's true, and I hope color-TV manufacturers were listening to Mr. Duncan's comments. *Zenith*, as you know, has talked about the serviceability of their hand-wired chassis for a long time. Now *Motorola* has joined them and talks freely about trying to make their color-TV receivers easier to service. I'm glad to see these two companies have the courage to try to sell 'serviceability,' and I hope other manufacturers join them. Admittedly, it takes courage to talk about the possibility that the product you are trying to sell requires repair. That is not a pleasant thought for the customer to have in mind when he is shopping for a color set. The salesman would prefer that the customer thought only of how much he was going to enjoy his receiver watching the Rose Parade or 'Laugh-In's' bikini girls in living color.

"Automobile manufacturers went through much the same thing. For a long time they argued that people wouldn't buy safety, when actually they were reluctant to suggest, even indirectly, that their customer might be involved in a crippling or fatal accident in the chromed beauty they were trying to sell him. It was 'bad sales psychology' to bring up such a distasteful possibility. But once public opinion and the government forced all car manufacturers to include basic safety features, they discovered that talking about safety didn't frighten away customers at all; and now they actually compete with one another in telling about how much they have done to make their products safe.

"And right now it looks as though they, too, may be forced to give more thought to the serviceability of automobiles. Designs that make necessary excessive costs for replacing

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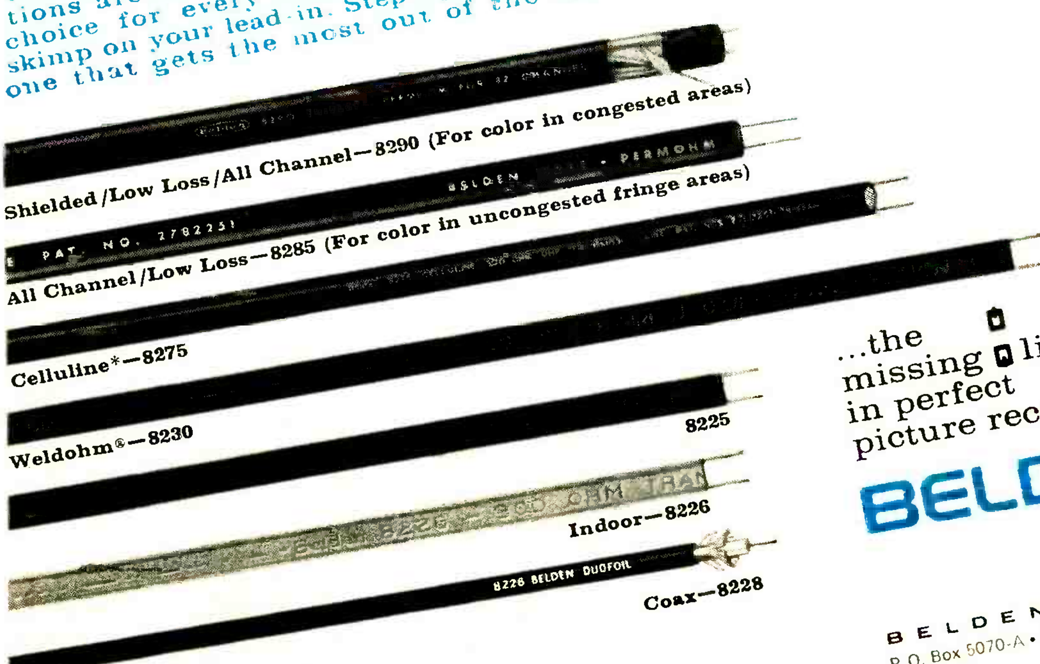

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easily-damaged parts are under investigations, along with new-car warranties, and out of these investigations may well come further government regulations. TV set manufacturers might do well to take heed.

"Strictly speaking, now is an excellent time for the color-TV set manufacturers to do some soul-searching and head-scratching on this matter of making their products easier and less-costly to service. We are just on the verge of a whole new line of solid-state color-TV receivers; so what better time could there be for designing more serviceability into this new breed of receivers?"

"Yeah man!" Barney agreed, "and I think a darned good place to start would be to include sockets for the transistors and the IC's that will go into those receivers. Not long ago I was reading where Gerald F. Hunt, vice-president for new products of the *Cinch Manufacturing Co.*, estimated that 10% of all IC's are now socketed and that there is a significant trend toward the use of still more sockets in areas where the IC's will need replacement. Beyond a doubt, that will include color-TV receivers. Here's hoping the manufacturers don't solder those 14-contacts-plus directly to the circuit board!"

"Amen!" Mac seconded. "Actually I wonder if maybe the military may not be pointing the way toward color-TV servicing in the future with the automatic testing equipment they use to keep vital communications and avionics gear in top operating condition. I'm thinking of the Navy's Versatile Avionics Shop Test (Vast) system; the Air Force's General Purpose Automatic Test Sets (GPATS); and the Army's Depot Installed Maintenance Automatic Test Equipment (Dimate) and Land Combat Support System (LCSS)."

"How do they work?"

"Well, the Dimate system is typical. A magnetic tape directs Dimate's pre-programmed computer which operates signal-generating and signal-detecting instruments to compare actual and ideal test results to determine if the unit under test is working properly. If not, Dimate prints out a description of the malfunction. Recently equipment of this kind was used at the Sacramento Depot to check out some 1000 Vietnam-bound walkie-talkies in an average time of 8½ minutes per set. It takes a skilled technician 1½ hours to check out one of the transceivers."

"Hey, you're surely not suggesting every service shop should have one of these little Dimate gems that probably take up a couple of Army trucks and cost several hundred thousand dollars!"

"You're low. The cost is between two and three million dollars. Of course I'm not suggesting anything so elaborate as that. What I do have in mind, though, is that the basic principle might well be applied to color-TV servicing. If the manufacturers will get together *now* and decide upon some standardization in the location and marking of circuit test points—both for signal injection and signal pick-off—and if these test points are either brought out to a standard test panel or are made readily accessible so that such a panel can be quickly connected to all of them, then it would not be too difficult to design a compact signal-generating and signal-detecting battery of instruments that would plug into that panel and at the dictation of a simple, versatile programmer, say a punched tape, would test all the circuits of the TV receiver in proper sequence and reveal to the eye of the the technician exactly what circuit was malfunctioning."

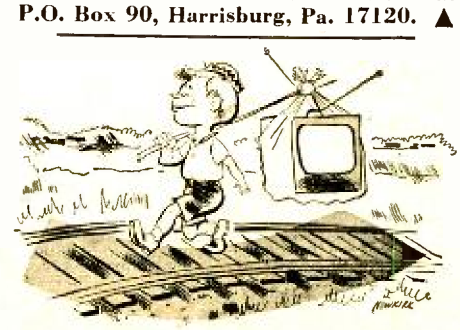
"I *know* it could be done," Barney said enthusiastically. "For people who have worked out all the tough problems that had to be overcome to produce color-TV as we have it today, designing such an automatic test set should be duck soup."

"I feel we should say one thing before leaving the subject," Mac concluded. "Up until now color-TV manufacturers have been chiefly concerned with trying to get the cost of their sets down until almost everyone could afford a color receiver. If, in their determination to do this, they have ignored the problem of serviceability, this can be understood. But now the fear of high service costs is beginning to be as much a detriment to sales as is the initial cost. This is a good thing to ponder—but not for too long!" ▲

LASER REGISTRATION

THE Pennsylvania Department of Health has recently adopted a new regulation, Article 436, which calls for the registration of all lasers and laser systems being used in the Commonwealth and for the reporting of all accidents resulting from the use of such laser systems.

Their Division of Occupational Health has issued "Hygienic Information Guide No. 72" covering various facets of laser operation and control. The department is asking the cooperation of all laser users in complying with Article 436 so that laser usage may be expanded safely and in an orderly manner. The Commonwealth of Pennsylvania's Department of Health can be addressed at P.O. Box 90, Harrisburg, Pa. 17120. ▲



D.C.-D.C. Converter

(Continued from page 37)

in square centimeters; and F=switching frequency in Hz.

Using a *Magnetics, Inc.*, core 50425-4A, B_m is 16.5 x 10^3 gauss and A is 0.817 cm^2. Substituting these numbers in equation (2), the number of turns required in each half of the primary for 400-Hz operation is 46. From equation (1) the number of turns for the secondary is:

$$N_s = \frac{N_p}{2} \times \frac{E_s}{E_p} = 46 \times \frac{115}{10} = 530 \text{ turns}$$

To allow for transformer losses, its is advisable to increase this number by about 5%, or to 556 turns. The feedback winding should consist of about 35% of the primary (*i.e.*, a total of 34 turns center-tapped).

Figs. 4 and 5 show actual performance curves for a completed unit. Fig. 4 shows that the output voltage regulates within ±1% for input voltage variations of 11 to 20 volts. The converter efficiency peaks at 85%, at an input of approximately 11.3 volts d.c. From this point, efficiency falls rapidly as the input voltage is increased.

Fig. 5 is a plot of output voltage versus converter loading. The regverter maintains the output constant to within ±1% for all loads from 10% to 150% of the design value.

When the output is bridge rectified and filtered by 20 μF of capacitance, output ripple can be minimized to less than 0.2%.

These actual measured performance characteristics show clearly the advantages of a simple regverter circuit in achieving first class performance. With this basic circuit in the transformer primary, the designer is free to select secondary circuits to meet an infinite variety of output requirements. The Regverter is especially valuable where a stable a.c. supply is required for operation of 60- or 400-Hz equipment. ▲

"My husband's in the aerospace industry. I'd like one of those Van Allen radiation belts."

EW Lab Tested

(*Continued from page 22*)

96 dB below the rated 40-watt output.

An input of 0.72 volt was required to develop 10-watts output; about 2 volts drove the amplifier to its full 70 watts. Into 16-ohm loads, maximum power was about 39 watts; into 4 ohms it was 107 watts per channel.

The manufacturer also makes this amplifier available without the cabinet as the SE408S, for installation in the rear panels of some models of their speaker systems. In this application, the exposed metal panel of the amplifier serves as a heat-radiating surface, and the amplifier can run continuously.

There is little more to be said about this superb instrument. The amplifier combines the practically total freedom from distortion under all conditions of operation, compact size, light weight, attractive styling, and relatively moderate price ($300, $276 without cabinet). It is clear to us that in the SE400S *JBL* has a "winner." ▲

Teac A-6010 Tape Deck

For a copy of manufacturer's brochure, circle No. 30 *on Reader Service Card.*

THE *Teac* A-6010 impressed us, even at first glance, as an unusually attractive tape deck/preamplifier. As we used it, we were gratified by its ease of operation, fine sound, and its smooth, positive-action push-button-operated solenoid controls. Our subsequent laboratory tests fully justified these subjective reactions. The *Teac* A-6010 is one of the best all-around home tape decks we have used, and it should satisfy the most critical user.

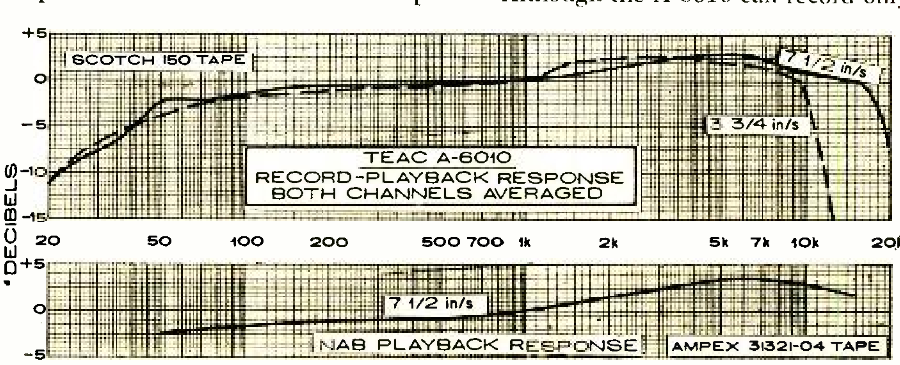
The Japanese-made A-6010 is the top model of the *Teac* line. It comes in an oiled-walnut cabinet, which can be installed either vertically or horizontally. This solidly built tape deck, containing solid-state recording and playback preamp electronics, but no power amplifiers or speakers, weighs 46 pounds. It accommodates reels up to 7 inches in diameter, at speeds of 7½ and 3¾ in/s. A 15-in/s conversion kit is available for about $6. The deck has four quarter-track heads: erase, record, and playback in the forward direction, and another playback head for the reverse direction. (The unit can be special-ordered with half- or full-track heads at no added cost.) It has an excellent automatic tape-reversal system.

The A-6010 transport has three motors, with the capstan driven by a dual-speed hysteresis synchronous motor. All transport controls are solenoid-operated, with three lever-type push-buttons for selecting normal or fast speeds in either direction, and an extra wide Stop button beneath them. The tape

speed is selected by a push-button, which controls the capstan motor speed electrically. The equalization is changed automatically with the speed. Another button provides reduced tape tension for safe handling of 0.5-mil tape.

The separate recording and playback amplifiers and heads permit monitoring from the tape while recording. The Tape/Source monitor switch connects the twin illuminated vu meters (which are large and highly legible) and the monitor outputs to the playback or recording amplifiers. There are microphone and line inputs for each channel, with concentrically mounted individual mixing-type level controls. The two line-output level controls are also concentric. Microphone and low-impedance headphone jacks are on front panel; line outputs and inputs are in rear.

Although the A-6010 can record only



in the normal (forward) direction, its extra playback head permits it to play the second half of a reel of tape without interchanging reels. The transport control buttons can be used to change directions, or this can be done automatically in two ways. One method is to cement a piece of conducting foil on the tape where reversal is desired, and when the foil passes over a sensing contact, the tape will reverse and continue to play. (With an optional Tape Repeat unit, foil can be added at two points to repeat any section of the tape indefinitely.)

More convenient is the Phase-Sensing Auto-Reversal System. Depressing the Signal Record button at any point on a tape where reversal is desired records a 60-Hz signal to saturation level. This button simultaneously connects the recording heads out of phase. When the tape is playing normally, with the Auto-Reversal turned on, the record heads are used as auxiliary pickup heads, with their outputs connected out-of-phase. Their outputs are summed and fed to a special tuned amplifier and relay control circuits. Because of their normal phase characteristic, program signals will have no effect on the control circuits, even if they are in the 50- to 60-Hz region and quite strong. The reversing action is rapid and smooth, and since the phase-sensing comes before the normal playback head, no sound is heard in the recorder outputs when reversal occurs.

Our laboratory measurements showed an over-all record/playback frequency response of +3, −2 dB from 50 to 18,000 Hz at 7½ in/s, and +3, −2 dB from 80 to 10,500 Hz at 3¾ in/s, using *Scotch* 150 tape. The playback frequency response with the *Ampex* 31321-04 test tape was +4, −2 dB from 50 to 15,000 Hz.

The signal-to-noise ratio was 50 dB at both speeds. Harmonic distortion was exceptionally low, under 1 percent at 0 vu, and only 3 percent at +10 vu (off scale on the meters). Wow was 0.02 percent at 7½ in/s, 0.03 percent at 3¾ in/s, and flutter was 0.07 percent at both speeds. The speeds were exact and the fast tape speeds were really fast, handling 1800 feet of tape in 100 seconds.

In use, we found the controls to be foolproof. The pleasure of operating the deck was enhanced by the fact that, recording from an FM tuner, we were not able to distinguish the input signal from the output at either tape speed. No more could be asked of a recorder from the standpoint of sound quality. The lack of noise (both mechanical and electrical) and tape hiss were especially notable.

The *Teac* A-6010, complete with cabinet, sells for $664.50. An optional remote-control unit lists at $40. ▲

One of our students wrote this ad!

Harry Remmert decided he needed more electronics training to get ahead. He carefully "shopped around" for the best training he could find. His detailed report on why he chose CIE and how it worked out makes a better "ad" than anything we could tell you. Here's his story, as he wrote it to us in his own words.

Harry Remmert on the job. An Electronics Technician with a promising future, he tells his own story on these pages.

By Harry Remmert

AFTER SEVEN YEARS in my present position, I was made painfully aware of the fact that I had gotten just about all the on-the-job training available. When I asked my supervisor for an increase in pay, he said, "In what way are you a more valuable employee now than when you received your last raise?" Fortunately, I did receive the raise that time, but I realized that my pay was approaching the maximum for a person with my limited training.

Education was the obvious answer, but I had enrolled in three different night school courses over the years and had not completed any of them. I'd be tired, or want to do something else on class night, and would miss so many classes that I'd fall behind, lose interest, and drop out.

The Advantages of Home Study

Therefore, it was easy to decide that home study was the answer for someone like me, who doesn't want to be tied down. With home study there is no schedule. I am the boss, and I set the pace. There is no cramming for exams because I decide when I am ready, and only then do I take the exam. I never miss a point in the lecture because it is right there in print for as many re-readings as I find necessary. If I feel tired, stay late at work, or just feel lazy, I can skip school for a night or two and never fall behind. The total absence of all pressure helps me to learn more than I'd be able to grasp if I were just cramming it in to meet an exam deadline schedule. For me, these points give home study courses an overwhelming advantage over scheduled classroom instruction.

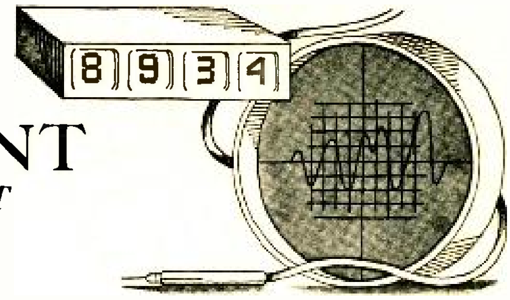
Having decided on home study, why did I choose CIE? I had catalogs from six different schools offering home study courses. The CIE catalog arrived in less than one week (four days before I received any of the other catalogs). This indicated (correctly) that from CIE I could expect fast service on grades, questions, etc. I eliminated those schools which were slow in sending catalogs.

FCC License Warranty Important

The First Class FCC Warranty* was also an attractive point. I had seen "Q" and "A" manuals for the FCC exams.

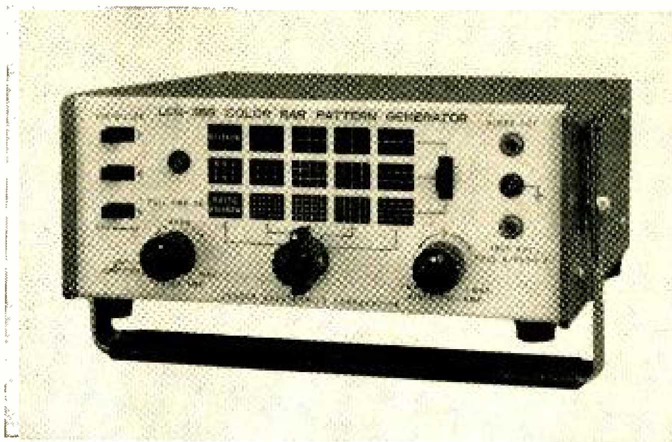
*CIE backs its FCC License-preparation courses with this famous Warranty: graduates must be able to pass the applicable FCC License exam or their tuition will be refunded in full.

TEST EQUIPMENT
PRODUCT REPORT



Leader LCG-388 and LCG-389 Color-Bar Generators

For a copy of manufacturer's brochure, circle No. 31 on Reader Service Card.



THE *Leader Electronics Corp.* of Yokohama, Japan has a large and rather impressive array of test equipment both for the service industry and for laboratories. This equipment is widely used in Japan and other overseas countries. Some of these products are now being distributed in this country by *Leader Instruments Corp.*

We recently had a chance to examine and use two of the company's color-bar generators, the Model LCG-388 (shown in photo) and the LCG-389. The former is really an elaborate and slightly larger version of the latter, which is one of the most compact solid-state color-bar generators that we have seen (measuring only 8 by 6 by 2½ in). The smaller unit has the usual five basic patterns: color bars, dots, crosshatch, vertical lines, and horizontal lines along with the three gun-killer switches. The LCG-388 produces no less than fifteen patterns, ten of which are really scaled-down versions of the original five. For example, the technician can switch from the usual gated rainbow pattern with its ten color bars, to a three-bar pattern (red, blue, and green), or to a continuous, ungated rainbow display. He can switch from a 15 by 21 dot or line pattern, to a 7 by 11 pattern, or to a 1 by 1 pattern. In the latter case, a single dot, a single cross, a single vertical, or a single horizontal line is generated. Still other outputs from this instrument include the video signal and vertical and horizontal trigger pulses for an oscilloscope.

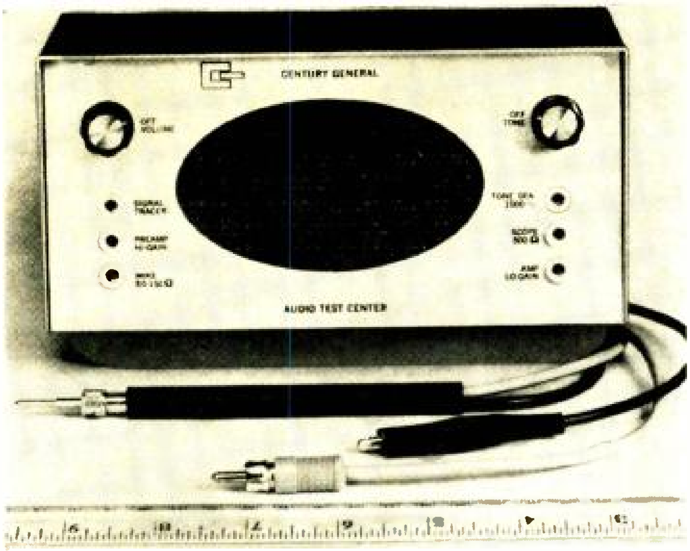
The reason for the small size of these generators is their unique construction. The basic generator employs two 5 by 5½-in computer-type printed-circuit boards, which are stacked one above the other, and plugged into two 18-contact in-line connectors. The two boards slide into a pair of channels in the sides of the instrument. The more elaborate LCG-388 incorporates a 2 by 2-in printed board for the additional circuit functions. The construction of the generators is quite beautiful and simple too. The various brackets and shields are screw-mounted rather than being riveted into place.

Performance of the units matches their construction. All patterns come on promptly with rock-steady stability and this was maintained as long as the power was kept on. The manufacturer credits this high stability to the use of binary counters and gates in the logic circuitry. We counted over 40 plastic-molded silicon transistors, over 50 glass diodes, 2 crystals, and associated *RC* components on the two basic printed boards. No temperature compensation is needed although a regulated power supply is used to eliminate the effects of any changes in the a.c. power-line voltage.

The r.f. output is switchable to either TV channel 5 or 6. The Model LCG-389 is priced at $99, including a black leather carrying case. The more elaborate Model LCG-388, which has a heavy carrying handle that doubles as a tilt stand, is priced at $149. ▲

Century General 140 Audio Tester

For a copy of manufacturer's brochure, circle No. 32 on Reader Service Card.



THIS versatile audio tester, the Model 140 by *Century General Corp.*, shows what can be done with a transistor amplifier having multiple inputs and outputs, an audio oscillator, and a crystal detector. We can use such a device as an r.f., i.f., and audio signal tracer for troubleshooting receivers and amplifiers. If the amplifier has enough gain, we can use it to check tape heads, microphones, and phono cartridges as well. We can also use it as a preamplifier for a scope to make low-amplitude signals readily visible. The oscillator stage can be used to produce an audio tone for signal injection into preamps, amplifiers, or the audio portions of receivers.

When you package these circuits conveniently and attractively and supply all the necessary probes and test leads, you end up with a piece of test equipment that should be of considerable help to the technician, especially if he services much audio and hi-fi equipment.

The audio amplifier in the Model 140 has a gain of 70 dB over a range from 100 to 12,000 Hz (±3 dB), and a 200-mW output which feeds a built-in oval speaker and 500-ohm output terminals for a scope. Inputs are high impedance, low impedance, or through a crystal detector. The tone produced by the audio oscillator is 1000 Hz.

The tester uses 6 transistors (5 for the amplifier, 1 for the tone generator), 1 thermistor, and comes complete with probes and 6 penlight cells. Price of the unit is $48. ▲

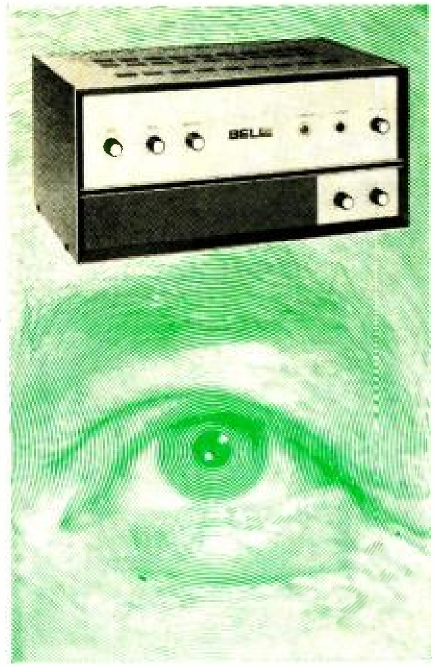
Terado 50-150 A. C. Line Monitor-Regulator

For a copy of manufacturer's brochure, circle No. 33 on Reader Service Card.

IF your a.c. line voltage is consistently high or low, or if it varies widely, you should be able to use one of these new *Terado* "Korect-a-Line" a.c. line monitor-regulators. The unit is simply plugged into the line, and your piece of test equipment, or your CB rig, or your ham receiver, or any other piece of equipment that does not exceed the power rating of the regulator is plugged into it.

Line-voltage monitoring is done on an expanded-scale a.c. voltmeter, which is calibrated from 80 to 140 volts and which has a 2-percent accuracy at 120 volts. Then by means of the six-position switch, you can boost the incoming line voltage by about 13 or 26 volts, you can reduce the voltage by the same two amounts, you can feed the line voltage straight through, or you can switch the line off altogether. This is accomplished by simply interconnecting the unit's built-in center-tapped transformer to either buck or boost the incoming line voltage. The device does not provide line-voltage regulation, and should more properly be called a monitor-adjuster.

The Model 50-150, shown here, has a capacity of 300 to 500 watts and lists for $21.95. Other models in the company's line have lower and higher capacities and are priced from $11.95 to $32.95 without the monitor meter. ▲



TRANSISTORS MADE OF GLASS

By A. H. SEIDMAN / Contributing Editor

Is this newly publicized device a real challenge to the more conventional germanium and silicon crystalline transistor?

A recently publicized device made of amorphous material, like glass, may herald another revolution in the electronics industry, challenging the supremacy of germanium and silicon devices used today. On the other hand, the device, which recently received front-page publicity from such respected newspapers as *The New York Times, The Wall Street Journal, Washington Post,* and *Boston Globe,* may just be a re-hash of an old idea that semiconductor manufacturers know about but have discarded. The "glass transistor" was announced several years ago in the technical press and has even been licensed to several U.S. and foreign firms. Patented by Stanford R. Ovshinsky, president of *Energy Conversion Devices, Inc.* of Troy, Michigan, a somewhat similar mechanism has also been patented by *Bell Labs.*

The material used can be one of the oxide- and boron-based glasses or a composition of tellurium, arsenic, silicon, and similar elements. Behaving as a switch or memory, operation of the device was described most recently in an article by Ovshinsky in the November 11, 1968 issue of the erudite journal *Physical Review Letters.* If the device proves itself, it could have a tremendous impact on the computer industry where switching and memory functions are performed in really stupendous quantities.

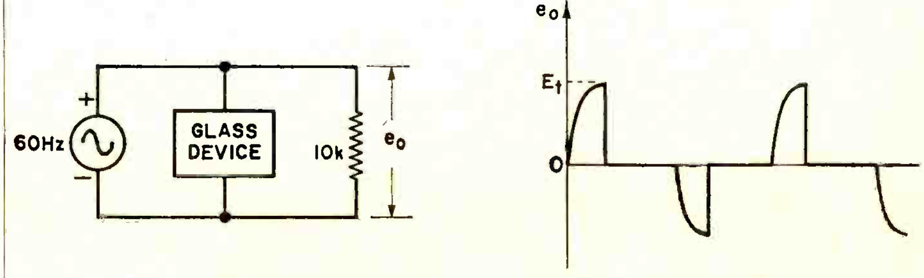
Commonly used materials for solid-state devices, like silicon and germanium, have a well-ordered lattice structure referred to as crystal. Glass on the other hand, an amorphous material, exhibits a disordered structure. An amorphous material, though, does share some properties common to silicon and germanium. For example, the energy gap for glass, *i.e.*, the region where no current carriers exist, is in the same order of magnitude as for silicon and germanium: 0.6 to 1.4 electron volts. The conducting mechanism for these materials is different.

The voltage-current characteristic of a glass device is symmetrical with respect to applied voltage and current. Referring to Fig. 1A, if a 60-Hz voltage is supplied to the device, shunted by a 10,000-ohm resistor, the output appears as shown in Fig. 1B. When the input voltage exceeds a certain minimum or threshold voltage, E_t, the device conducts and acts as a closed switch. In this state, the current can be increased or decreased without an appreciable change in voltage across the device; the dynamic resistance is therefore close to zero ohms. The switching mechanism appears to depend on localized and close-spaced energy states in the material.

The device described in the journal contained, in atomic percentages, 48% tellurium, 30% arsenic, 12% silicon, and 10% germanium. A specimen of this material, an evaporated film 5×10^{-5} cm thick, was mounted between two carbon electrodes having a contact area of approximately 10^{-4} cm^2. If the percentage of arsenic is reduced to 5 percent, the device exhibits memory properties. After switching from a nonconducting or "off" state, the conducting "on" state is preserved even if the excitation current is removed. To return to its "off" state, a suitable current pulse of either polarity is applied to the device.

Before the glass device, or for that matter any new device, becomes competitive with existing diodes and transistors, it has to prove itself in terms of reliability, ease of application, frequency and temperature stability, and cost. It may be further noted that in the paper by Ovshinsky no mention was made of how glass devices can be used for linear amplifiers. Still, the device is interesting and worth watching. ▲

Fig. 1. Behavior of glass device with a 60-Hz sine-wave input signal. (A) shows test circuit used while (B) illustrates the output waveform.



(A)

(B)

Hi-Fi Receiver Design

(Continued from page 34)

built around a direct-coupled fully complementary circuit which protects itself as well as the speaker from damage under abnormal operating conditions. Eliminating the large electrolytic coupling capacitor between amplifier and loudspeaker has improved low-frequency response, phase linearity, and damping factor.

The problems of d.c. offset voltage at the speaker terminals have been solved and eliminated. As much as 30% line-voltage change produces totally acceptable d.c. offset variations. Ambient temperature changes are compensated for by a diode sensing element in the d.c. feedback loop. Correct d.c. bias in the output stage is maintained by a stabistor diode in thermal contact with the large heat sink. There are none of the usual turn-on/turn-off transients.

The amplifier is completely indestructible even under short-circuit conditions occurring during maximum power output. The output current is sampled and compared to a reference standard. If the power delivered exceeds the maximum design limit, a protective circuit goes into action instantaneously and reduces the drive signal to a safe limit. If the short is removed, the circuit will return to normal in a fraction of a millisecond. If the short circuit is maintained under full power, a slow-acting resettable circuit breaker opens the circuit. There are no fuses to replace.

Modular Construction

In addition to the electronic features that have been described, the construction of this receiver is based on a different packaging concept. Modular construction or packaging in electronics is not entirely new and has been employed in some areas for several decades. It is significant that the modular approach has gained widespread acceptance in computer electronics where reliability and serviceability are prime objectives. With the advent of transistors, IC's, and miniaturization, it has become possible and practical to build consumer electronic equipment by integrating, within a single container, a system of functional subassemblies or modules as is done in a computer.

Many of *H. H. Scott's* future FM receiver designs will be assembled entirely from a set of basic modules, with the exception of the main power supply and r.f. assembly. All modules are of the plug-in type and all undergo an accelerated "burn-in" test as well as a listening check. Replacement modules are aligned and tested at the factory before they are sent to the dealer. Replacing a module is no more difficult than replacing a bad tube in a TV set, consequently the technician can often repair the unit in the home. Some technically inclined users may even wish to replace their own modules.

The interconnection system used for the modules is manufactured by *AMP Inc.* The interconnection system was selected to meet the following specifications:

1. Connections must be electrically and mechanically equal or superior to solder joints.
2. System must offer maximum flexibility to design engineer.
3. Product variations must be possible with minimum expenditure.
4. Modules must be replaceable without tools; it must be physically impossible to insert a module incorrectly.
5. System must withstand shock and vibration due to shipping.
6. Electrical connection and mechanical mounting must be achieved in a single step.
7. Process of mounting connectors must be automated.
8. Increased material cost should be at least balanced by labor savings this method of construction affords.

The photograph on page 34 shows a close-up of the receptacles as they are mounted on the PC board module. The 6-post plug assembly normally mounted in the chassis is also visible. The plug assembly snaps into a rectangular cutout; interconnections are made by a wire-wrap technique on the underside of the chassis while the module plugs in from the top. The box-like receptacle contains two flat cantilever contacts for each terminal which make electrical contact with both flat sides of each post. The large contact area accounts for the excellent connection.

The use of computer circuitry and modular construction should provide hi-fi components with more new features yet the equipment will be simpler to operate. ▲

"Guess what I found down there . . . a bunch of TV's tagged 'impossible'!"

FCC PROPOSED RULE MAKING FOR 2-3 MHz Marine Band

By RICHARD HUMPHREY

Another step has been taken in the transition from AM to SSB in the medium-frequency marine radio band.

ON September 12, 1968, the Federal Communications Commission released the Notice of Proposed Rule Making in regards to Docket #18307, the transition from AM to SSB in the 2-3 MHz marine band. The dates were pretty much what was expected but a v.h.f./FM eligibility requirement in order to install the new equipment was foreseen by very few.

The dates: *January 1, 1971,* no more new installation of AM marine phones; *January 1, 1977,* no more use of AM (double sideband) emission with certain exceptions (mainly distress) on 2182 kHz, the International Calling & Distress frequency.

The 1971-1977 dates are (*a*) quite different from those adopted by the World Administrative Radio Conference of the International Telecommunication Union in Geneva in 1967 and (*b*) at considerable variance from those the communications industry has been publicizing.

The 1970-1975 dates supported by Donald K. Child (Chief of the FCC's Aviation and Marine Division) were much nearer those asked for by the Commission than the 1973-1982 concept from Geneva which was regarded by many as the communications gospel of this century.

The Commission may be expecting considerable opposition to one proposed amendment which came as a surprise to nearly everyone. This is the requirement found on page 10 of the Notice and reads: *"After January 1, 1971, new 2 Mc/s (MHz) SSB telephony installations aboard ship stations will be authorized only where such ship stations are equipped also with v.h.f."*

The philosophy of separating long-distance and short-distance communications is strengthened in the proposed amendment to 83.351(c) which says that SSB installations after January 1, 1971 will be authorized only for ship stations which are *equipped and operate* beyond the v.h.f. range of Marine Operator, limited coast, and U.S. Coast Guard shore stations. In other words, vessels—both commercial and pleasure—who *can* and *do* operate at substantial distances offshore will be considered for SSB licensing. The amendment further states that ship-to-ship communications "in excess of v.h.f. range" be necessary to qualify for SSB.

This is the strongest statement in support of v.h.f./FM marine communications to come from the FCC and it is strange to find it in a Notice of Proposed Rule Making devoted to the transition from AM to SSB in the 2-3 MHz band.

Those ship stations which are already licensed and also those which will be licensed *before* January 1, 1971 for AM equipment will be permitted to use this equipment until January 1, 1977. As indicated, it's rather doubtful that, when single sideband begins knifing its way through on the 2-3 MHz band, there'll be too many AM rigs left on the air for too long.

83.517(a), which sets forth the minimum carrier power for mandatorily equipped vessels (25 watts for AM), has been altered to include the SSB comparable rating of 50 watts of peak envelope power.

In summary: while the rest of the world seems satisfied with January 1, 1973 and January 1, 1982 as the beginning and end dates of the transition period, the U.S. has its peculiar problems with its pleasure-boating boom which no other nation in the world has; therefore, the FCC is now proposing 1971 and 1977 as the effective dates to apply in this country.

The intent of the FCC is clearly seen in its proposal to limit installation of SSB equipment after January 1, 1971 to only those vessels which have v.h.f./FM equipment aboard.

Those ship stations already AM-licensed and those licensed prior to January 1, 1971 may continue to use AM until January 1, 1977 when they, too, will have to switch to SSB. ▲

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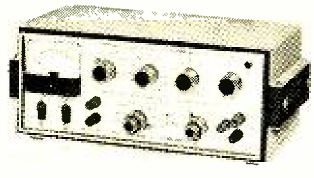
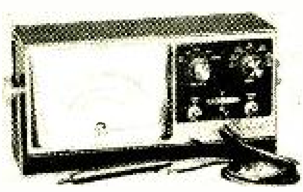
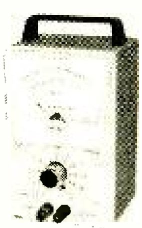
NEW
kit IG-18
$67.50
wired IGW-18
$99.50



kit IM-18
$28.50
wired IMW-18
$47.95





kit IM-13 **$36.50** wired IMW-28 **$56.95**

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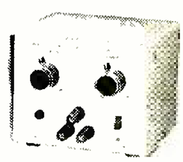

kit IT-18
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kit IM-17
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kit IG-57
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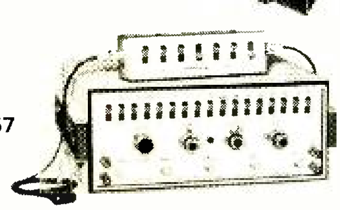

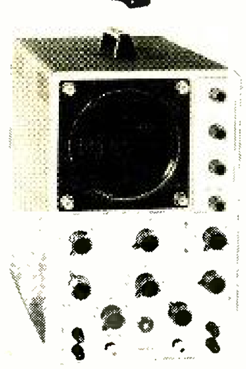

kit IO-18
$84.95
wired IOW-18
$139.95

HEATHKIT IG-18 Solid-State Sine-Square Wave Generator

A precision source of sine or square waves at a low kit price . . . that's the new solid-state IG-18 from Heath. Delivers 5% accuracy thru the wide range of 1 Hz to 100 kHz. The sine wave section features less than 0.1% distortion thru the audio range, 8 output voltage ranges from 0.003 to 10V, switch-selected internal 600 ohm load or external load and metered output of both voltage & dB. The square wave section has a 50 nS rise time and three output voltage ranges from 0.1 to 10 V P-P. Both sine & square waves are available simultaneously and the frequency is switch-selected for constant repeatability and fast operation. Circuit board construction makes the new IG-18 easy to build . . . new Heathkit styling and engineering excellence make it easy to use. Put the new IG-18 on your bench now. 10 lbs.

HEATHKIT IM-18 VTVM

The new Heathkit IM-18 continues the features that made the IM-11 famous . . . 7 AC and 7 DC voltage ranges that measure from 0-1500 volts full scale . . . 7 ohms ranges for measurements from 0.1 ohm to 1000 megohms . . . the convenience of a single probe . . . 11 megohm input impedance . . . ± 1 dB 25 Hz to 1 MHz response . . . precision 1% resistors . . . DC polarity reversing position on the function switch . . . RMS & P-P AC voltage and dB measurement capability . . . precision 4½", 200 uA meter for extra sensitivity. In addition, the new IM-18 has 120 V. or 240 V. AC wiring options, new Heathkit styling and a 3-wire line cord for safety. 5 lbs.

HEATHKIT IM-13 "Service Bench" VTVM

The Heathkit IM-13 has the same performance specifications as the new IM-18 above, but it also incorporates other features that put it in a class by itself, such as a large, easy-to-read 6" meter . . . extra 1.5 and 5 volt AC ranges for additional accuracy . . . convenient gimbal mounting that allows attachment to your most convenient surface . . . "Set and Forget" calibration — all controls are adjustable from the front panel with a screwdriver . . . smooth ten-turn vernier control of Zero and Ohms adjust for greater accuracy and easier setting . . . clean, open parts layout and a readily accessible "ohms" battery. Assembly is easy, thanks to the famous Heathkit manual, and operating convenience and versatility are tops. For maximum value in a general service VTVM, you just can't beat the Heathkit IM-13. 7 lbs.

HEATHKIT IM-38 Laboratory AC VTVM

For all around general service work, audio design or laboratory analysis, there isn't a better value than the new Heathkit IM-38 AC VTVM. Here's why — 10 voltage ranges measure from 0.01 to 300 volts RMS full scale . . . extended frequency response of 10 Hz to 500 kHz at ± 1 dB . . . 10 megohm input on all ranges for higher accuracy . . . . wide —52 to +52 dB range . . . VU-type ballistic meter damping . . . very low AC noise . . . 120 or 240 VAC wiring options and new Heathkit styling in sharp beige & brown with an easy-to-grasp, easy-to-read knob. 5 lbs.

HEATHKIT IP-18 1-15 VDC Power Supply

If you work with transistors, this is the power supply for you. All solid-state circuitry provides 1-15 VDC at up to 500 mA continuous. Features adjustable current limiting, voltage regulation, floating output for either + or — ground, AC or DC programming, circuit board construction, and small, compact size. 110 or 220 VAC. 5 lbs.

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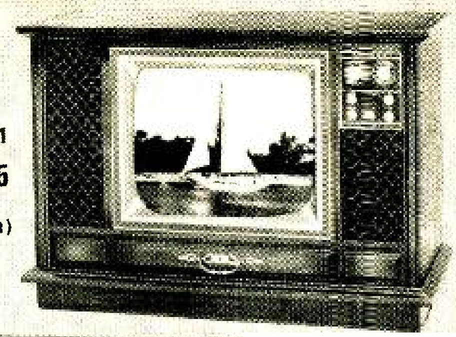

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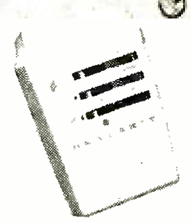

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LSA Microwave Diodes

(*Continued from page* 40)

to dominate the over-all behavior of the device. Electrons in the low-energy band flow through the diode in a smooth stream much like any ordinary semiconductor. Electrons in the high-energy band, however, collect into a small packet or space-charge near the cathode, and travel in a group through the high-energy band toward the anode. When this space-charge disappears into the anode, all current flows through the low-energy band until another space-charge begins to form at the cathode.

One other difference between the two conduction bands concerns the drift velocity of the carrier electrons. The free electrons in the low-energy band travel through the material with a much higher average velocity than does the space-charge in the high-energy band. Thus, when electrons are using the low-energy band, the average current through the device is higher.

The fact that the current flow through the bulk *GaAs* diode grows smaller when the applied voltage is increased above a certain threshold value shows that the device would have the negative-resistance characteristic curve as illustrated in Fig. 1C.

A forward d.c. potential large enough to drive the bulk diode deep into its negative-resistance region will force most electrons to use the slow-moving, high-energy conduction band as long as a space-charge is present to carry them *via* that route. However, as soon as the space-charge disappears into the anode, electrons have no choice but to rush through the high-velocity band until the next space-charge begins to form.

Without the benefit of external tuned circuitry, the bulk semiconductor diode will oscillate in the Gunn mode at a frequency determined by the transit time of the space-charge. To increase the operating frequency, the device must be shortened in the direction of current flow, and this operation decreases the device's ability to dissipate heat.

An external *LC* circuit with a time-constant shorter than the transit time of the diode's space-charge may be connected into a Gunn-type circuit, as shown in Fig. 2.

If the diode is properly doped for LSA operation, each birth of a high-energy band space-charge will be followed by a reverse-biasing half-cycle from the tuned circuit. This reverse-biasing energy will quench a newly formed space-charge, and reset the diode to its high conductance state until another space-charge can form. During the high-conduction state of the diode, the tuned circuit has a chance to move through its positive half-cycle and restore energy lost during the negative swing. By limiting the space-charge accumulation to a small fraction of its mature value, and by letting the tuned circuit determine the operating frequency, the bulk diode circuit can operate effectively at frequencies exceeding 50 GHz with power outputs near 100 mW.

Dr. Copeland developed the LSA diode as a result of a careful computer analysis of the Gunn effect. He found that a diode can operate in the LSA mode only if the product of the electron density, *N*, times the length of the device, *L*, is nearly equal to a very critical value of 10^{12} donors per square centimeter. A bulk diode having an *NL* product less than 10^{12} will not oscillate at all because the negative-resistance effect is spread over too much of the high-energy conduction band. On the other hand, a diode with an *NL* product greater than 10^{12} will operate only in the Gunn mode because the *LC* circuit will not have enough energy to reverse-bias and quench such strong space-charges.

An analysis and comparison of frequencies and power limits for Gunn oscillators, LSA circuits, tunnel-diode oscillators, and small klystron circuits cannot be truly meaningful at this time. Microwave technology is in such a state of flux that any figures published today may be obsolete tomorrow.

Many observers believe solid-state microwave devices, such as the Gunn oscillator and LSA diode, are pushing the communications industry toward the brink of a sweeping solid-state revolution. To be sure, these devices will find a place in the industry, but only where their advantages will pay off—not in vast, safe, well-manned, air-conditioned, megawatt communications complexes; but in tiny, remote radio stations and in the incredibly demanding environments of space. ▲

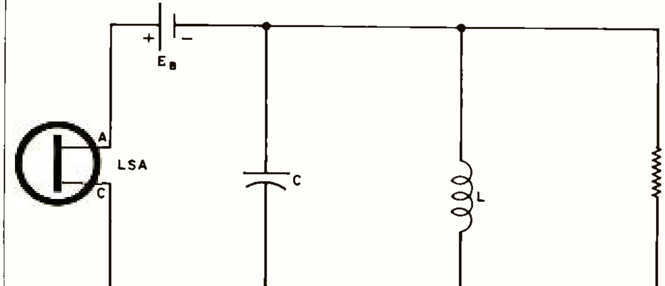


Fig. 2. An LSA diode in the negative-resistance region delivers energy back into the diode, quenching the space charge. Operating frequency is the resanant frequency of the LC circuit.

Protection System

(Continued from page 39)

Although this thermistor shunts the Q4 emitter resistor, it is actually mounted on the r.f. power amplifier's heatsink. As the temperature of the heatsink goes up, the resistance of the thermistor goes down—thereby swinging the emitter of Q4 in a negative direction. This action tends to turn Q4 on and decrease the voltage at point A. As before, this lowers the voltage delivered to the r.f. power amplifier and will therefore decrease the power dissipated in this device.

(Editor's Note: Reliable operation of a transistor over a wide temperature range requires bias voltage and current to remain relatively constant. Leakage currents increase exponentially with temperature. This effect is also counterbalanced by the change in resistance of thermistor T.)

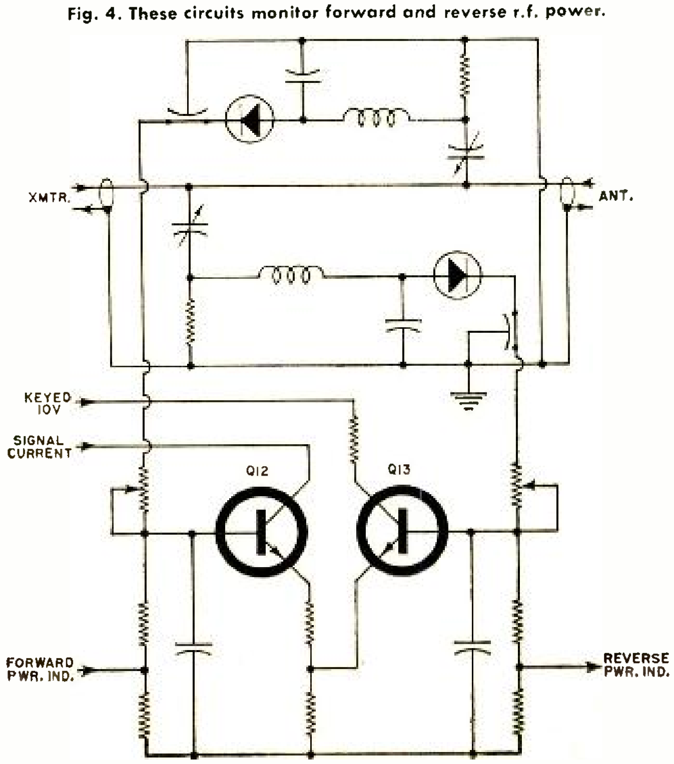
Shorted Supply Bus

If the transmitter voltage supply line (collector of Q3) becomes shorted to ground, Q3 will turn off and protect the circuit from excessive power dissipation. This is accomplished by the Q5 circuit. When the circuit is operating normally, the voltage divider R3 and R4 keeps the emitter of Q5 positive with respect to its base, and Q5 is turned off. When Q3's collector is shorted to ground, the voltage at the emitter of Q5 disappears and the transistor saturates. This action reduces the voltage at point A and removes the drive to Q1, Q2 and Q3, turning Q3 off. The circuit will not turn on again until the voltage is removed from Q5, by releasing the PTT switch. If the short is removed, the unit will key in a normal manner.

Simultaneous Faults

The protective circuits work individually, or together. If any combination of the above abnormal conditions occurs, the protective circuits will work together to control the voltage to the transmitter. Usually, however, only one circuit has control. This will be the circuit controlling the condition which is most dangerous to the transmitter at that instant. ▲

Fig. 4. These circuits monitor forward and reverse r.f. power.



A Sub-Ohm Continuity Tester

By CARL DAVID TODD/Consulting Engineer

A continuity tester which will permit "go/no-go" testing at 0.1-ohm levels, yet is safe to use with even most sensitive semiconductors.

CONTINUITY testers are useful in checking out a system, equipment, or cable and connector wiring. They are also handy in locating faults on a printed-circuit board. However, a tester should have certain characteristics if it is to be used with circuitry containing solid-state devices. Here are a few of the desirable features:

1. A "go/no-go" indication rather than a meter indication.
2. A threshold level below 1 ohm.
3. Operation unimpeded by sneak paths through diodes, transformers, etc.
4. Must be incapable of damaging sensitive semiconductor devices and integrated circuits.
5. Portability and small size.
6. Aural as well as visual output indication.

A voltohmmeter is most often used for continuity testing, but it has several limitations. It is not as small as could be desired and at low ohm levels, it is difficult to read the meter accurately. Too, the short-circuit current on the R × 1 range is typically about 350 mA, which can cause severe damage to some semiconductors and integrated circuits. A higher range would produce less current but would not permit low-resistance checking. The ohmmeter will also yield an upscale reading due to sneak paths through diodes, etc.

A simple continuity tester is shown in Fig. 1, but here again there are problems. Although the maximum current level can be reduced to 60 mA by using a #49 lamp, we can still damage some semiconductors. Also this approach will not permit checking out paths less than 1 ohm. The lamp in the circuit of Fig. 1 begins to glow when R_X is 65 ohms. We could use a higher power lamp to reduce the resistance threshold, but the maximum current and voltage will be greater and more dangerous.

Another continuity test technique which is still used occasionally is the vibrating buzzer. With its high current and transient voltages, it can destroy many semiconductor devices.

By adding a transistor to the lamp continuity tester as shown in Fig. 2, we obtain a definite improvement. By making the value of $B1$ just high enough to turn $Q1$ on when the value of R_X is quite low, we can obtain the desired low-threshold test level. The maximum current which can flow will be that of the lamp when the transistor is fully saturated. Any appreciable resistance between the R_X terminals will very quickly reduce the current to a safe level and extinguish the lamp.

The most critical part of the circuit of Fig. 2 is the value of $B1$ with respect to the base-emitter voltage needed to turn transistor $Q1$ on and light the lamp. Since this voltage

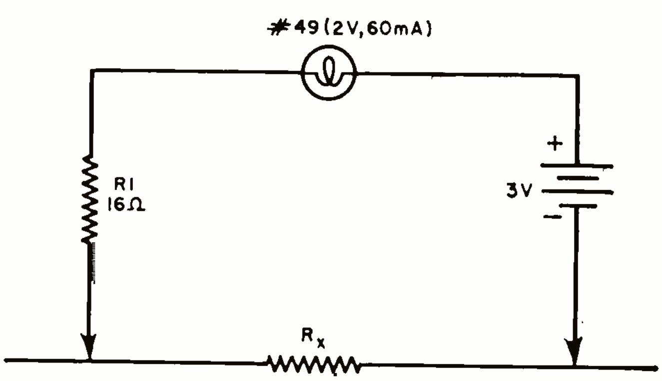


Fig. 1. A simple continuity tester uses a lamp and battery.

Fig. 2. Better performance is obtained by adding transistor.

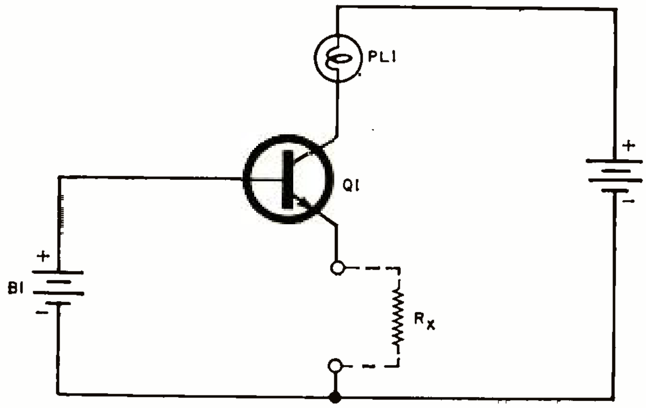
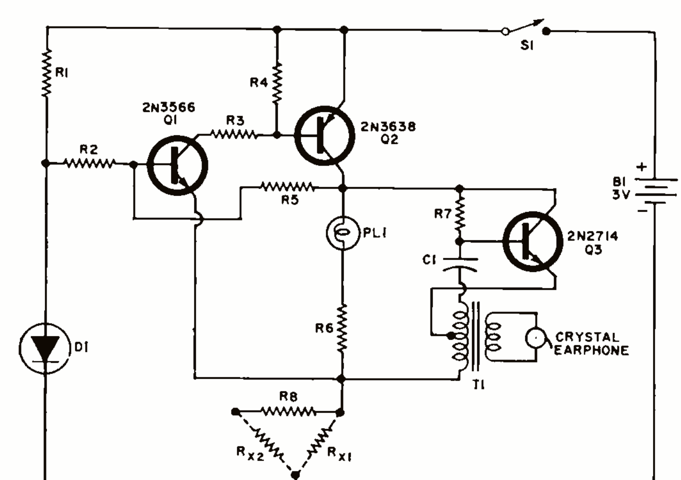


Fig. 3. SOCT tester will check continuity levels of 0.1 ohm.



R1, R7—10,000 ohm carbon res. ±10%
R2, R3—1200 ohm carbon res. ±10%
R4, R5—47,000 ohm carbon res. ±10%
R6—22 ohm carbon res. ±10%
R8—0.4 ohm (see text)
C1—0.05 μF ceramic capacitor
S1—S.p.s.t. switch
PL1—#49 lamp (2 V at 60 mA)
T1—Trans. trans 10,000 ohms:2000 ohms c.t. (see text)
D1—1N4152 or 1N3605 diode
Q1—2N3566 transistor
Q2—2N3638 transistor
Q3—2N3566, 2N2714, etc.
B1—Two AA cells

is of the same order as the voltage drop across a forward-biased diode, we can use it to develop a bias signal. This would also provide some temperature compensation since the diode voltage would change with temperature in the same manner as the V_{BE} of $Q1$.

As the value of R_X becomes low enough to permit substantial current flow, the transistor must dissipate more and more heat. This elevates the temperature of the junctions, and lowers V_{BE} in regenerative fashion. Once heated, however, a higher value of R_X is required to turn on the lamp.

The circuit shown in Fig. 3 gives the final design for a sub-ohm continuity tester (SOCT) with several improvements which overcome the problems of the basic approach.

The bias voltage, $B1$ as indicated in Fig. 2, is developed across diode $D1$. ($D1$ is a controlled forward diode—the manufacturer guarantees certain forward voltage drops for specific currents. Other silicon diodes will work but the value of R_1 must be empirically derived.) Decreasing the value of $R1$ will increase the threshold value of R_X, while a higher value for $R1$ will reduce the threshold value. Since a low bias current is used, the forward voltage drop of $D1$ and the V_{BE} of $Q1$ will track quite well with variations in temperature.

The single drive transistor in the basic circuit of Fig. 2 has been replaced by an *n-p-n/p-n-p* combination which allows us to separate the V_{BE} threshold (performed by $Q1$) from the power driving amplifier (performed by $Q2$) and thus remove the problem of self-heating.

Positive feedback, which will greatly improve the snap-action of the tester, is provided by resistor $R5$. As the value of R_X is decreased to a level where $Q1$ starts to conduct, $Q2$ will also be turned on and the voltage at the collector of $Q2$ becomes more positive with respect to the negative terminal of $B1$. This drives the base of $Q1$ more positive and overcomes the negative feedback due to the resistance in the emitter of $Q1$.

Two connections are provided for different levels of continuity testing. R_{X1} has a threshold value of about 0.5 ohm. (As mentioned earlier, a variation in the value of $R1$ will change the threshold slightly—a higher value of $R1$ reduces the threshold value of R_X.) This means that the resistance connected across the terminals must be 0.5 ohm or less in order to fire the circuit. By adding a low-value resistor, $R8$, we have a new set of terminals, R_{X2}. The value of R_{X2} must drop to 0.5 ohm less 0.4 ohm in $R8$ or a net value of 0.1 ohm before we get a continuity indication.

Resistor $R8$ should be chosen to be

about 0.1 to 0.2 ohm less than the maximum value which will produce a continuity indication when connected across the R_{X1} terminals. It may be made from #34 enameled copper wire whose resistance is 0.1 ohm per 4.6 inches (or #30 wire with 11.6 inches equal to 0.1 ohm). Measured lengths of wire may be used to check the performance of the SOCT.

The purpose of resistor $R6$ is to limit the voltage applied to the lamp. It also improves the speed at which the positive feedback takes over.

In order to provide an aural indication for SOCT, we can tie a simple audio oscillator across the output as shown and use it to drive a crystal earphone. Neither transistor $Q3$ nor transformer $T1$ is critical. Any good *n-p-n* silicon transistor (or even a *p-n-p* if you reverse the connections) may be used for $Q3$. $T1$ is an audio transformer designed to match a 1,000 to 10,000 ohm impedance. One of the miniature transformers used for driving transistor radio push-pull stages works quite well. The value of $R7$ or $C1$ can be varied to change the tone.

Using SOCT

Operation of SOCT as a continuity tester is quite simple. The R_X terminals are connected across the path to be checked. If the resistance of this path is less than about 0.5 ohm (using R_{X1} terminals), then the lamp will turn on and a tone will be produced.

To test very low resistances, on the order of 0.1 ohm, use the second set of terminals shown as R_{X2} in Fig. 3. In making these measurements, it is necessary to insure that good electrical contact exists at both ends.

The open-circuit voltage of SOCT is only 0.52 V—a value safe enough for most sensitive components. With only a 10-μA current flowing, the terminal voltage drops to about 100 mV. This means that even if SOCT were connected across a backward diode (a tunnel diode especially made for use in the reverse direction as a very low voltage-drop device), insufficient current will flow to either damage the device or to indicate a completed path. Connected across a normal diode or integrated circuit, the current will be less than 1 microampere.

Size is an important extra benefit of the SOCT design. The entire package can be made to form a hand probe measuring 3" x 1" x 1½". Almost all of the circuitry can be mounted on a small phenolic board. The oscillator section can be wrapped around the transformer and forced into a corner of the case. The tip of the probe could be used for one of the R_X terminals and banana jacks used for the other two. A banana plug, wire, and alligator clip complete the assembly. ▲

Automating the Railroads

(*Continued from page 47*)

commands until a correction is received. Once all functions agree, a control signal is transmitted every 21 seconds as a continuity check.

If the reply transmission from the slave unit is not received within 100 milliseconds after a control command has been transmitted, or if there is a change in the status of the slave unit's operating conditions, an alarm is sounded at the control console.

In the second mode of operation, the circuits which sense the status of the lead unit's control are disconnected. Thus, the engine man controls the lead locomotive normally, but operates the slave unit remotely *via* special switches on the control console.

If isolation of the slave unit is desired, a switch on the lead engine's control console permits the engine man to operate the slave as a "dummy", that is, without any power or braking functions.

Designed to Fit

Various modifications of the basic Locotrol system are usually required to cope with specific railroad requirements. For example, a special console was added to the system installed on *Southern Pacific* trains testing the system. And special control stand and other modifications were made for *Norfolk & Western* trains. The *Norfolk & Western* recently operated a four-mile-long automated train consisting of 500 cars and nine locomotives. This gigantic train transported enough coal to generate electricity for a city the size of San Francisco for 30 days.

Penn-Central also employed Locotrol in moving a huge train—this one comprising 341 cars which carried 25,500 tons of ore on a 96-mile run in Ohio, between the terminals of Hudson and Mingo Junction. It was pulled by three diesel units assisted by five radio-controlled units positioned two-thirds of the way back in the train.

Still another major railroad testing this system, *The Great Northern*, is now able to run a 200-car iron ore train between the Mesabi Iron Ore Range in northern Minnesota and the railroad's new ore shipping facility at the port of Superior, Wisconsin. Because the train is never uncoupled during loading and unloading, it is called a "unit train."

Locotrol systems are undergoing evaluation runs on trains of the *Kansas City Southern* and the *Union Pacific*. Perhaps the most rugged trial runs for the automated trains may well be those conducted by the major transcontinental carriers in the Pacific northwest, served by *The Great Northern* and *Northern Pacific* in the United States and, farther north, by the *Canadian Pacific*. Midwinter temperatures in the mountains frequently sink to −30°F and days of unremitting below-zero readings are common.

At these temperatures, the cost of operating a train soars. This is because leakages from air brake lines and cylinders increase as temperatures plummet to zero and below. To cope with the air supply problem, train lengths are reduced during the winter and, therefore, more trains must be operated to maintain an adequate flow of freight. More trains mean higher operating and maintenance costs.

Special tests conducted by the *New York Air Brake Company* with a 150-car train using 26-L brake equipment, indicated that trains equipped with an automated control system required only one-third as much time to charge their air systems as non-automated trains. In some instances, charging times of an hour were reduced to 15 minutes.

Radio-controlled systems such as Locotrol may well be one solution to the modern railroad's most critical problems —how to bolster shrinking profit margins in the face of ever-stiffening competition. ▲

UJT Sine-Wave Generators

By FRANK H. TOOKER

Unijunction transistors can produce more than just pulses and saw-tooth waveforms: with a little ingenuity they can make acceptable sine waves.

USUALLY unijunction transistors are not used in sine-wave generators. In fact, they are most often used to produce pulses or saw-tooth waveforms. Yet a sine-wave output can be obtained from a UJT in circuits properly designed for the purpose.

For example, a sine-wave output is produced by the crystal oscillator circuit of Fig. 1. This circuit is useful in applications where efficiency and waveform purity (freedom from harmonic distortion) are relatively unimportant. Actually, efficiency and waveform purity is dependent upon the base-2 impedance and supply-voltage level. In Fig. 1 this is accomplished by adjusting potentiometer *R2*.

A more efficient and much less critical circuit can be designed when the operating frequency is to be determined by *LC* components, that is, an inductor and capacitor, as shown in the circuit of Fig. 2. The field-effect transistor, *Q2*, in this case, is not part of the oscillator proper but is simply a source-follower whose sole purpose is to reduce loading. UJT *Q1* is the oscillator. Operating frequency is determined by *L1* and *C1*. In this application, *C1* is made adjustable over a limited range to permit setting the output frequency at exactly 50 kilohertz.

However, UJT *Q1* does not produce the sine waveform directly. In fact, it pulses. The pulse is applied in series with *L1* and *C1*, and occupies only a short interval of the entire cycle. The sine-wave output signal is the result of a change in voltage across capacitor *C1*.

Actually, the waveform at the emitter of *Q1* is not ideal for the task, but it comes so close that a critical inspection of the trace on an oscilloscope screen would be needed to note the departure from true sine waveform.

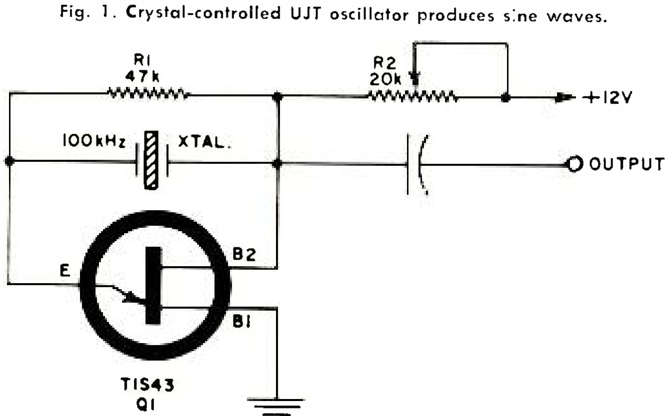
The advantage of this circuit is that, with the value of resistors *R1* and *R2* as given in Fig. 2, the output waveform is not significantly affected by variations in the power-supply voltage level. The prototype operates as efficiently at 12 and 3 volts d.c. as it does at 9 volts d.c. Only the amplitude changes as the supply-voltage level is changed.

This UJT sine-wave oscillator can be used at frequencies as high as 100 kHz and as low as 100 Hz by choosing appropriate values for *L1* and *C1*. A 400-Hz circuit is shown in the schematic diagram of Fig. 3. In this case, the inductor is an iron-core audio-frequency choke having an inductance of about 3 henrys. The Mylar capacitor, *C1*, is a 0.047-μF unit.

In both Figs. 2 and 3, it will be noted that the *LC* ratio is quite high. It is necessary to use a high *LC* ratio to produce the sine waveform. If the ratio decreases, distortion occurs in the positive-going excursions of the waveform. Furthermore, as distortion increases, the operating frequency increases beyond that indicated by the *LC* product.

If the *LC* ratio is made much too low, the oscillator produces an output signal having a saw-tooth waveform. ▲

Fig. 1. Crystal-controlled UJT oscillator produces sine waves.



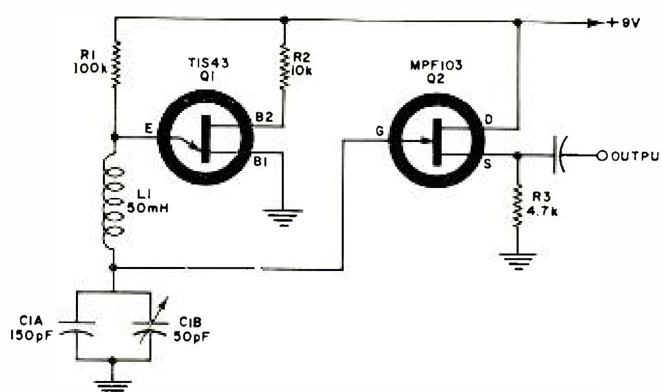
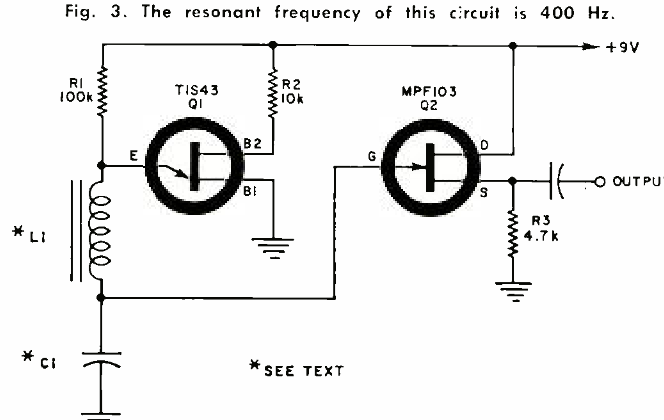


Fig. 2. In this circuit L1 and C1 determine the frequency.

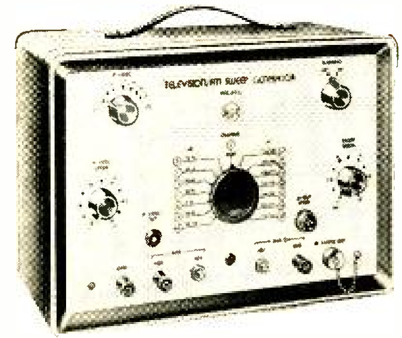
Fig. 3. The resonant frequency of this circuit is 400 Hz.



generate

The RCA WR-50B RF Signal Generator with sweep features is versatile, portable, and exceptionally well suited for alignment and signal tracing of AM, FM, hi-fi and citizen's band receivers and trouble-shooting in nearly all sections of TV receivers. IT'S ONLY $65.00.* Also available in an easy to assemble kit, WR-50B(K).

The RCA WA-504A Transistorized Sine/Square Wave Audio Signal Generator covers a frequency range from 20 Hz to 200,000 Hz with exceptional frequency stability. For use in audio, hi-fi and general electronics applications, as well as in electronics training, demonstrations and lab work. ONLY $95.00*



The RCA WR-69A Television/FM Sweep Generator is designed for lab, service, and production applications for sweep-frequency alignment of color and black and white TV receivers and broadcast FM receivers. It's also used to align VHF tuners, picture-and-sound IF amplifiers, video amplifiers and chrominance circuitry in color TV receivers. AND IT'S ONLY $295.00.*

The RCA WP-700A and WP-702A Power Supplies are extremely reliable, solid-state, constant voltage DC power supplies that provide 0 to 20 volts dc at current levels up to 200mA. WP-702A is actually identical to WP-700A, except it is a dual unit with two complete power supply sections. WP-700A IS ONLY $40.00* in quantities over five, and WP-702A IS ONLY $73.00* in quantities over five. Prices on less than five units are $48.00* and $87.00* respectively.

The RCA WR-70A RF/IF/VF Marker Adder is designed for use with conventional markers and sweep generators such as the RCA WR-39, WR-89 and WR-99 series calibrators and the WR-59 and WR-69 series sweep generators to produce clean, narrow markers on the sweep-response curve on an oscilloscope. AND IT'S ONLY $96.00.*

The RCA WR-99A Crystal-Calibrated Marker Generator combines in one compact, accurate, and stable instrument the functions of a multiple-marker generator, crystal calibrator and a heterodyne frequency meter. Ideal for servicing and aligning color and black and white TV receivers, communications and other equipment in the frequency range of 19 to 260 MHz ONLY $256.50.*

*Optional Distributor resale price.

For a complete catalog of descriptions and specifications for all RCA test equipment see your RCA Test Equipment distributor or write RCA Electronic Components, Commercial Engineering, Department No. B41W, Harrison, N. J. 07029.

RCA

LOOK TO RCA FOR INSTRUMENTS TO TEST MEASURE/VIEW MONITOR GENERATE

CIRCLE NO. 84 ON READER SERVICE CARD

IMPROVING SAWTOOTH LINEARITY

By FRANK H. TOOKER

ONE technique used to improve the linearity of a UJT sawtooth-wave generator is to feed the timing capacitor from a constant-current source. But this is not always convenient. Another method is shown in Fig. 1.

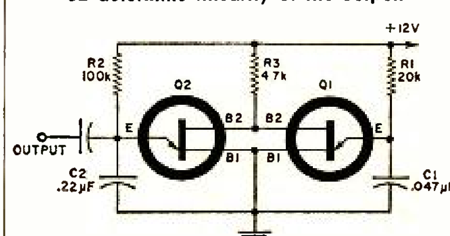
Here two UJT sawtooth-wave oscillators are independent except for the common base-2 resistor, *R*3. The time constant of *R*2-*C*2, in the emitter circuit of Q2, is much longer than that of *R*1-*C*1 in the emitter circuit of *Q*1. Thus, if the two oscillators were entirely independent, the repetition rate of *Q*2 would be slower than that of *Q*1. With *R*3 in the circuit, however, the firing rate of *Q*2 is determined by the firing rate of *Q*1. In other words, the two UJT's fire in unison and the UJT having the fastest firing rate determines the repetition rate.

When a capacitor is charged, the charging rate is non-linear, that is, the charging rate is quite fast initially but slows more and more as the potential across the capacitor approaches that of the power supply. The initial portion of the charging curve is the most linear, because during this interval, the ratio of the voltage across the capacitor to that of the power supply is greatest. If only this portion of the curve is used, the linearity of the resulting sawtooth waveform is considerably improved.

Resistor *R*1 and capacitor *C*1 determine the repetition rate, while *R*2 and *C*2 determine the linearity. The larger the ratio of the two time constants, the better the linearity will be. But the larger the ratio, the lower will be the amplitude of the output signal.

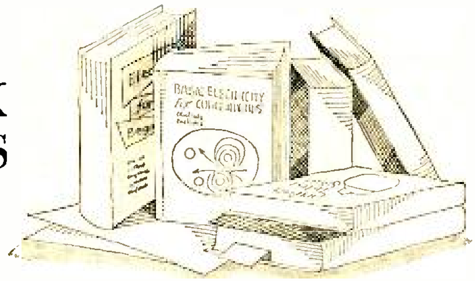
For the circuit values shown in Fig. 1, the repetition rate is about 500 Hz and the output signal amplitude is 375 mV. The relatively low output level is due to the unusually high ratio of the time constants in this particular setup—on the order of 50:1. A ratio of this order is rarely needed, but was used to demonstrate that the circuit will function even with this high a ratio of time constants. Much higher output and entirely satisfactory improvement in linearity is possible with ratios as low as 5:1. ▲

Fig. 1. In this UJT oscillator, R2 and C2 determine linearity of the output.



Q1,Q2—TIS43—TEXAS INSTRUMENTS UNIJUNCTION TRANSISTOR

BOOK REVIEWS



"CIRCUIT DESIGN FOR INTEGRATED CIRCUITS" by H.R. Camenzind. Published by *Addison-Wesley Publishing Company, Inc.*, Reading, Mass. 01867. 263 pages. Price $12.95.

This volume is intended for the practicing electronics engineer who has circuit design experience or for students at the graduate level. It is designed to serve as a bridge into IC technology, using language already familiar to the engineer.

After an introductory chapter where the author explains that the new art of integrated circuitry requires an entirely different approach from the usual one involving discrete components, he launches into a discussion of the various integrated-circuit processes, components in IC's, general design considerations, digital IC's, linear IC's, computer analysis and design of IC's, and measurements on integrated circuits.

The text is lavishly illustrated and each chapter carries references, a bibliography, and problems pertaining to the material covered. An easy familiarity with mathematics is a "must" for this text.

* * *

"EASY WAY TO SERVICE RADIO RECEIVERS" by Leo G. Sands. Published by *Tab Books*, Blue Ridge Summit, Pa. 17214. 173 pages. Price $6.95. $3.95 soft cover.

Whether or not there is still a place in the scheme of things for a technician specializing in servicing AM receivers is a moot point, but the author believes that there are still customers who have their AM sets repaired rather than replacing them. It is for this fraternity that this book is written.

In ten chapters the book covers various types of receiver circuits, causes of no reception, noise and crosstalk, hum and its causes, causes of distortion, intermittent operation, receiver alignment, parts replacement, receiver modifications, and test equipment for servicing. The text is illustrated with photos, line drawings, pictorials, schematics, and tables to amplify the text material.

* * *

"ELECTRICAL INSTALLATIONS TECHNOLOGY" by J.F. Whitfield. Published by *Pergamon Press Inc.*, 44-01 21st Street, Long Island City, N.Y. 11101. 347 pages. Price $7.00. $5.50 soft cover.

This is a handbook prepared to qualify electricians for the English "B" certificate and is written at a level understandable by the average apprentice and electrician. A basic knowledge of simple math is prerequisite.

The text is divided into fifteen chapters, each with its quota of exercises and examples for classroom or home use. The author covers mechanics, heat, basic electrical principles, magnetic fields and materials, magnetic fields and electric currents, power and energy, primary and secondary cells, direct-current motors, electric fields and capacitors, basic alternating current theory, power in a.c. circuits, electrical measuring instruments, alternating-current motors, conversion of a.c. to d.c., and planned lighting.

Like most British "exam" texts, the treatment is fairly rigorous but the writing is easy and informal so there is no reason why this can't be used as a self-instruction handbook for the student.

* * *

"PRACTICAL CB RADIO SERVICING" by R. R. Freeland. Published by *Hayden Book Company, Inc.*, 116 W. 14th St., New York, N. Y. 10011. 171 pages. Price $4.75. Soft cover.

The "practical" in the title virtually writes the review of the book. Written by the president of *International Crystal*, the text is a no-nonsense approach to troubleshooting and maintaining Citizens Band equipment. Each chapter is self-contained, making it easier for the technician to find the information he wants and needs without thumbing through extraneous material.

An introductory section covers such CB basics as FCC requirements, signal paths, tuning, power supplies, frequency synthesizers, rules and regulations, test equipment, etc. The rest of the book is divided into twelve chapters and three appendices. Covered are the operational check, base and fixed-station check, mobile check, frequency measurement, modulation measurement, power measurement, sensitivity, selectivity, receiver troubleshooting, transmitter troubleshooting, troubleshooting the power supply, and noise and TV interference. The appendices include tables, operational check procedures, and troubleshooting charts: CB radio channels; and a glossary of CB terms and abbreviations.

* * *

"SPECIAL SEMICONDUCTOR DEVICES" by Walter A. Sowa & James M. Toole. Published by *Holt, Rinehart and Winston, Inc.*, New York. 185 pages. Price $3.95. Soft cover.

This volume is an over-all review of seven special semiconductors which the technician can be expected to encounter in equipment he is called upon to service. The devices include photoelectric, zener diodes, diffused-junction silicon rectifiers, tunnel diodes, unijunction transistors, SCR's, and FET's. Each device is covered in a separate chapter, complete with questions and problems to be answered after the technician has mastered the material. The text is copiously illustrated, mathematics are used as required, and the explanations are clear and straightforward. Answers are given to the odd-numbered problems and questions so the user can check his grasp of the subject matter.

Because of the clear presentation, there is no reason why this book cannot be used as a self-instruction text as well as in the classroom.

* * *

"AN EXAMINATION OF THE ENGINEERING PROFESSION" by R. P. Loomba. Published by Center for Interdisciplinary Studies, San Jose State College, San Jose, California 95114. Price $3.00. Soft cover.

Those working as engineers and those planning an engineering career will find this book a valuable aid in making decisions regarding their futures. In a carefully researched study, Dr. Loomba has taken a long hard look at those entering the field. career selection, periodic mass lay-offs, the plight of the engineer over 45 years old, technical obsolescence, and future research on the profession.

The text is lavishly peppered with tables compiled from surveys, interviews, and research projections all of which make it easy for the reader to recap the text material quickly.

* * *

"THE INTEGRATED CIRCUIT DATA BOOK" compiled and published by *Motorola Semiconductor Products Inc.*, Dept. TIC, Box 20924, Phoenix, Arizona 85036. Price $3.95.

This book contains complete data sheet specifications and other application and test data on all of the firm's standard IC's (both digital and linear).

As a special feature, the book includes an interchangeability guide to all major manufacturers of digital and linear IC's. The guide lists manufacturer type numbers in alphanumerical order by product family and cross references each to the *Motorola* direct replacement. A description of the circuit function is also included.

The 960-page book also includes a digital application selection guide, separate sections on MECL, MHTL, MTTL, MDTL, MRTL, MOS, and linear IC data sheets, plus a 12-gate complex array. The company plans to provide a semi-annual updating service for this volume. ▲

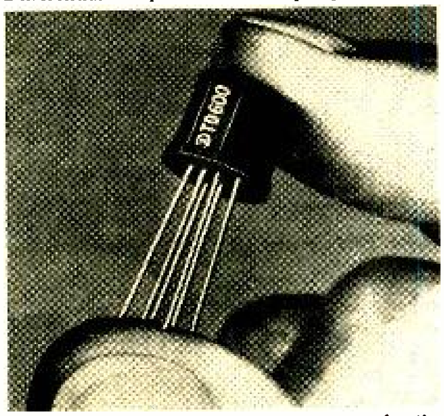
NEW PRODUCTS & LITERATURE

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

DUAL PLASTIC TRANSISTORS

Six dual low-cost plastic transistors in one-piece molded packages are now on the market. Differential amplifiers with "p-n-p" polarity



have been designated as the TD-400 family. These units feature a typical base-to-emitter voltage matching within 2.5 mV and will track within 6 μV/° C. Minimum beta is 120 at 100 μA.

Complementary dual transistors, designated TD-600 series, are specified for low-level applications such as s.p.d.t. switching. These units feature low noise (2 dB maximum) and high gain.

All standard "Econoline" transistor types can be made available in this dual configuration to meet customer volume requirements. Technical literature is available. Sprague

Circle No. 126 on Reader Service Card

SELENIUM RECTIFIERS

A new line of low-cost, high-voltage, cartridge-type selenium rectifiers is now on the market. Small in size, these rectifiers offer high reliability, efficiency, and long life, according to their maker. The rectifier cells are made on thin aluminum base stock, which reduces the cartridge length. Also, the new high-density selenium material allows the use of smaller diameter cells without any sacrifice of current capacity or reliability.

The standard construction uses plated end caps and pigtail leads. The leads may be removed for clip mounting. Lengths are dependent upon voltage requirements which are from 800 to 20,000 volts per cartridge. Rectifier Components

Circle No. 127 on Reader Service Card

ADHESIVES KIT

A new multi-purpose "Bond-All" adhesives kit, designed especially for industry, R&D labs, and service shops, is now available. The adhesives in the kit can be used to bond glass, plastics,

iron, steel, copper, gold, silver, woods, glass-to-metal, wood-to-metal, and other combinations of materials.

The kit contains more than 20 pieces of equipment including tweezers, clamps, mixing cups and mixing sticks, applicators, syringes, and knives. Four different epoxy adhesives provide a selection of bonding characteristics. Tescom

Circle No. 128 on Reader Service Card

SNAP-IN SWITCHES

A complete line of standard-size rocker switches is now being offered with optional snap-in mounting designs. Snap-in mounting eliminates the need for screw fastening or other types of fasteners. The switch is simply pressed into the opening and held in place by snap-in hardware tension. This feature is now available on 6 and 20 A rocker switches. McGill

Circle No. 129 on Reader Service Card

LOW-MELTING-POINT SOLDER

A new ultra-low-melting-point solder is now being marketed as "Cerrosolder", a bismuth-based alloy which softens at 209° F and is fully liquid above 212° F. The new solder was formulated to solve production problems where conventional soldering temperatures, or even special alloy solders, cause damage in assembling IC's where heat from a conventional soldering iron can cause damage or even harm some of the discrete components.

The new solder can also be used for assembling thermally sensitive electrical and electronic components, such as relays with nylon moldings for their coil forms. In order to use solder, lead wires, pins, etc. must be pretinned to assure proper intermolecular bond. It is normally supplied in ⅛-in diameter wire form. Electrical conductivity is 2.9% that of copper and resistivity is 349 circular mil-ohms per foot. Cerro

Circle No. 130 on Reader Service Card

INDIVIDUAL PC BOARDS

A new economical process which permits a printed-circuit board to be made from an ink drawing has been introduced. Since boards can be made on an individual basis, research groups developing new products can have one or two boards made for experimental purposes. No elaborate drawings are necessary.

The new process permits an engineer to simply make an ink sketch of the board he desires—to scale or larger. For extremely small boards, all that is necessary is that the sketch be made in such a way that it will reduce photographically in proportion. Available sizes run from one square inch up to 300 square inches and boards can be delivered within three days. Complete details on the service will be supplied on request. American Engraving

Circle No. 131 on Reader Service Card

LOW-NOISE COAX CABLES

A series of low-noise coaxial cables for applications where such cables may be subjected to mechanical flexure or vibration has been developed and is now available for distribution.

The new low-noise cables are available in three popular standard sizes: 50, 75, and 95 ohms. All three come with #29 AWG silver-plated annealed copperclad steel inner conductor, Teflon dielectric, silver-plated copper braid, and taped and sintered Teflon TFE jacket. Modifications are available on request. Temperature rating for all cables is −90°C to +200° C. According to tests performed on these cables, the Hitemp cables offer a 74% decrease in generated noise over standard miniature coax cables with Teflon dielectric. Simplex Wire

Circle No. 132 on Reader Service Card

RECHARGEABLE BATTERIES

A new series of rechargeable alkaline batteries which can be recharged up to 100 times is now available.

The new Duracell batteries are being made in the popular "D" size, the slightly smaller "C" size, and the "AA" penlight size. A charger, designed to be used exclusively with these batteries, operates from a 117-V a.c. outlet and can charge either two or four Duracell batteries in any pair combination, simultaneously. Mallory

Circle No. 1 on Reader Service Card

ONE-PIECE INDICATOR LIGHTS

A new series of "Glo-Dot" indicator lights, with one-piece lens body for ruggedness and economy, has been introduced as the Series 2900.

The new lamps come in six standard lens shapes, four body sizes, and a varied choice of lens colors, both in transparent designs. The units come with bare leads (cut and terminated to the

customer's specifications), insulated leads, or solder lugs and can be ordered with neon or incandescent bulbs.

The one-piece housing eliminates sockets and spring contacts for shockproof design. Speed-nut mounting reduces assembly time to a minimum. The housing is of self-bezeled polycarbonate construction. The lights come complete with built-in resistor. Industrial Devices

Circle No. 133 on Reader Service Card

4-DECADE DISPLAY TUBE

The Model SA is a four-decade version of the "nimo" cathode-ray display system and is identical to the discrete version except for the characters displayed, being reduced from ⅝" to ⅜". The shaped beam of the SA is electromagnetically deflected from its normal center screen target, resulting in a multiple decade display, easily legible in only a 1.135" maximum diameter package. IEE

Circle No. 134 on Reader Service Card

HIGH-POWER WIREWOUNDS

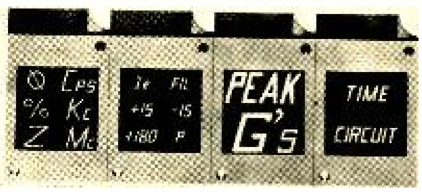
A new line of high-power, silicone-coated wirewound resistors, capable of dissipating from 35 to 375 watts, has been introduced as the Series HLZ. High power is obtained by using a ribbon-type wire edgewound around a hollow ceramic core. A specially formulated silicone coating is applied to the unit, holding the ribbon in firm contact with the core while allowing maximum heat transfer from the wire surface area.

Twelve different models are available with the following ratings: 35, 90, 100, 105, 110, 140, 165, 220, 240, 275, 300, and 375 watts. The line spans a resistance range from 0.05 ohm to 1.9 ohms for the 35-watt HLZ-33 to 0.30 ohm to 32 ohms for the 375-watt unit. Dale

Circle No. 135 on Reader Service Card

CAPTION MODULES

The new caption modules can be used independently as message modules or in conjunction with the company's numeric readout modules. Anything that can be put on film can be shown



on this module, including numbers, letters, words, symbols, and special characters. Up to six messages per module may be displayed, in any combination, individually, or all at once by lighting the corresponding lamp or lamps.

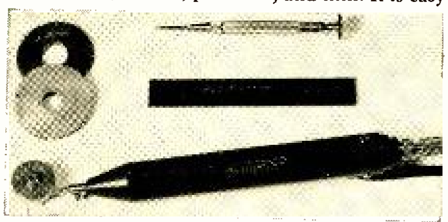
When not illuminated, the captions can be either hidden or visible, depending on whether non-glare or polished viewing screens are used. Dialight

Circle No. 136 on Reader Service Card

MARKING STYLUS

A compact stylus, designed for hand marking small electronic parts used in production and engineering departments, is on the market. It can be used to mark serial numbers, proto run numbers, production numbers, dates, etc. on any part.

The stylus will mark on all materials: plastic, glass, metal, leather, porcelain, and film. It is easy



to handle since it is only ¾" in diameter and has no overhang. It operates from 117-V, 60-Hz a.c.

The unit is available with standard steel, carbide, or diamond points. Electro Stylus

Circle No. 137 on Reader Service Card

HI-FI — AUDIO PRODUCTS

CASSETTE RECORDER LINE

A new line of cassette tape recorders has been added to the firm's line of reel-to-reel and 8-track cartridge units. One representative model in the new line weighs 5½ pounds, is all solid-state, equipped for a.c.-d.c. operation, and is simple to operate. It is designed for recording and playing back interviews, lectures, dictation, and music selections.

There are walnut-enclosed stereo deck models with and without AM-FM radio combinations, plus complete cassette recorder/AM-FM radio combinations in portables or walnut finish for desk use.

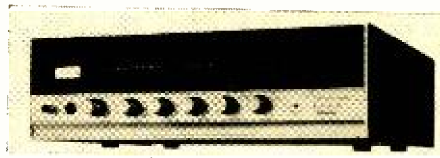
The cassettes feature 3-digit tape counters and start/stop microphones, a cassette eject lever, push-button operation, and come equipped with batteries, auxiliary cable, blank cassette, microphone, and telephone pickup. Roberts

Circle No. 2 on Reader Service Card

70-WATT AM-FM-STEREO RECEIVER

The Model 800 AM-FM-stereo receiver provides 70 watts of IHF music power; has an FET, three-gang variable capacitor front-end; four i.f. stages; and three limiters.

It has an all-silicon transistor amplifier for a frequency response of 15-50,000 Hz and a 20-40,000 Hz IHF power bandwidth. The power transistors are protected from overloads and



shorts by quick-acting fuses. The receiver has two output speaker terminals for two pairs of stereo speaker systems and a four-way front-panel speaker selector switch.

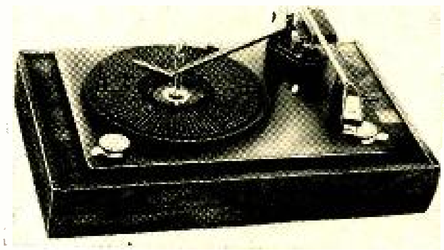
The circuit features automatic stereo switching plus a new noise canceller which eliminates noise on FM-stereo without changing the high-frequency characteristics. A ceramic filter is used in the AM i.f. section to improve selectivity and the unit's ability to reject beat interference, according to the company. Sansui

Circle No. 3 on Reader Service Card

SMALL CHANGER

A new changer designed for shelf component audio systems has been introduced as the No. 21-1401.

The four-speed changer is equipped with a



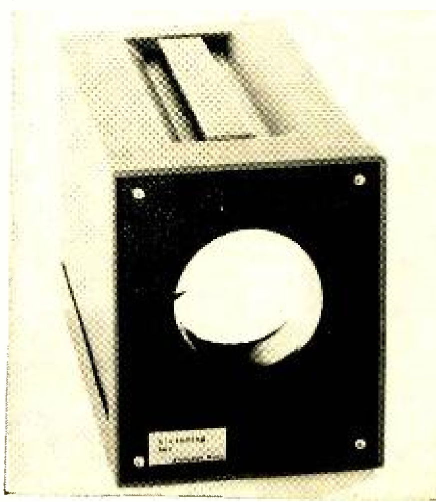
high-quality ceramic turnover stereo cartridge and diamond stylus. Made in England, the unit features a low-mass tonearm, dynamically balanced two-pole motor, and automatic shut-off after the last record is played. Stacking and intermixing of up to six records of 10" and 12" sizes of the same speed or manual single play are possible. The changer comes with a detachable spindle, audio cables, tinted plastic dust cover, and an a.c. line cord. It is mounted on a walnut wood base measuring 14⅜" x 5" x 10". The changer will operate at 110-130 V, 60 Hz a.c. Lafayette

Circle No. 4 on Reader Service Card

RESEARCH SPEAKER

An electrostatic speaker designed for research applications where a wide frequency response is required (10 kHz to 100 kHz) is now available. For use in general acoustic research, the speaker has applications in the study of animals' hearing abilities, atmospheric sonar ranging, measurement of the acoustic reflective coefficients of materials, etc.

Frequency response is smooth (±2 dB) and the acoustic output intensity from 10 kHz to 100 kHz is 90 dB re 0.0002 dyne/cm² at one yard, on axis. Random support for the diaphragm



results in a combination of excellent high-frequency response and high output, according to the manufacturer.

The speaker diameter is 3 inches; radiation pattern is equivalent to a 2.7-inch disc source. The input impedance is 50,000 ohms to the self-contained power amplifier and the input level is 0.3V r.m.s. for full output. Listening, Inc.

Circle No. 138 on Reader Service Card

OMNIDIRECTIONAL SPEAKER

The HK50 omnidirectional speaker, which was designed to be part of the firm's SC2350 compact music system, is now available as a separate component.

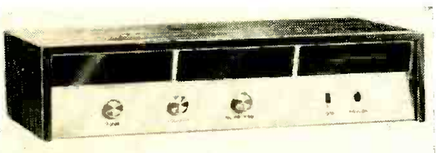
The new speaker provides 360-degree radiation which permits the unit to be placed anywhere in the room and still provide a total stereo effect. The housing is of functional design which makes it possible to use the speaker as an end table or lamp pedestal. Harman-Kardon

Circle No. 5 on Reader Service Card

HOME REVERB AMPLIFIER

A solid-state home reverberation amplifier which is specially designed to operate with a stereo receiver or amplifier having a 3-way speaker selector switch has been introduced as the R-777.

The reverb amplifier features a "percentage of reverberation" control to allow for the best reverb mix to match the acoustics of the room. It includes a tone control, volume control, and "on/off" switch with pilot light. Power output is 10 watts r.m.s. at 8 ohms, output impedance is 8 ohms. The circuit uses four transistors and four diodes. The amplifier is housed in a walnut wood enclosure measuring 19" x 8½" x 4⅜" high. The unit is made under a Hammond Organ license. Lafayette



Circle No. 6 on Reader Service Card

TRANSISTORIZED INTERCOM

A fully transistorized intercom system featuring touch-and-talk push-button operation and easy, one cable installation has been introduced as the Model 7000.

The system's audio components have been specially designed for this application. Each station has a built-in sensitive microphone that picks up sound clearly, even from a distance, while the built-in speaker provides natural voice transmission. Controls include a privacy switch, an audio-visual call signal that emits a clear tone and lights a pilot light at the called station, individual station control for setting volume level, and an index on the face of each station unit that makes it easy to find individual names and station numbers.

The a.c.-operated system includes a central control unit measuring 24" x 14" x 4" which contains an amplifier, switching, and power supply. Individual station units are styled in ebony and silver and measure 8" x 9" x 4½". The station unit includes 15 control keys. Norelco

Circle No. 7 on Reader Service Card

200-WATT AM-FM RECEIVER

The Model TK-140x is a 200-watt AM-FM solid-state stereo receiver which features a number of innovations. The receiver has a blue-green luminous dial that glows from dark to bright when the set is turned on. There is also a new larger tuning meter and stereo light indicator to insure pinpoint tuning. When the set is turned off, all the numbers disappear, leaving an opaque panel.

The front-end features a four-gang tuning capacitor, three FET's, and four IC i.f. circuits. Sensitivity is 1.7 μV and selectivity is good, according to the manufacturer. The unit includes output terminals for two sets of stereo speakers, two-channel preamp outputs and main amplifier inputs, and an electronic protection circuit.

The TK-140x measures 16½" wide x 5½" high x 12¼" deep. Kenwood

Circle No. 8 on Reader Service Card

AIR-SUSPENSION SPEAKER

A high-efficiency, air-suspension speaker system which has been designed especially for use with low-power amplifiers has been introduced as the CS-5.

Consisting of a two-way speaker system, the unit is capable of handling 25 watts with smooth transient response from 35 to 20,000 Hz. The woofer features a newly designed cone that avoids breakup at maximum power input. It has a specially developed cloth surround for greater compliance. The tweeter is a cone type with wide-angle dispersion.

The CS-5 is an intermediate size bookshelf unit which is housed in an oiled-walnut cabinet.

The grille cloth is a pebble weave which contrasts with the chrome inner frame. The grille is removable to permit the fabric to be changed, if desired. Pioneer

Circle No. 9 on Reader Service Card

STEREO TAPE DECK

The Model A-7030 stereo tape deck will handle up to 10½-inch reels and incorporates a number of professional features. There is a con-

trol for convenient cueing during fast-forward and rewind operation, instant stop remote-control option, adjustable tape tension for various reel sizes, and newly designed motors for stable tape travel and accurate tape speeds.

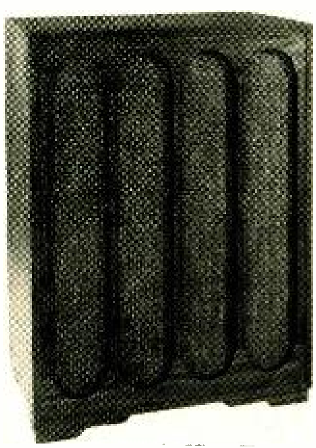
The deck has both 15 and 7½ in/s speeds and includes three-stage direct-coupled amplifiers for good sound quality and minimum distortion. The deck is fully transistorized and silicon transistors are used to insure reliability and long life. Teac

Circle No. 10 on Reader Service Card

THREE-WAY SPEAKER SYSTEM

The "Concertmaster VI" is a three-way speaker system housed in an oiled rubbed walnut cabinet of Mediterranean styling with a cathedral window grille. It measures 40½" high x 29" wide x 18" deep.

The housing contains a 24-inch woofer which covers the range from 16 to 300 Hz then crosses



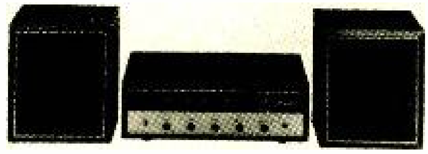
over to a 10-inch midrange unit which covers the 300 to 3000 Hz band. The 7-inch tweeter handles the frequencies from 3000 to 25,000 Hz. Over-all response is ± 3 dB. The crossover droops at 12 dB per octave.

The interior of the cabinet is acoustically treated with over 80 square feet of material in two Soundsorber forms. This eliminates cabinet resonance and boom, according to the company. The system is also available with two speakers instead of three. Hartley

Circle No. 11 on Reader Service Card

RECEIVER/SPEAKERS SYSTEM

The new Model STA-15 AM-FM-FM-stereo receiver comes with its own acoustically matched bass-reflex bookshelf speaker systems. Designed for use in a stereo component music system, the STA-15 can be used in conjunction with stereo cassettes or reel-to-reel tape decks for off-the-air music recording and reproduction.



The circuit that is employed is all solid-state and includes a sensitive front-end circuit for excellent reception in low signal areas, according to the company. Special features include a new high-sensitivity multiplex circuit; separate volume, bass, treble, and stereo balance controls; a 5-position selector for AM, FM, FM-stereo, phono, and tape; external folded dipole FM antenna; back-lighted tuning dial; stereo tape and phono inputs; and stereo tape outputs. Power output is 15 watts. The system is housed in matching solid-teak cabinets. Concord

Circle No. 12 on Reader Service Card

WALL-MOUNTING INTERCOM

A new intercom system which will mount flush in a standard 2 x 4 wall is now on the market. Master stations can originate calls to 12 and 24 stations. The masters are of both the local amplifier and central amplifier type. When local amplifier types are used, any number of conversations can be carried on simultaneously. The central amplifier system is designed for medium traffic applications where only one conversation need be carried at any one time.

The system may be integrated with units designed for desk use. The system is completely solid-state and calls are announced by light and chime. All units have selectable privacy which makes it impossible to be overheard by another station.

The system is powered by a single, UL-listed central supply. High quality, 4-inch, 93-dB sensitivity speaker-microphones are used. Fisher Berkeley-Ektacom

Circle No. 13 on Reader Service Card

CASSETTE PLAYER/CHANGER

The Micro 90 playback deck has an automatic changer that plays one side of up to six cassettes automatically. Cassettes stacked in the glass sleeve automatically play in sequence and eject into a built-in storage compartment. The second side of each cassette may be played by turning the stack over and replacing it in the sleeve.

The deck connects to any amplifier for stereo playback through a speaker system. Push-button controls include fast-forward, rewind, stop, pause, play/reject, and "on/off". The unit measures 15¼" wide x 9¼" deep x 4⅜" high. With the cassette sleeve mounted, it is 6¾" high.

The Micro 95 is a record/playback version of the Micro 90 and includes two matched and balanced 6" x 9" walnut speakers powered by a 20-watt (peak) audio amplifier. Two dynamic, omnidirectional microphones with detachable stand are also supplied. Ampex

Circle No. 14 on Reader Service Card

STEREO CASSETTE-CORDER

Sony's TC124 CS stereo cassette-corder comes complete with one built-in speaker and two external matching speakers for true stereo separa-

tion. It will operate on either a.c. or d.c. Weighing only five pounds (including batteries) and measuring approximately 6" x 9", the unit incorporates a pop-up lid and cassette ejector for handling both 60- and 90-minute tape cassettes. An automatic recording control adjusts recording levels in the four-track stereo-record mode.

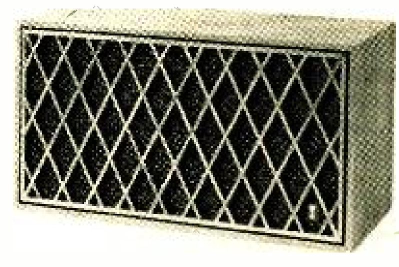
A meter indicates battery condition. Accessories included with the unit are an F-995 cardioid stereo microphone with stop/start switch, a C-60 tape cassette, a personal earphone, two patch cords, four batteries, and two full-range extension speakers. A briefcase-size black vinyl tote bag houses all components. Superscope

Circle No. 15 on Reader Service Card

SMALL SPEAKER

The L75 "Minuet" measures 16½" x 9" x 7¾" deep and is housed in a hardwood veneer cabinet which is finished on all four sides for horizontal or vertical placement.

The unit houses one LE8T full-range speaker



and one 8-inch passive radiator for full frequency coverage. Impedance is 8 to 16 ohms and the speaker is designed to be used with amplifiers rated at 10 watts or more. JBL

Circle No. 16 on Reader Service Card

CB-HAM-COMMUNICATIONS

SCANNER RECEIVER

The "Bearcat" automatic scanner receiver has eight flashing red lights that light up as the receiver scans the eight channels, picking up calls as they come on the air. There are three models available: BCH for 150-174 MHz, BCL for 30-50 MHz, and BCU for 450-470 MHz. The unit is solid state and incorporates IC's. It will operate on 117-volt a.c. or 12-volt d.c. Electra

Circle No. 17 on Reader Service Card

CB TRANSCEIVER

The "23-Plus" CB transceiver features a new cascode front-end and nuvistor mixer, 23 crystal-controlled channels, 19-tube performance, and full 5-watt input.

An exclusive "Modulation Sampler" takes a weak voice and amplifies it. The a.c.-d.c. power supply is transistorized. Controls include an illuminated "S"/r.f. meter and channel selector, a.v.c., floating gate squelch circuit, automatic noise limiter, single-knob tuning, and modulation indicator. The transceiver can be used as a p.a. system and there is an auxiliary speaker jack.

The unit comes complete with crystals for all 23 channels, mounting brackets, power cords, and microphone. Courier

Circle No. 18 on Reader Service Card

DELTA-TUNED CB UNIT

The new GT-523 CB transceiver features a delta-tune facility and a Collins mechanical filter. The compact unit is designed primarily for mobile applications, although an optional "sounding board" power supply is available for operating the radio as a base station.

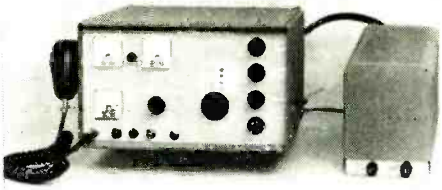
An "S" meter, "on/off/volume" control, squelch and channel selector controls, plus the delta tuning control are located on the front panel. The 5½" x 2¼" x 7½" cabinet is laminated with vinyl on steel and trimmed in chrome. External speaker terminals are located on the back panel. Standard 12-14 volt d.c. powers the unit.

Transmitter output is 3 watts. The squelch circuit is designed to eliminate popping, while the double-conversion superhet receiver performance is enhanced by a Collins mechanical filter and sensitivity of less than 1 μV for 10 dB (S+N)/N at 1000 Hz, 30% modulated. Transmitter carrier frequency accuracy is ±0.005% minimum. Regency

Circle No. 19 on Reader Service Card

SSB/AM TRANSCEIVER

The new "Multra" H.F. 125 TR-1 transceiver can provide simple, economical medium-to-long range SSB/AM communications between 3 and



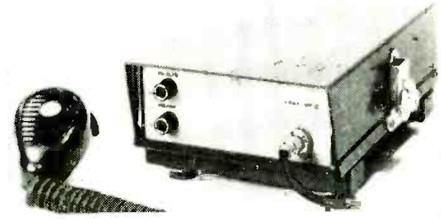
15 MHz, with adapters for radiotelephony, radiotelegraphy, and other specialized requirements.

The unit is housed in two compact units, which makes it ideal for mobile operations, according to the company. An extension control unit with microphone can be fitted to the transceiver for transmit/receive, "on/off" and volume control as far as 25 feet from the unit. Output is 125 watts p.e.p. with power supplies for 110-150, 190-250 volt fixed or 12-volt mobile operation. The transceiver is a tube unit while the power supplies are transistorized. Multronics

Circle No. 20 on Reader Service Card

LOW-POWER TWO-WAY RADIO

The "Imp II" (industrial mobile phone) is a low-power, all solid-state two-way radio for use at fixed locations and on vehicles. It is operable on any one of the relatively uncrowded low-power radio communications channels within the 27.5-42.98 MHz range. Such channels are available to the Business, Local Government, Police, Fire, and Special Industrial Radio Services.



The unit can be installed under the dash of a vehicle or, by means of a shock mount, on materials-handling vehicles, locomotives, commercial vessels, aircraft, cranes, heavy trucks, and other industrial equipment. In addition to radio transmission and reception, the unit can be used as a mobile p.a. system. With an accessory power supply, the "Imp II" can be operated from a 117-volt a.c. power source at fixed locations.

The circuit uses 22 transistors and 11 diodes, including a zener diode voltage stabilizer. Battery drain from a 12-volt electrical system is less than 1/3 A when receiving and 1 A when transmitting. The unit measures $2\frac{5}{8}$" x $6\frac{1}{2}$" x $9\frac{1}{4}$" and weighs 7 pounds. Kaar

Circle No. 21 on Reader Service Card

FM MOBILE UNIT

A new 30-watt r.f. output two-way radio which covers the band from 136-170 MHz has just been added to the "Mocom-30" line.

It provides dash/trunk mount plug-in interchangeability of a basic drawer-type radio set for convenience in systems with both types of installations. It features a fully transistorized receiver and power supply for high reliability and low operating costs. Audio output is 5 watts. A "radio-on" indicator light is included for operator convenience and an optional "automatic dimmer" circuit is available which adjusts the brightness of the indicator light from daytime to nighttime. Reverse polarity protection is also included. Motorola

Circle No. 22 on Reader Service Card

"FOUR-WAY" RADIO

A "four-way radio", the Model 2x2 radiotelephone can be used as a conventional two-way radio for ship-to-shore and ship-to-ship calls, as a loud hailer, and as "big ear" to amplify distant sounds.

The 2x2 has six crystal-controlled channels to accommodate the International Calling and Distress frequency (2182 kHz) and five other channels in the marine band for ship-to-shore, ship-to-ship, and marine operator frequencies.

The 101-watt input enhances the radio's ability

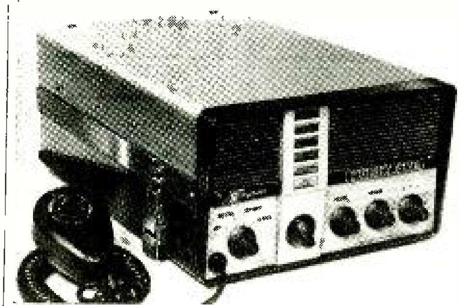
to pierce interference and span long ranges to summon aid. The loud-hailer speaker is driven at 25 watts to provide ample power for communications. Raytheon

Circle No. 23 on Reader Service Card

MARINE RADIOTELEPHONE

The Model 85-A is designed for those who need a reliable operating range of 85 miles or more. It operates on six marine channels and includes reception of standard broadcasts. Crystals for all six channels are included.

The marine unit features "Posi-dent" channel identification markers, adjustable gate squelch, universal mounting cradle, front-mounted speaker, automatic noise limiter, low-drain re-



ceiver, transmitter standby switch, and power plug.

The radio is housed in a single compact case which fits a space 6" high x 10" wide x 15" deep. It weighs 17 pounds. It operates from 12 volts d.c. and draws 0.8 amp on receive, 2.9 amps on standby, and 20 amps on-the-air. Simpson Electronics

Circle No. 24 on Reader Service Card

MANUFACTURERS' LITERATURE

COAXIAL CABLES

A 16-page catalogue designed to assist in the selection of coaxial and CATV cables has been issued as CP-2. It details the design considerations, conductor selection, and properties of dielectric insulating materials.

An RG/U table illustrates all the cable constructions and gives complete attenuation information. Indexed inside the back cover are all commonly used military and governmental wire specifications. ITT Wire and Cable

Circle No. 139 on Reader Service Card

TAPE-RECORDER HEADS

A 20-page, two-color catalogue containing complete mechanical specifications as well as electrical and performance data on an extensive line of tape-recorder heads is now available for distribution.

A selection from the heads illustrated will meet almost all requirements for full-track, half-track, quarter-track, eight-track, and cassette heads. Each head is completely illustrated and described. The procedure for ordering standard as well as non-standard heads is clearly explained. Copies of "Consumer Audio Catalogue #680" will be forwarded on request. Michigan Magnetics

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POWER-SUPPLY MODULES

A 16-page, two-color general catalogue describing of broad line of regulated power-supply modules has just been issued.

Listed in the catalogue are specifications on thousands of models with outputs from 0 to 400 volts, 50 mA to 25 A. Models are short-circuit-proof and designed for full-load operation at 71° C. without additional heat sinking.

The back pages of the catalogue present mechanical data, connections, output impedance, options, accessories, and a price list. Power/Mate

Circle No. 140 on Reader Service Card

BATTERIES FOR STANDBY

A two-color folder (Form 6834R) giving details on five of the latest models of batteries recommended for standby power systems is now available for distribution.

Battery types described in the folder include Ironclad, Tytex silvium, Tytex calcium, Manchex, and nickel-cadmium. Also explained briefly are solid-state chargers and static uninterruptible a.c. power systems. Exide

Circle No. 26 on Reader Service Card

PRECISION INSTRUMENTS

Catalogue 600 describes a complete line of precision instruments including resistance decades, decade voltage dividers, potentiometer circuits, resistance bridges, and a wide variety of Wheatstone bridges for general use. Also covered are bridges for applications such as fault location, rapid "go/no-go" resistor testing, a megohm Wheatstone bridge assembly for the precision measurement of resistances as high as 1,000,000 megohms to four significant figures, and a magnetic bridge assembly for rapid measurement of either Epstein specimens or laminated cores.

Illustrated and explained is the Sarmar system, a new mobile, environmentally isolated high-accuracy resistance measuring and recording system. Shallcross

Circle No. 141 on Reader Service Card

HIGH-FIDELITY PRODUCTS

An all-new high-fidelity sound products catalogue has just been issued as No. 165-P. Illustrated in color are all of the company's new speaker systems, including the recently introduced Models TF-15 and TF-25.

Also illustrated and described is the company's line of "Sigma", "Delta", and "Triaxial" coaxial and triaxial speakers plus a complete series of hi-fi component speakers and accessories as well as stereo headphones. Jensen

Circle No. 27 on Reader Service Card

HAND TOOLS

An 8-page illustrated catalogue covering an extensive line of precision hand tools is now available for distribution. Included in the line are tool kits for radio-TV technicians, audio service personnel, and those working on printed-circuit boards and miniature electronic equipment. Tools available individually include wrench sets, screwdrivers, tap drills, scribers, pin vises, and precision screwdrivers. Moody

Circle No. 28 on Reader Service Card

CAPACITOR BULLETIN

An extensive line of axial-lead aluminum electrolytic capacitors is described in Bulletin 2240A. The new, 12-page bulletin contains application, stability, design, and performance data on Type 557 capacitors. These small, low-cost units are available in capacitances ranging from 3.3 μF to 1000 μF. Sangamo

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COMPONENT SELECTOR

A 36-page component selector (Catalogue 300) has been issued listing hundreds of products available as off-the-shelf items at the company's local distributors. Included are resistors, rheostats/pots, trimmers, tap switches, variable transformers, capacitors, relays, power controls, light dimmers, r.f. chokes, a meter saver, and a line of design aids.

Each item is pictured and described in some detail. Available models are listed in tabular form for easy selection. Ohmite

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WIRE & CABLE DATA

A 1969 catalogue containing technical data on military electronic wire as well as popular commercial types of wire and cable has been issued. There are 46 pages of tables of wire characteristics, a military specification index, alphabetical index, and numerical index. Standard Wire

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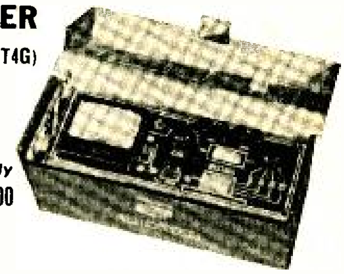

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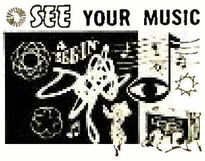

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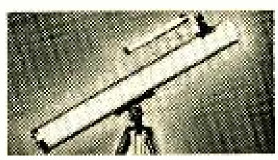

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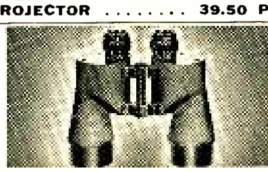

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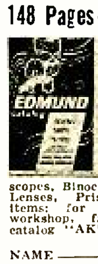

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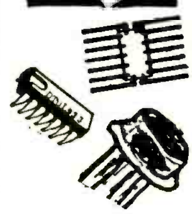

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***b*/** Tear out one of the perforated postage-free cards. Please print or type your name and address where indicated.

***c*/** Circle the number on the card that corresponds to the key number at the bottom of the advertisement or editorial mention that interests you. (Key numbers for advertised products also appear in the Advertisers' Index.)

***d*/** Simply mail the card. No postage is required.

***e*/** Inquiries for information other than "Free Information Service" are to be directed to Electronics World, One Park Avenue, New York, N.Y. 10016.

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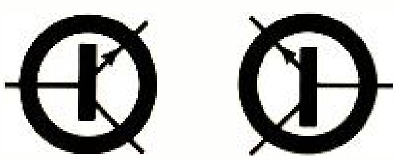
***g*/** Electronics World's Free Information Service lets you "shop by mail".



Important: BLACK numbers are of general interest and you do not have to include your company name and address to receive the information requested.

BLUE numbers correspond to an ad or editorial mention of professional interest. Manufacturers will honor your request **only** if it is to be mailed direct to your company—so be sure to include your company's name and address.

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SB 269

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
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Read each month by the world's largest audience of electronics professionals

It's a color bar generator, too.

You're looking at the only tube tester that can check out almost every receiving tube and throw an alignment signal into the picture tube.

It's a combination tube tester and color bar generator.

So now all you need is a single instrument to do two of your most important servicing jobs: Make sure the tubes in a set are good. And make the adjustments you need to get a good, sharp picture on color and black-and-white TV sets.

We built it like a brick. (After you've carried it through a thousand doorways, you'll know why.)

And we've done everything to make it accurate and stable.

The new instrument starts off with a regulator-type transformer that doesn't give a hoot how the line voltage is acting up. (It doesn't even need a fuse.) There are 73 tube sockets that let you run all kinds of tests on all kinds of tubes. All you have to do is set 3 knobs. You can even check each section of a multi-section tube separately.

The color bar generator is all solid state. It puts out 6 crystal-controlled, rock-stable test patterns: 10 color bars, a clear raster, 10 vertical lines, 13 horizontal lines, 130 dots and a 10 x 13 crosshatch. All operating and calibration controls are right in front of you on the panel.

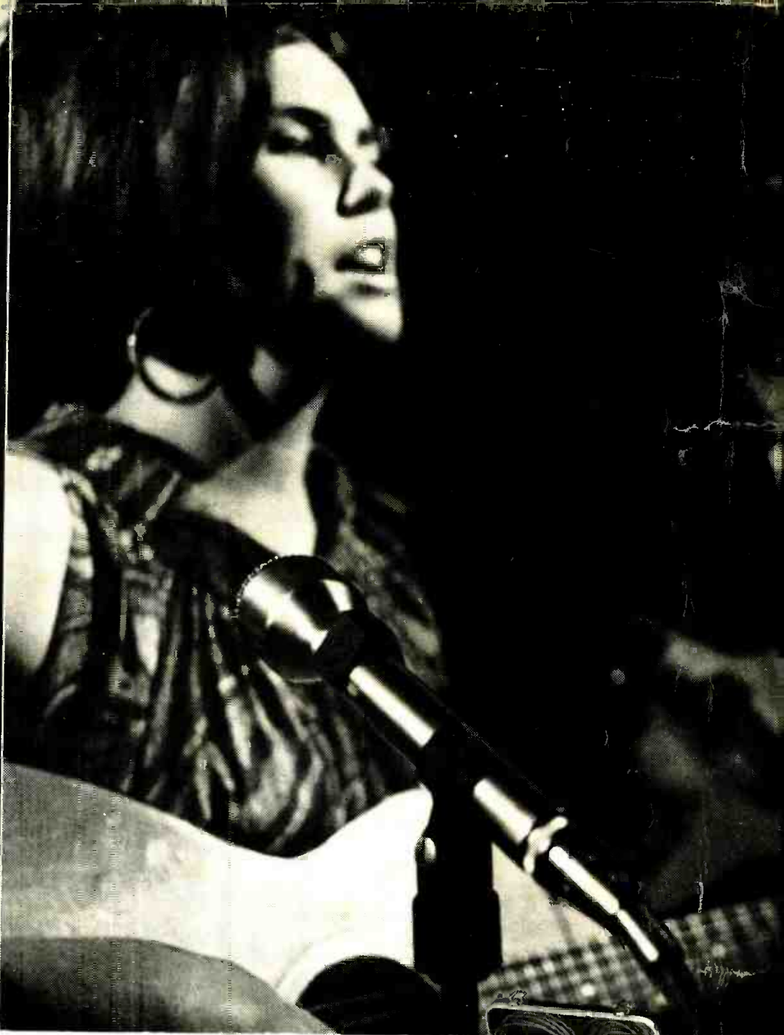
Putting both instruments into one package also gives you a small bonus.

It leaves your other hand free to carry something else.

For more information, see your Sylvania distributor or write to: Sylvania, CADD, 1100 Main Street, Buffalo, N.Y. 14209.

SYLVANIA
A SUBSIDIARY OF GENERAL TELEPHONE & ELECTRONICS

CIRCLE NO. 92 ON READER SERVICE CARD



Model 627 Cardioid Dynamic Microphone
$63.00 List*

Mode 631 Omnidirectional Dynamic Microphone
$63.00 List*

The New Generation of Microphones... for the Now Generation of Performers!

Here are two bright new ways to better sound at modest cost, both unique products of Electro-Voice engineering. Designed to meet the special needs of modern musical groups, and inspired by the E-V microphones so widely used on TV, radio, and in the movies.

Rugged Construction

Both the 627 and 631 are dynamic microphones, for ruggedness, dependability, and smooth, peak-free response. And both are housed in tough, die-cast bodies finished in your choice of satin chrome or matte satin nickel finish.

Advanced Internal Construction

Inside, the design takes full advantage of the E-V "nesting" principle to offer outstanding protection against shock to the element. And a viscous vinyl cushion cuts down on mechanical noise while it guards the delicate moving assembly.

Diaphragms are of exclusive E-V Acoustalloy®, and are protected by a 4-stage acoustic filter inside the microphone that stops "pops" and blasting while it traps dirt and foreign particles.

Choice of Directional Patterns

But while these two microphones have many essential features in common, they differ significantly in operation. The Model 631 is omnidirectional, with natural, wide-range pickup from any angle. Specially designed so that performers can work as close as they wish without noise or distortion.

The Model 627, on the other hand, offers a cardioid pickup pattern, using the Single-D principle that accentuates bass as performers move closer. It's ideal for controlling feedback in many installations, and for reducing unwanted noise to a minimum.

New Uniseal™ Switch

Both models offer an on-off switch, but the switch on the Model 631 deserves special attention. The unique E-V Uniseal switch is a magnetically operated reed relay buried inside the sealed case. Snap off the magnetic actuator, and the 631 is set permanently "on". Snap it back on and the actuator returns the 631 to normal "on-off" operation. Unusually reliable and exclusively Electro-Voice.

Look closely at these two new microphones from Electro-Voice. Better yet, listen to them under the toughest conditions you can find. You'll agree they're unlike any other microphones in their price class, with distinct advantages in many sound applications. Available now at your nearby Electro-Voice microphone headquarters.

*Less normal trade discounts. Available singly or as matched pairs, and with standard or deluxe carrying cases and phone plugs at extra cost.

ELECTRO-VOICE, INC., Dept. 292N
629 Cecil St., Buchanan, Michigan 49107

high fidelity speakers and systems • tuners, amplifiers, receivers • public address loudspeakers • microphones • phonograph needles and cartridges • organs • space and defense electronics

Electro-Voice®
A SUBSIDIARY OF GULTON INDUSTRIES, INC.

CIRCLE NO. 111 ON READER SERVICE CARD